

RECLAMATION

Managing Water in the West

Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

**Central Valley Project, California
Mid-Pacific Region**

Final Biological Assessment



**U.S. Department of the Interior
Bureau of Reclamation**

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Mission Statements

The mission of the Department of the Interior is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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List of Abbreviations / Acronyms

| | |
|---------------------|-------------------------------------------------------|
| °C | Degrees Celsius |
| °F | Degrees Fahrenheit |
| 7DADM | 7 day average daily maximum |
| ACID | Anderson Cottonwood Irrigation District |
| AFRP | Anadromous Fish Restoration Program |
| AFSP | Anadromous Fish Screen Program |
| ARG | American River Group |
| AT | acoustic tag |
| AUCo | AUC of the overlapping portions |
| AUCt | area under the curve |
| Banks Pumping Plant | Harvey O Banks Pumping Plant |
| Bay-Delta | San Francisco Bay/Sacramento-San Joaquin- Delta |
| BMPs | Best Management Practices |
| BO | Biological Opinion |
| Caltrans | California Department of Transportation |
| CAMT | Collaborative Adaptive Management Team's |
| CCC | Central California Coast |
| CCF | Clifton Court Forebay |
| CCR | Clear Creek |
| CCWD | Contra Costa Water District |
| CDFW | California Department of Fish and Wildlife |
| CESA | California Endangered Species Act |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| CM1 | conceptual model |
| CNDDB | California Natural Diversity Database |
| CNFH | Coleman National Fish Hatchery |
| CNOR | Candidate Notice of Review |
| CNPS | California Native Plant Society |
| CNRA | California Natural Resources Agency |
| COA | Coordinated Operations Agreement |
| COS | Current Operations |
| CSAMP | Collaborative Science and Adaptive Management Program |
| CV | Central Valley |
| CVO | Central Valley Operations Office |
| CVP | Central Valley Project |
| CVPA | Central Valley Project Act |
| CVPCP | Central Valley Project Conservation Program |
| CVPIA | Central Valley Project Improvement Act |
| CVSMP | Central Valley Steelhead Monitoring Program |

| | |
|----------|--------------------------------------------------|
| CWT | Coded Wire Tag |
| DADM | Daily Average Daily Maximum |
| DAT | Daily Average Temperature |
| DCC | Delta Cross Channel |
| Delta | Sacramento-San Joaquin Delta |
| DFW's | Department of Fish and Wildlife's |
| DJFMP | Delta Juvenile Fish Monitoring Program |
| DLO | driver-linkage-outcome |
| DMC | Delta-Mendota Canal |
| DO | dissolved oxygen |
| dph | days post hatch |
| DPS | distinct population segment |
| DWR | Department of Water Resources |
| EATSM | Enhanced Acoustic Tag Salmonid Monitoring |
| eDNA | Environmental DNA |
| EDSM | Enhanced Delta Smelt Monitoring |
| EFH | Essential Fish Habitat |
| EMP | Environmental Monitoring Program |
| ESA | Endangered Species Act |
| ESU | Evolutionarily Significant Unit |
| FCCL | Fish Conservation and Culture Laboratory |
| FERC | Federal Energy Regulatory Commission |
| FMS | Flow Management Standard |
| FMWT | Fall Midwater Trawl |
| FR | Federal Register |
| FRFH | Feather River Fish Hatchery |
| FRWP | Freeport Regional Water Project |
| GCID | Glenn Colusa Irrigation District |
| HAB | harmful algal blooms |
| HAPC | Habitat Areas of Particular Concern |
| HFC | High Flow Channel |
| HLT | Middle River at Holt |
| HORB | Head of Old River Barrier |
| HRP | Habitat Restoration Program |
| IEP | Interagency Ecological Program |
| Intertie | Delta-Mendota Canal/California Aqueduct Intertie |
| IPaC | Information for Planning and Conservation |
| IPO | Interim Plan of Operations |
| ISP | Invasive Spartina Project |
| JSATS | Juvenile Salmon Acoustic Telemetry System |
| km | kilometers |
| LFC | Low Flow Channel |
| LOBO | Long-term Operations Biological Opinions |
| LSNFH | Livingston Stone National Fish Hatchery |

| | |
|--------------------|-----------------------------------------------------------------|
| LSZ | low-salinity zone |
| M&I | municipal and industrial |
| MAF | million acre-feet |
| MHHW | mean higher high water |
| MIDS | Morrow Island Distribution System |
| MMPA | Marine Mammal Protection Act |
| MOA | Memorandum of Agreement |
| MRR | Minimum Release Requirement |
| Napa County FC&WCD | Napa County Flood Control and Water Conservation District |
| NBA | North Bay Aqueduct |
| NMFS | National Marine Fisheries Service |
| NMI | New Melones Index |
| NOAA | National Oceanic and Atmospheric Administration |
| O&M | operations and maintenance |
| OCO | Operations Control Office |
| OID | Oakdale Irrigation District |
| OMR | Old and Middle River |
| OTMI | Oroville Temperature Management Index |
| PA | proposed action |
| PAHs | polyaromatic hydrocarbons |
| PBDEs | polybrominated diphenyl ethers |
| PBFs | Physical and Biological Features |
| PBT | parentage based tagging |
| PCBs | polychlorinated biphenyls |
| PCEs | primary constituent elements |
| PFMC | Pacific Fishery Management Council |
| PG&E | Pacific Gas and Electric Company |
| PGS | Pittsburg Generating Station |
| ppt | parts per thousand |
| PSMFC | Pacific States Marine Fisheries Commission |
| RBDD | Red Bluff Diversion Dam |
| Reclamation | United States Department of the Interior, Bureau of Reclamation |
| RHJV | Riparian Habitat Joint Venture |
| RPA | reasonable and prudent alternative |
| RRDS | Roaring River Distribution System |
| RSFS | Rock Slough Fish Screen |
| RST | rotary screw trap |
| SacPAS | Central Valley Prediction and Assessment of Salmon |
| SAIL | Salmon and Sturgeon Assessment of Indicators by Lifestage |
| SCARF | San Joaquin River Conservation and Research Facility |
| SCDD | Spring Creek Debris Dam |
| SCWA | Solano County Water Agency |
| SDWSC | Sacramento Deepwater Ship Channel |
| sf | square feet |

| | |
|-------------------|---------------------------------------------------------------------|
| SJRA | San Joaquin River Agreement |
| SJRRP | San Joaquin River Restoration Program |
| SKT | Spring Kodiak Trawl |
| SMPA | Suisun Marsh Preservation Agreement |
| SMSCG | Suisun Marsh Salinity Control Gates |
| SONCC | Southern Oregon/Northern California Coast |
| SRCD | Suisun Resource Conservation District |
| SRP | Stepped Release Plan |
| SRS | Sacramento River Settlement |
| SRTTG | Sacramento River Temperature Task Group |
| SRWTP | Sacramento Regional Wastewater Treatment Plan |
| SSJID | South San Joaquin Irrigation District |
| SST | Salmonid Scoping Team |
| Suisun Marsh Plan | Suisun Marsh Habitat Management, Preservation, and Restoration Plan |
| SWP | State Water Project |
| SWPAO | State Water Projects Analysis Office |
| SWRCB | State Water Resources Control Board |
| TAF | thousand acre-feet |
| TBP | Temporary Barrier Project |
| TCD | Temperature Control Device |
| TFCF | Tracy Fish Collection Facility |
| TMDLs | total maximum daily load programs |
| TNS | Townnet Survey |
| TOC | top of conservation pool |
| Trinity ROD | Trinity River Record of Decision |
| USACE | U.S. Army Corps of Engineers |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| WCM | Water Control Manual |
| WDRs | Waste Discharge Requirements |
| WERC | Western Ecological Research Center |
| WIIN Act | Water Infrastructure Improvements for the Nation Act |
| WOA | Without Action |
| WQCP | Water Quality Control Plan |
| WUA | Weighted Usable Area |

Chapter 1 Introduction

On August 2, 2016, the United States Department of the Interior, Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP, or Project). The United States Fish and Wildlife Service (USFWS) accepted the reinitiation request on August 3, 2016, and the National Marine Fisheries Service (NMFS) accepted the reinitiation request on August 17, 2016. This biological assessment supports Reclamation's consultation under Section 7 of the Endangered Species Act (ESA) of 1973, as amended, and documents the potential effects of the proposed action on federally listed endangered and threatened species that have the potential to occur in the action area and critical habitat for these species. It also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH).

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reclamation is the largest wholesale water supplier in the United States, and the nation's second largest producer of hydroelectric power. Its facilities also provide substantial flood control, recreation, and fish and wildlife benefits. In Northern California, Reclamation operates the CVP in coordination with DWR's operation of the SWP. The mission of DWR is to manage the water resources of California, in cooperation with other agencies, to benefit the state's people and to protect, restore, and enhance the natural and human environment.

The CVP consists of 20 dams and reservoirs that together can store nearly 12 million acre-feet (MAF) 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 MAF of water for farms; 600 thousand acre-feet (TAF) of water for municipal and industrial (M&I) uses (enough water to supply about 2.5 million people for a year); and 355 TAF 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 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 MAF 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, M&I, 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.

The proposed action analyzed in this consultation centers on a Core Water Operation that provides for Reclamation and DWR to operate the CVP and SWP for water supply and to meet the requirements of State Water Resources Control Board (SWRCB) Water Right Decision 1641 (D-1641), along with other project purposes. The Core Water Operation consists of operational actions that do not require subsequent concurrence or extensive coordination to define annual operation. The proposed action also includes conservation measures designed to minimize or reduce the effects of the action on listed species. In addition, this biological assessment and resulting consultation evaluates actions that will require further development and may change during repeated implementation as more information becomes available (i.e., “adaptive management”). Adaptively managed actions will require additional coordination prior to implementation through program-specific teams established by Reclamation and DWR with input and participation from partner agencies and stakeholders.

In 2015, the USFWS and NMFS (collectively, the Services) promulgated an addition to the regulations on Interagency Cooperation (50 Code of Federal Regulations [CFR] § 402) that is relevant to this consultation. The regulation added a “mixed programmatic action” for the purpose of issuing an Incidental Take Statement for take authorization. The regulation describes a mixed programmatic action as “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.”

This distinction allows for an Incidental Take Statement to be issued for those parts of the action that are specific enough that the Services can meet the regulatory burden of reasonable certainty. Where that degree of certainty is not met, the Services may analyze the future action to determine whether jeopardy of a listed species or destruction or adverse modification of designated critical habitat is likely to result from the entirety of the proposed action, and make an overall conclusion for the listed species and designated critical habitat. Once sufficient detail is available for future actions, Reclamation agrees to initiate targeted Section 7 consultation on these actions.

The proposed action includes immediate site-specific actions, as well as future actions that may be subject to subsequent site-specific Section 7 consultation. This aligns with the description of a “mixed programmatic action,” and Reclamation proposes to consult on the overall action as such.

On December 12, 2018, the California Natural Resources Agency (CNRA) presented a framework for Voluntary Agreements to the SWRCB in response to proposed Bay-Delta Water Quality Control Plan (WQCP) amendments. This framework was the result of years of coordination between CNRA, Reclamation, and several public water agencies in California. The SWRCB is currently considering the Voluntary Agreements as part of its proceeding, with at least two upcoming dates in 2019 (March and December) for deliberation. If approved, the Voluntary Agreements would provide additional flows, facility improvements, and habitat restoration that benefit listed species, with a proposed funding mechanism to implement these enhancements. Reclamation and DWR support the Voluntary Agreements and continue to participate in their development. Preliminary analysis indicates that when combined with the Core Water Operation proposed in this consultation, the Voluntary Agreements are beneficial to listed species and critical habitat. However, Reclamation is not consulting on Voluntary Agreements in this biological assessment.

1.1 Background

In this biological assessment, consistent with the ESA and applicable regulations, Reclamation separates the proposed action from the environmental baseline in order to determine whether the action is likely to adversely affect ESA-listed species. Reclamation's analysis is informed by the complex history of water and infrastructure development in California. The environmental baseline includes impacts to ESA-listed species resulting from the original construction and development of dams in the action area as well as decades of man-made and other alterations to fish species that occurred during the last 300 years (as described below).

When developing and assessing the potential effects of the proposed action, Reclamation considers the context of the complex history of water and land development in California in order to separate the proposed action from the environmental baseline and determine whether it is likely to adversely affect ESA-listed species.

Water storage and diversion in California began in 1772, with a 12-foot high dam on the San Diego River. The discovery of gold in the Sierra Nevada in 1849 intensified the human development of the Central Valley. Natural water flows were diverted to aid in hydraulic mining, and the Sacramento River and San Joaquin River watersheds were polluted with contaminants originating from historic and active mine sites. Major flood protection efforts began in 1840 with levee construction along Grand Island. Revetments and bank armoring, and other protection measures to prevent erosion along the levees, caused and continue to cause channel narrowing and incision and prevent channel migration. Levees have also isolated former floodplains from the river channel, preventing access for rearing for juvenile salmonids.

Commercial harvest of salmon began in the 1850s (CDFG 1929) and gill net salmon fisheries became well established in the lower Sacramento and San Joaquin Rivers by 1860. In 1910, there were 10 million pounds of commercial salmon catch; that yield declined to 4.5 million pounds by 1919, when the last inland cannery closed (CDFG 1929).

Striped Bass (*Morone saxatilis*), introduced from the East Coast in the 1880s, supported a commercial fishery for almost 50 years and currently provide a recreational fishery. Striped Bass and other introduced species prey upon listed species. A Striped Bass population of 1,000,000 could consume 9 percent of out-migrating Winter-Run Chinook Salmon (*Oncorhynchus tshawytscha*) based on Bayesian population dynamics modeling (Lindley and Mohr 2003). Other invasive animal and plant species alter sediment dynamics, compete for resources, change the physical habitat, and disrupt the foodweb. Invasive clams were first introduced in the 1940s, and the invasion of the Amur River clam (*Potamocorbula amurensis*) in 1986 fundamentally altered the Delta foodweb. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt (*Hypomesus transpacificus*) and young Chinook Salmon.

1.1.1 Construction and Operation of the CVP and SWP

Congress authorized Reclamation to develop the CVP for the public good of delivering water and generating power, while providing flood protection to downstream communities and protecting water quality for water users within the system. Congress envisioned a large, complex project integrated across multiple watersheds that Reclamation would operate to ensure the most beneficial use of water released into the system.

The 1935 Rivers and Harbors Act authorized Reclamation to take over the CVP from the State of California and its initial features were authorized for construction. In 1937, the Rivers and Harbors Act

reauthorized the CVP under Reclamation Law. The 1937 Act and subsequent authorizations completed Friant Dam in 1942, Shasta Dam in 1944, Folsom Dam in 1956, San Luis Dam in 1967, Trinity Dam in 1962, and New Melones Dam in 1978. Today, Reclamation operates the CVP consistent with the CVP's federally authorized purposes, including:

- river regulation;
- improvement of navigation;
- flood control;
- water supply for irrigation and municipal and industrial uses;
- fish and wildlife mitigation, protection, and restoration;
- power generation; and
- fish and wildlife enhancement.

The Burns-Porter Act, approved by the California voters in November 1960 (Water Code [Wat. Code] §§ 12930–12944), authorized issuance of bonds for construction of the SWP. DWR's authority to construct state water facilities or projects is derived from the Central Valley Project Act (CVPA) (Wat. Code § 11100 et seq.), the Burns-Porter Act (California Water Resources Development Bond Act) (Wat. Code §§ 12930–12944), the State Contract Act (Pub. Contract Code § 10100 et seq.), the Davis-Dolwig Act (Wat. Code §§ 11900–11925), and special acts of the State Legislature.

In 1978, the SWRCB issued Water Rights Decision 1485 (D-1485). D-1485 required spring outflow and set salinity standards in the Delta while setting standards for the diversion of flows into the Delta during winter and spring.

In 1986, Public Law 99-546 directed the Secretary of the Interior to execute the Coordinated Operations Agreement (COA). The COA defined CVP and SWP facilities and their water supplies, coordinated operational procedures, identified formulas for sharing joint responsibility for meeting Delta standards (such as those in D-1485), identified how unstored flow was shared, and established a framework for exchange of water and services between the projects.

In 1992, Public Law 102-575 included Title 34, the Central Valley Project Improvement Act (CVPIA) that refined water management for the CVP. The CVPIA added fish and wildlife mitigation, protection, and restoration as a project purpose with the same priority as water supply, and also added fish and wildlife enhancement as a project purpose with the same priority as power generation. In addition, the CVPIA prescribed a number of actions to improve anadromous fish and provided for other fish and wildlife benefits.

In 1999, the SWRCB issued D-1641, obligating the CVP and SWP to the 1995 Bay-Delta Water Quality Control Plan. Revised in 2000, D-1641 provided standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. A new export to inflow ratio limited exports at Banks and Jones Pumping Plants to 35 percent of total Delta inflow from February through June, and 65 percent of total Delta inflow from July through January. Additionally, flow and salinity requirements on the San Joaquin River near Vernalis were imposed.

1.1.2 Current Requirements

The coordinated long-term operations of the CVP and SWP are currently subject to the 2008 and 2009 biological opinions issued pursuant to Section 7 of the ESA. Each of these biological opinions included

Reasonable and Prudent Alternatives (RPAs) to avoid the likelihood of jeopardizing the continued existence of listed species, or the destruction or adverse modification of critical habitat that were the subject of consultation.

The 2008 USFWS Biological Opinion concluded that the long-term operations of the CVP and SWP were likely to jeopardize the continued existence of Delta Smelt and were likely to destroy or adversely modify their designated critical habitat. Therefore, an RPA was included with five components comprising three types of actions to avoid jeopardy:

- Reduce the magnitude of net reverse Old and Middle River (OMR) flows to reduce Delta Smelt entrainment;
- Implement a “Fall X2” standard requiring that the location of the low-salinity zone (defined as 2 parts per thousand isohaline) be located at no greater than 46 and 50 miles (74 and 81 kilometers [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; and
- Implement 8,000 acres of tidal restoration in Suisun Marsh and/or the north Delta to provide suitable habitat for Delta Smelt.

The OMR and Fall X2 actions have been implemented to various degrees, and portions of the 8,000 acres of tidal restoration are currently in the planning, development, or construction stages.

The 2009 NMFS Biological Opinion concluded that the long-term operations of the CVP and SWP were likely to jeopardize the continued existence of Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, 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*). In addition, it concluded that the long-term operations of the CVP and SWP were likely to destroy or adversely modify designated critical habitat for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, California Central Valley Steelhead and proposed (subsequently designated) critical habitat for the Southern DPS of North American Green Sturgeon. Therefore, an RPA was included consisting of a suite of actions that addressed Delta and upstream conditions throughout the CVP and SWP to avoid jeopardy of these species and the destruction or adverse modification of critical habitat for these species.

Several components of the NMFS RPA have been implemented or are in the planning stages. Examples include Delta operational changes implemented since 2009 intended to reduce entrainment loss of Chinook Salmon and Steelhead; current planning efforts for the restoration of the Yolo Bypass; changes in water operations to improve temperature conditions for aquatic resources in the Sacramento, American, and Stanislaus Rivers; adjustments to the operations of the Suisun Marsh Salinity Control Gates and the Delta Cross Channel (DCC); investigation into the efficacy of non-physical barriers in the Delta to improve salmonid survival; upstream habitat improvement projects; and a host of monitoring activities, studies, and investigations to better understand the ongoing effects of CVP and SWP operations.

1.1.2.1 Mitigation Measures Included in the 2009 State Water Project Longfin Smelt Incidental Take Permit

The 2009 SWP Longfin Smelt (*Spirinchus thaleichthys*) Incidental Take Permit (ITP) was issued by the California Department of Fish and Wildlife (CDFW) on February 23, 2009. The ITP was extended by 1 year on December 31, 2018, subject to DWR’s compliance with and implementation of Conditions of Approval. Several conditions have the potential to affect species addressed in this biological assessment. Conditions include minimizing entrainment at Banks Pumping Plant (Conditions 5.1 and 5.2); minimizing

entrainment at Morrow Island Distribution System in Suisun Marsh (Condition 6.1); improving salvage efficiencies (Conditions 6.2 and 6.3); maintaining fish screens at North Bay Aqueduct (NBA), Roaring River Distribution System (RRDS), and Sherman Island diversions (Condition 6.4); fully mitigating through the restoration of 800 acres of intertidal and associated subtidal wetland habitat in a mesohaline part of the estuary (Conditions 7.1–7.3); and monitoring and reporting (Conditions 8.1–8.5). Conditions 5.1 and 5.2 are being implemented through DWR’s participation in the Smelt Working Group. Conditions 6.1 through 6.4 are currently being planned or implemented, and are in various stages of completion. Conditions 7.1 through 7.3 are being planned consistent with the planning for restoration required for the 2008 RPA described above. Additionally, the various monitoring programs required in Conditions 8.1–8.5 are being planned or implemented consistent with the settlement agreement associated with the permit.

1.1.2.2 *WIIN Act*

The Water Infrastructure Improvements for the Nation Act (WIIN Act) (Pub. L. 114–322, 130 Stat. 1628), is among the federal statutes that govern operation of the CVP and SWP. Section 4001 of the WIIN Act directs the Secretary of the Interior and the Secretary of Commerce to provide the maximum quantity of water supplies practicable to CVP contractors and SWP contractors by approving, in accordance with federal and applicable state laws, operations or temporary projects to provide additional water supplies as quickly as possible, based on available information. Although the duration of this biological assessment and the biological opinion(s) from this consultation may extend beyond the expiration of the WIIN Act, the congressional direction provided by the WIIN Act governs the preparation of the biological opinion(s) that will result from this ongoing Section 7 consultation. Moreover, the general principles that underlie the direction provided by Congress in section 4001 of the WIIN Act are consistent with the purposes of the proposed action and federal interests. In addition, the science and general principles behind sections 4002 and 4003 warrant incorporation into the proposed action to govern operations of the CVP and SWP beyond expiration of the WIIN Act.

Section 4004 provides for cooperation with state and local agencies to resolve water resource issues in concert with conservation of endangered species, consistent with the ESA. Public water agencies in particular shall be informed by the consulting agency, the USFWS, or NMFS, of the schedule for preparation of the biological opinion at such time as the biological assessment is submitted to the consulting agency by the action agency; 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; have the opportunity to confer with the action agency and applicant, if any, about reasonable and prudent alternatives prior to the action agency or applicant identifying one or more reasonable and prudent alternatives for consideration by the consulting agency; and where the consulting agency suggests a reasonable and prudent alternative, be informed how each component of the alternative will contribute to avoiding jeopardy or adverse modification of critical habitat and the scientific data or information that supports each component of the alternative, and why other proposed alternative actions that would have fewer adverse water supply and economic impacts are inadequate to avoid jeopardy or adverse modification of critical habitat. Additional provisions provide for coordination with Collaborative Science and Adaptive Management Program (CSAMP) and quarterly stakeholder meetings.

1.2 Action Area

The action area is defined as 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). For the purposes of this biological assessment, the action area encompasses the following reservoirs, rivers, and the land between the levees adjacent to the rivers: (1) Trinity Reservoir and Trinity River downstream of Lewiston Reservoir; (2) Sacramento River from Shasta Lake downstream to and including the Sacramento–San Joaquin Delta; (3) Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (4) Feather River from the FERC boundary downstream to its confluence with the Sacramento River; (5) American River from Folsom Reservoir downstream to its confluence with the Sacramento River; (6) Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (7) San Joaquin River from Friant Dam downstream to and including the Sacramento–San Joaquin Delta; (8) San Francisco Bay and Suisun Marsh; and (9) the nearshore Pacific Ocean on the coast from Point Conception to Cape Falcon in Oregon. The action area was derived by considering several factors to account for potential effects of the proposed action.

Shasta, Whiskeytown, Oroville, Folsom, and New Melones dams and reservoirs are part of the Central Valley Project operations, and therefore within the Action Area.

Reclamation diverts water from the Trinity River watershed to the Sacramento River through Carr Powerplant and Spring Creek tunnel. The amount of this diversion affects flows in both the Trinity and Sacramento Rivers, affecting both Sacramento River listed species and Trinity River listed species. Therefore, the Trinity River downstream of Lewiston Reservoir is included in the action area.

DWR already has undergone Section 7 consultation on the operations of Oroville Dam on the Feather River through the Federal Energy Regulatory Commission's (FERC) process. Oroville Dam is part of the coordinated operations of the CVP and SWP; however, its effects have been addressed previously in the USFWS and NMFS biological opinions through the FERC process. This consultation addresses effects of Oroville operations that are downstream of the FERC boundary in the Feather River to the Delta, and coordinated effects with CVP operation.

Starting in 2016, Friant Dam and the Upper San Joaquin River have been hydrologically re-connected to the Delta through the release of San Joaquin River Restoration Program flows and recapture of those flows in the Lower San Joaquin River or Delta. Therefore, the San Joaquin River from Friant Dam downstream to and including the Sacramento–San Joaquin Delta is included in the action area.

The CVP and SWP affects the abundance of Central Valley Chinook Salmon originating from the Sacramento and San Joaquin Rivers, which is a prey species for Southern Resident Killer Whale, a listed species under the ESA. The range of Central Valley Chinook Salmon in the ocean is approximately from Point Conception to Cape Falcon, Oregon (Satterthwaite et al. 2013; Can J Fish Aq Sci). Therefore, while Southern Resident Killer Whale has a larger range, the effects of this action are limited to the range of Chinook Salmon. Hence, the action area is limited to portions of the California and Oregon coasts.

Figures 1-1 through 1-8 below show the extent of the action area. Figure 1-1 has grey boxes to indicate subsequent zoomed-in maps. On Figure 1-2, the grey box indicates the action area in the Pacific Ocean.

CVP Overview



Figure 1-1. Overview of the CVP and SWP

Coastal Extent



Figure 1-2. Action Area—Coastal Extent

Trinity River

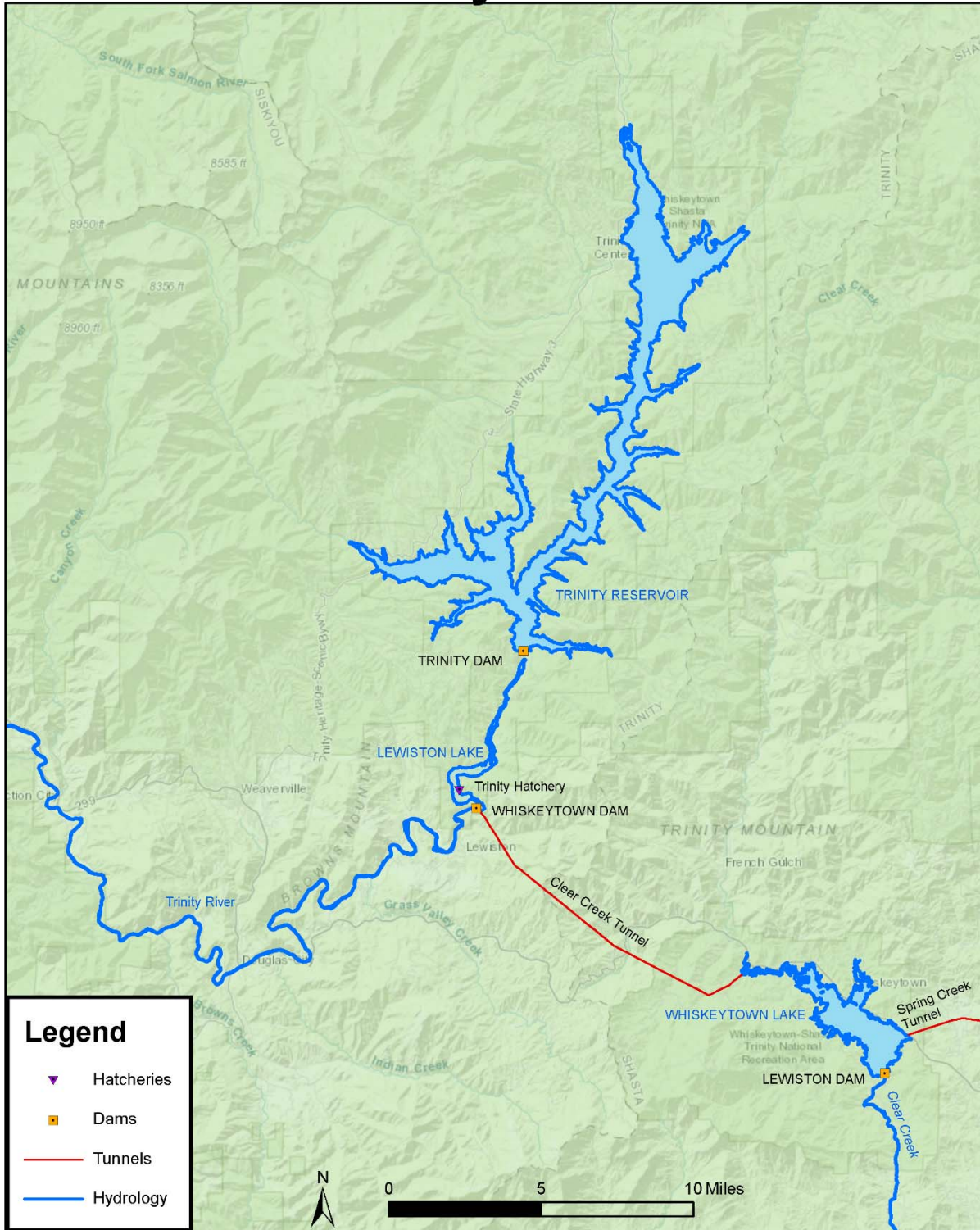


Figure 1-3. Action Area—Trinity River

Sacramento River

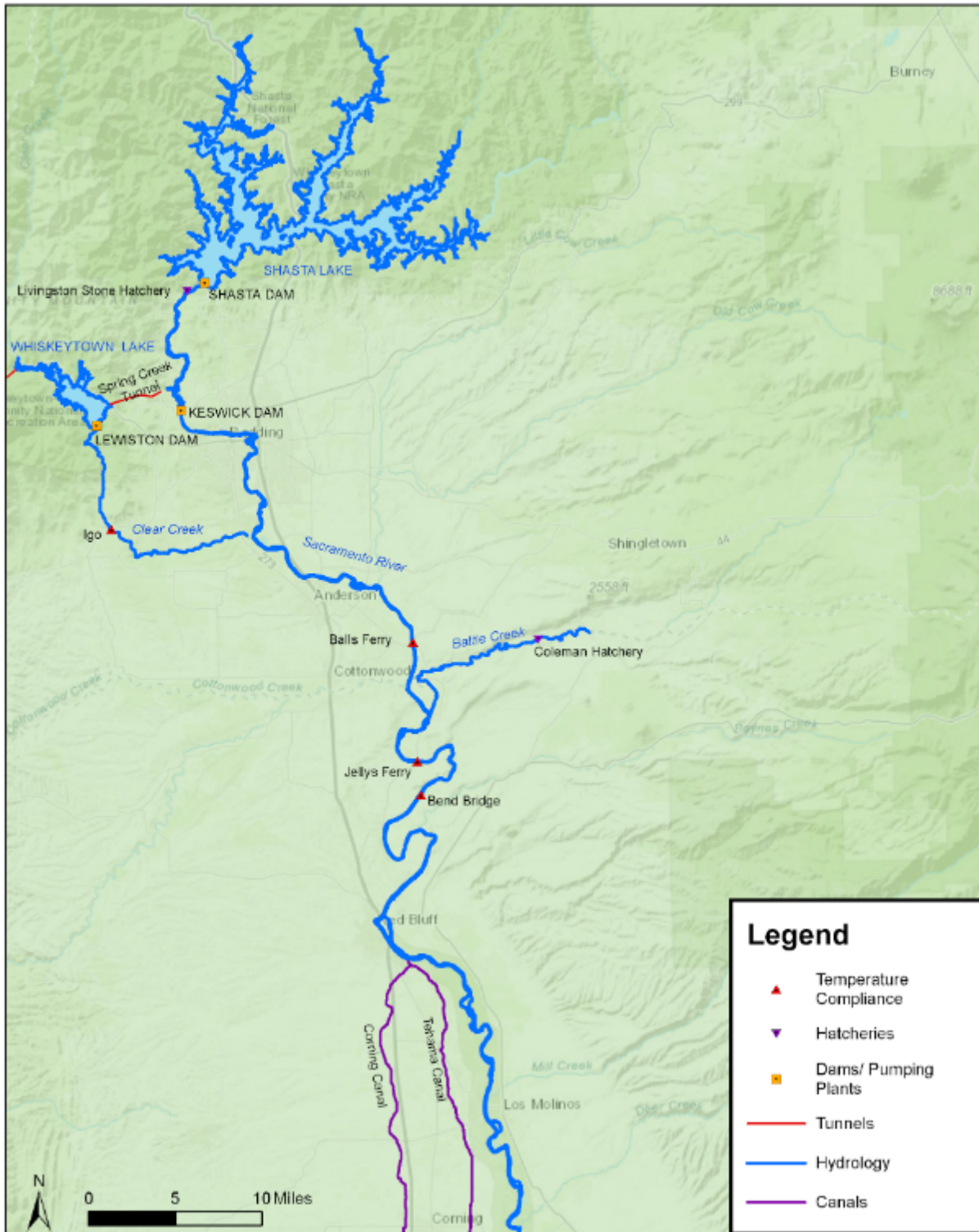


Figure 1-4. Action Area—Sacramento River

American River

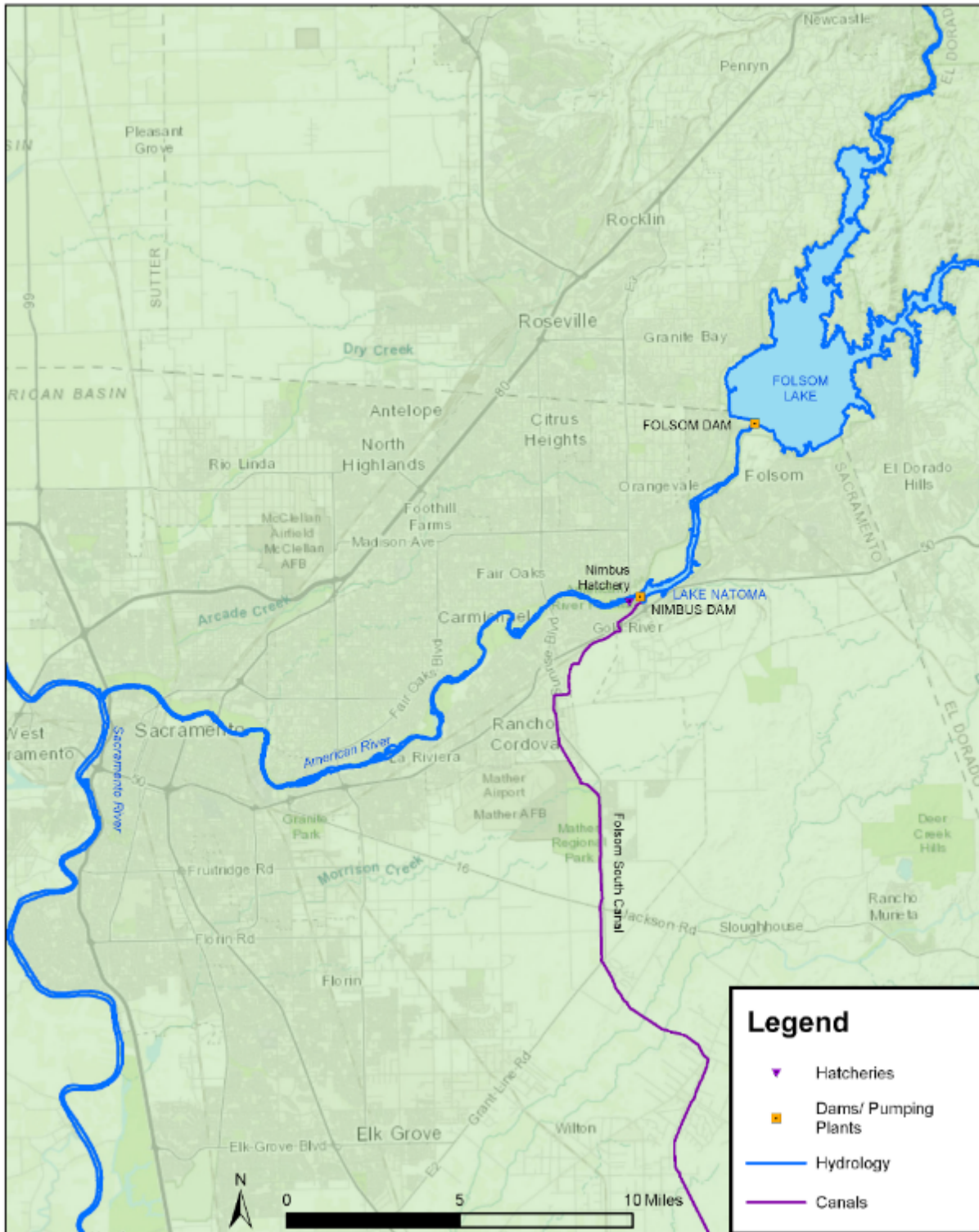


Figure 1-5. Action Area—American River

Delta

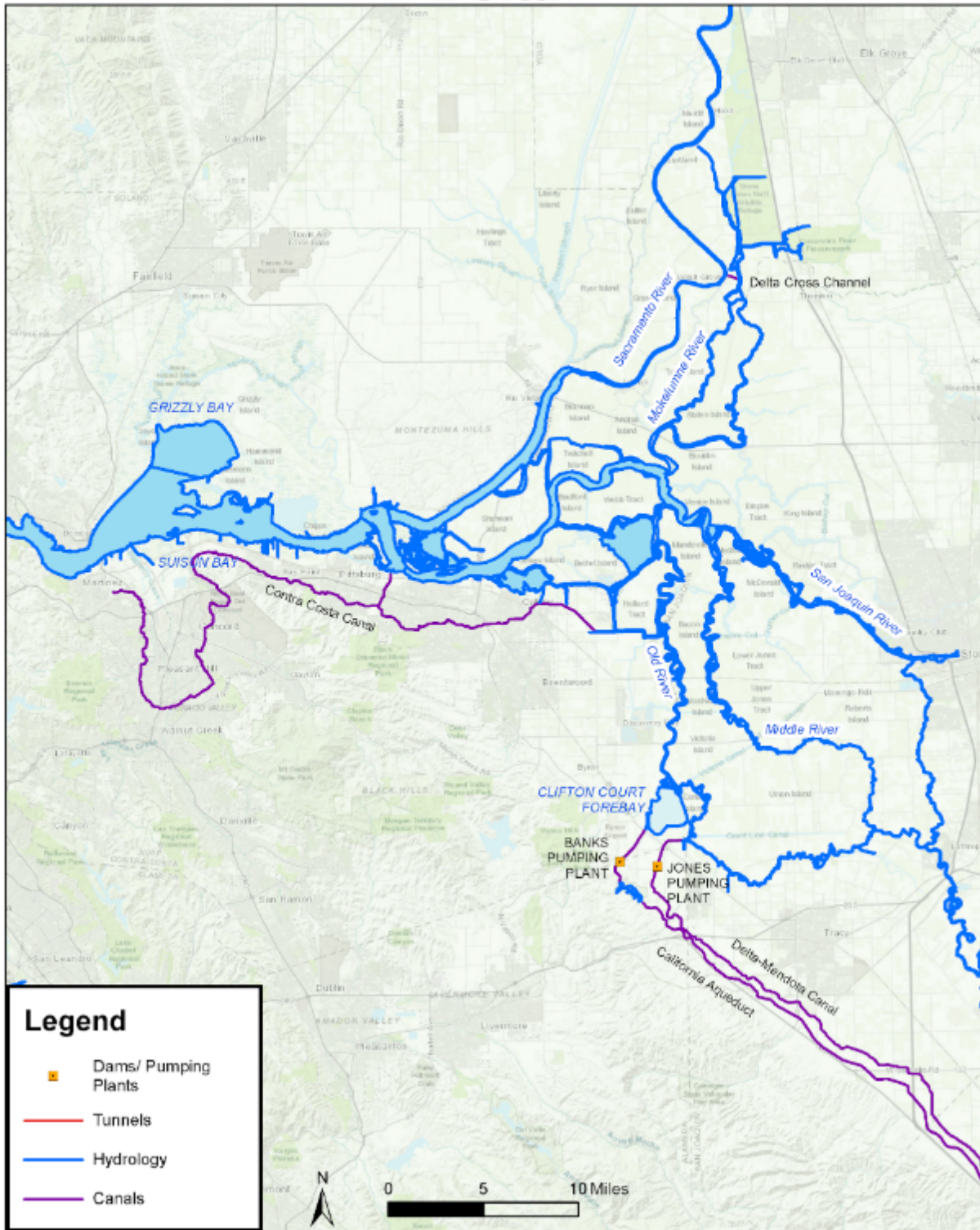


Figure 1-6. Action Area—Delta

Stanislaus River



Figure 1-7. Action Area—Stanislaus River

San Joaquin River



Figure 1-8. Action Area—San Joaquin River

1.3 Species Considered

Pursuant to the interagency consultation requirements of Section 7 of the ESA, this biological assessment has been prepared to assess the potential effects of the proposed action on federally protected species and designated critical habitat. Aquatic and terrestrial species considered in this biological assessment include those that are federally listed as threatened or endangered. The following input was used to determine which listed species should be considered for inclusion in this biological assessment:

- ESA-listed species distributional maps and literature review of species life-history requirements and habitat use
- Environmental documentation prepared in support of other Reclamation projects
- Discussions with federal and state agencies
- NMFS and CDFW online species lists (NMFS 2017; CDFW 2018)
- USFWS Information for Planning and Conservation (IPaC) system (USFWS 2018a)
- California Natural Diversity Database (CNDDDB) Rarefind 5 online application
- California Native Plant Society (CNPS) Online Inventory of Rare and Endangered Vascular Plants of California (CNPS 2018)

Based on this information, the species to be addressed are shown in Table 1-1.

Table 1-1. Federally Protected Species and Critical Habitat Addressed in this Biological Assessment

| Species | Status | Jurisdiction | Critical Habitat |
|------------------------------------------------------------------------------------------------|------------|--------------|-----------------------------------|
| Sacramento River Winter-Run Chinook Salmon ESU (<i>Oncorhynchus tshawytscha</i>) | Endangered | NMFS | Designated in action area |
| Central Valley Spring-Run Chinook Salmon ESU (<i>Oncorhynchus tshawytscha</i>) | Threatened | NMFS | Designated in action area |
| Central Valley Steelhead DPS (<i>Oncorhynchus mykiss</i>) | Threatened | NMFS | Designated in action area |
| Central California Coast Steelhead DPS (<i>Oncorhynchus mykiss</i>) | Threatened | NMFS | Designated in action area |
| Green Sturgeon Southern DPS (<i>medirostris</i>) | Threatened | NMFS | Designated in action area |
| Southern Resident Killer Whale (<i>Orcinus orca</i>) | Endangered | NMFS | Designated but not in action area |
| Southern Oregon/Northern California Coastal Coho Salmon ESU (<i>Oncorhynchus kisutch</i>) | Threatened | NMFS | Designated in action area |

| Species | Status | Jurisdiction | Critical Habitat |
|-----------------------------------------------------------------------------------|---------------|---------------------|-----------------------------------|
| Eulachon (<i>Thaleichthys pacificus</i>) | Threatened | NMFS | Designated in action area |
| Delta Smelt (<i>Hypomesus transpacificus</i>) | Threatened | USFWS | Designated in action area |
| Riparian brush rabbit (<i>Sylvilagus bachmani riparius</i>) | Endangered | USFWS | None designated |
| Riparian woodrat (<i>Neotoma fuscipes riparia</i>) | Endangered | USFWS | None designated |
| Salt marsh harvest mouse (<i>Reithrodontomys raviventris</i>) | Endangered | USFWS | None designated |
| California clapper rail (<i>Rallus obsoletus</i>) | Threatened | USFWS | None designated |
| Least Bell's vireo (<i>Vireo bellii pusillus</i>) | Endangered | USFWS | Designated but not in action area |
| Yellow-billed cuckoo ¹ (<i>Coccyzus americanus</i>) | Threatened | USFWS | Proposed |
| Giant garter snake (<i>Thamnophis gigas</i>) | Threatened | USFWS | None designated |
| Soft bird's beak (<i>Cordylanthus mollis</i> ssp. <i>Mollis</i>) | Endangered | USFWS | Designated in action area |
| Suisun thistle (<i>Cirsium hydrophilum</i> var. <i>hydrophilum</i>) | Endangered | USFWS | Designated in action area |
| Valley elderberry longhorn beetle (<i>Desmocerus californicus dimorphus</i>) | Threatened | USFWS | Designated in action area |
| Vernal Pool Fairy Shrimp (<i>Branchinecta lynchi</i>) | Threatened | USFWS | None designated |
| Vernal Pool Tadpole Shrimp (<i>Lepidurus packardii</i>) | Endangered | UFWWS | Designated but not in action area |
| California Tiger Salamander (<i>Ambystoma californiense</i>) | Endangered | USFWS | Designated but not in action area |

| Species | Status | Jurisdiction | Critical Habitat |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------|-----------------------------------|
| California Least Tern (<i>Sterna antillarum browni</i>) | Endangered | USFWS | None designated |
| California red-legged frog (<i>Rana draytonii</i>) | Threatened | USFWS | Designated but not in action area |
| ESU = Evolutionarily Significant Unit; NMFS = National Marine Fisheries Service; DPS = distinct population segment; USFWS = United States Fish and Wildlife Service ¹ = species included for programmatic construction actions | | | |

1.3.1 Species Considered but Not Addressed Further

In addition to the species listed in Table 1-2, a number of species and their critical habitat were considered for inclusion because initial review indicated they could occur in the Project vicinity. Although listed as potentially occurring within the wider surrounding area based on agency and county lists, several species can be considered as highly unlikely to occur in the action area and therefore do not warrant analysis of potential project impacts. These species considered but not addressed further are the following: giant kangaroo rat (*Dipodomys ingens*), gray wolf (*Canis lupus*), southern sea otter (*Enhydra lutris nereis*), California condor (*Gymnogyps californianus*), California least tern (*Sterna antillarum browni*), marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentalis caurina*), short-tailed albatross (*Phoebastria [=Diomedea] albatrus*), western snowy plover (*Charadrius nivosus nivosus*), Alameda whipsnake [=striped Racer] (*Masticophis lateralis euryxanthus*), green sea turtle (*Chelonia mydas*), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*), California tiger salamander (*Ambystoma californiense*), tidewater goby (*Eucyclogobius newberryi*), Bay checkerspot butterfly (*Euphydryas editha bayensis*), callippe silverspot butterfly (*Speyeria callippe callippe*), Delta green ground beetle (*Elaphrus viridis*), Lange's metalmark butterfly (*Apodemia mormo langei*), mission blue butterfly (*Icaricia icarioides missionensis*), Myrtle's silverspot butterfly (*Speyeria zerene*), San Bruno elfin butterfly (*Callophrys mossii bayensis*), California freshwater shrimp (*Syncaris pacifica*), Conservancy fairy shrimp (*Branchinecta conservation*), longhorn fairy shrimp (*Branchinecta longiantenna*), Shasta crayfish (*Pacifastacus fortis*), vernal pool fairy shrimp (*Branchinecta lynchi*), vernal pool tadpole shrimp (*Lepidurus Packard*), Antioch dunes evening-primrose (*Oenothera deltooides* ssp. *Howellii*), beach layia (*Layia carnosa*), Butte County meadowfoam (*Limnanthes floccosa* ssp. *Californica*), California seablite (*Suaeda californica*), Chinese Camp (*Brodiaea Brodiaea pallida*), clover lupine (*Lupinus tidestromii*), Colusa grass (*Neostapfia colusana*), Contra Costa goldfields (*Lasthenia conjugens*), Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*), El Dorado bedstraw (*Galium californicum* ssp. *Sierra*), fleshy owl's-clover (*Castilleja campestris* ssp. *Succulent*), Franciscan manzanita *Arctostaphylos franciscana*, fountain thistle (*Cirsium fontinale* var. *fontinale*), Greene's tuctoria (*Tuctoria greenei*), hairy Orcutt grass (*Orcuttia pilosa*), Hartweg's golden sunburst (*Pseudobahia bahiifolia*), Hickman's potentilla (*Potentilla hickmanii*), Hoover's Spurge (*Chamaesyce hooveri*), Keck's checker-mallow (*Sidalcea keckii*), large-flowered fiddleneck (*Amsinckia grandiflora*), Layne's butterweed (*Senecio layneae*), Marin dwarf-flax (*Hesperolinon congestum*), marsh sandwort (*Arenaria paludicola*), McDonald's rock-cress (*Arabis macdonaldiana*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *Albidus*), pallid manzanita (*Arctostaphylos pallida*), palmate-bracted bird's beak (*Cordylanthus palmatus*), Pine Hill ceanothus (*Ceanothus roderickii*), Pine Hill flannelbush *Fremontodendron californicum* ssp. *Decumbens*), Presidio clarkia (*Clarkia franciscana*), Presidio manzanita (*Arctostaphylos hookeri* var. *ravenii*), red hills vervain *Verbena californica*, robust

spineflower (*Chorizanthe robusta* var. *robusta*), Sacramento Orcutt grass (*Orcuttia viscida*), San Francisco lessingia (*Lessingia germanorum* [=*L.g.* var. *germanorum*]), San Joaquin Orcutt grass (*Orcuttia inaequalis*), San Mateo thornmint (*Acanthomintha obovata* ssp. *Duttonii*), San Mateo woolly sunflower (*Eriophyllum*), Santa Clara Valley dudleya (*Dudleya setchellii*), Santa Cruz tarplant (*Holocarpha macradenia*), Sebastopol meadowfoam (*Limnanthes vinculans*), Showy Indian Clover (*Trifolium amoenum*), slender Orcutt grass (*Orcuttia tenuis*), Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), Sonoma spineflower (*Chorizanthe valida*), Sonoma sunshine (*Blennosperma bakeri*), Stebbins' morning-glory *Calystegia stebbinsii*, Tiburon paintbrush (*Castilleja affinis* ssp. *Neglecta*), white-rayed pentachaeta (*Pentachaeta bellidiflora*), and yellow larkspur (*Delphinium luteum*), Fresno kangaroo rat (*Dipodomys nitratoides*), San Joaquin kit fox (*vulpes macrotis mutica*), and Blunt Nosed-Leopard Lizard (*Gambelia sila*). NMFS (2009, p.75) noted that DWR's Suisun Marsh Salinity Control Gates (SMSCG) in Montezuma Slough are located to the east of the three Suisun Marsh steelhead streams and Central California Coast Steelhead (CCC Steelhead) (*Oncorhynchus mykiss*) are unlikely to travel 10-15 miles eastward through Montezuma Slough to the SMSCG. Therefore, NMFS (2009, p.75) concluded that it would be unlikely that CCC Steelhead will encounter the SMSCG or the Delta pumping facilities during their upstream and downstream migrations, because their spawning streams are located in the western portion of Suisun Marsh. Therefore, Reclamation concluded no effect to CCC Steelhead.

1.4 Consultation History

Reclamation has consulted with the USFWS and NMFS on CVP operations as species were listed and critical habitat designated since the early 1990s. The most recent consultation on CVP operations was completed in 2008 and 2009. Both biological opinions were conditionally accepted by Reclamation and were challenged in federal court. On appeal, the biological opinions were upheld and Reclamation issued a Record of Decision to adopt them in 2016. Table 1-2 provides a summary of this consultation history.

Table 1-2. Consultation History

| Date | Issuer | Document | Rationale for Consultation | Subject / Species | Finding |
|---------------|--------|-------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| February 1992 | USBR | Interim Central Valley Project Operations Criteria and Plan | | OCAP | |
| June 1993 | NMFS | BO | Winter-Run listed in 1991 | Winter-Run Chinook Salmon | Jeopardy |
| March 1995 | USFWS | BO | Delta Smelt listed in March 1993; Splittail proposed in 1994 | Delta Smelt and Splittail | Non-jeopardy |
| June 2004 | USBR | BA | 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; |

| Date | Issuer | Document | Rationale for Consultation | Subject / Species | Finding |
|---------------|---------------|---------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| | | | | | May Affect/Not Likely to Adversely Affect: Coho, Delta Smelt |
| July 2004 | USFWS | BO | Coordinate with combined NMFS ESA species consultation | Delta Smelt | Non-Jeopardy |
| October 2004 | NMFS | BO | Combined ESA species consultation | Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon | Non-Jeopardy |
| May 2008 | USBR | BA | 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; LAA: CV steelhead, Winter-run, spring-run; Green Sturgeon; NLAA: Coho Salmon |
| December 2008 | USFWS | BO | Pelagic Organism Decline; conflicts with Sturgeon | Delta Smelt | Jeopardy |
| June 2009 | NMFS | BO and Conference Opinion | Green Sturgeon listed in 2006 | Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon | Jeopardy and Adverse Mod |
| January 2019 | USBR | BA | Drought; New Science; Declining status | Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho, Delta Smelt | See Effects Determination in this document |

Chapter 2 Status of Aquatic and Terrestrial Species and Designated Critical Habitat

2.1 Sacramento River Winter-Run Chinook Salmon ESU

2.1.1 ESA Listing Status

NMFS, under an emergency interim rule, listed the Sacramento River Winter-Run Chinook Salmon Evolutionarily Significant Unit (ESU) as a threatened species under the ESA in August 1989 (54 Federal Register [FR] 32085). In 1994, NMFS reclassified the ESU as endangered due to several factors: the continued decline and increased variability of run sizes including expected weak returns due to small year classes in 1991 and 1993, and continuing threats to the species (59 FR 440). The ESU consists of one population in the mainstem of the Upper Sacramento River in California's Central Valley below Keswick Dam. NMFS reaffirmed the listing of the Sacramento River Winter-Run Chinook Salmon ESU as endangered on June 28, 2005 (70 FR 37160), and expanded the ESU to include Winter-Run Chinook Salmon produced by the Livingston Stone National Fish Hatchery (LSNFH) artificial propagation program in the ESU.

On May 26, 2016, after a third 5-year status review (81 FR 33468), NMFS (2016a) determined that the viability of the ESU had continued to decline on average 15 percent per year, or from 38 percent to 67 percent since 2010. Although the population size and catastrophe rate and effect have remained at the low-risk threshold (<90 percent decline in one generation, or annual run size of less than 500 spawners) since the 2010 status review, the population decline and hatchery influence criteria have both been elevated to a moderate extinction risk (NMFS 2016a). NMFS concluded that the ESU classification as an endangered species is appropriate and should be maintained (NMFS 2016a).

2.1.2 General Life-History and Habitat Requirements

Chinook Salmon in the Central Valley have four distinct races: Fall, Late-Fall, Winter, and Spring. The name of the runs come from the peak migration timing with peak runs for Fall-Run occurring during August to November, late-fall occurring November to February, Winter-Run January to May, and Spring-Run April to August (Vogel and Marine 1991). Fall and late-fall enter as mature and ready to spawn. Winter-Run and Spring-Run return immature and hold in the river until reaching maturity. The adults enter freshwater in an immature state and migrate far upstream where spawning is delayed for weeks or months (Healey 1991). Juveniles migrate out to sea in November through April after several months of rearing in streams (Healey 1991). The adult Winter-Run Chinook Salmon upstream spawning migration in the Sacramento River occurs from December through July, with the majority of the run passing the Red Bluff Diversion Dam from January through May, peaking in mid-March (NMFS 2009; NMFS 2014). Adults prefer to hold in deep cold pools until they are sexually mature and ready to spawn during spring or summer. Winter-Run Chinook Salmon spawn primarily between mid-April and mid-August, with peak spawning generally occurring in June (Vogel and Marine 1991).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Depending on ambient water temperature, embryos hatch within 40 to 60 days, and alevin (yolk-sac fry) remain in the gravel beds for an additional 4 to 6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding typically in late July to early August and continuing through October (Fisher 1994). Emergence usually occurs in late July, but as early as mid-June through mid-October. Post-emergent fry inhabit calm, shallow waters with fine substrates and depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

Winter-Run Chinook Salmon fry and juvenile emigration past the Red Bluff Diversion Dam occurs as early as mid-July and extends as late as the end of March during dry water years (Vogel and Marine 1991; NMFS 1997, both as cited in NMFS 2014), although primary migration ends in December (Poytress and Carillo 2010, 2011, 2012). A large pulse of juvenile Winter-Run Chinook Salmon have been observed to emigrate past Knights Landing and into the Delta during and shortly after the first large autumn storm event (del Rosario et al. 2013). They occur in the Delta as early as November through as late as April (SacPAS, see Figure 2.1-1). Ocean entry begins as early as November and continues through May (Fisher 1994; Myers et al. 1998, both as cited in NMFS 2014). Winter-Run Chinook Salmon then, for the most part, spend 3 years in the ocean before returning to the river as spawning adults.

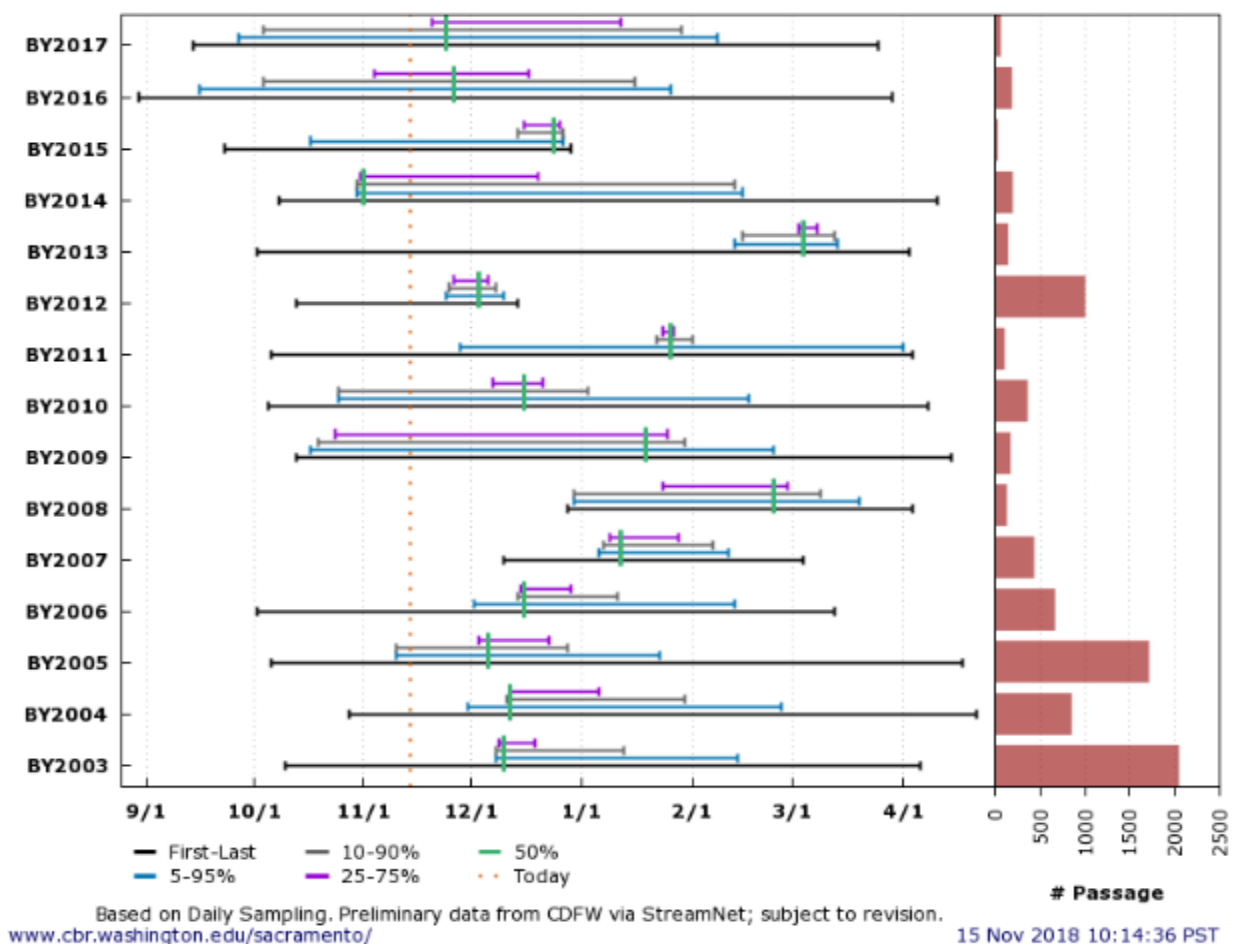


Figure 2.1-1. Migration Timing, Brood Years 2003–2017—Juvenile Winter Chinook, Knight’s Landing RST, 7/1–6/30

During juvenile rearing and downstream movement, salmonids prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. Ephemeral habitats, such as floodplains and the lower reaches of small streams, are also very important to rearing Chinook Salmon as these areas can be much more productive than the main channel and provide refuge from predatory fishes (Maslin et al. 1997; Sommer et al. 2001a). However, side channels with narrow inverts and nearshore areas with broad flat areas including low-gradient floodplains also can strand and isolate juveniles when high flows subside quickly (NMFS 1997). The greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem and this can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001a). However, newer research has not found that the Yolo Bypass, a large floodplain, consistently provides better survival conditions for Chinook Salmon than the mainstem of the Sacramento River (Sommer et al. 2005; Takata et al. 2017).

2.1.3 Historical and Current Distribution and Abundance

Areas where Winter-Run Chinook Salmon historically spawned are now inaccessible due to Keswick and Shasta Dams. Streams in which populations of Winter-Run Chinook Salmon were known to historically exist were fed by cool, constant springs that provided the flows and low temperatures required for spawning, incubation, and rearing during the summer season (Slater 1963). Winter-Run Chinook Salmon spawning occurs in the summer months. Naturally occurring summer flows in river reaches below Keswick Dam would have historically precluded spawning. This suggests that the area below Shasta and Keswick dams was likely utilized for Winter-Run Chinook Salmon juvenile rearing and migration only. The life-history timing of the Winter-Run Chinook Salmon, requiring cold summer flows, indicates that the run historically occurred upstream of Keswick and Shasta dams and included the upper Sacramento River, McCloud River, Pit River, Fall River and Hat Creek and Battle Creek a tributary below Keswick and Shasta Dams (Yoshiyama et al. 1996, 2001; Lindley et al. 2004; NMFS 2014b), where summer flow and water temperature requirements were met (Yoshiyama 2001).

Winter-Run Chinook Salmon are currently found in the mainstem Sacramento River downstream of Keswick dam. This population is maintained through cold water releases from Shasta Reservoir that create spawning and rearing habitat in the reach between Redding and the Red Bluff Diversion Dam. The construction of the Anderson-Cottonwood Irrigation District Diversion Dam in 1916 created a partial passage barrier as did the Red Bluff Diversion Dam in 1962. Since completion of Shasta Dam in 1945, primary spawning and rearing habitats have been confined to the cold water areas between Keswick Dam and the Red Bluff Diversion Dam (NMFS 2014).

Yearly Winter-Run escapement was estimated by counts in traps at the top of fish ladders at the Red Bluff Diversion Dam and more recently has been estimated using carcass counts. Escapements have declined from the 1960s and 1970s. The run size in 1969 was approximately 120,000, while run sizes averaged 600 fish from 1990 to 1997 (Moyle 2002). Escapement subsequently increased after Red Bluff Diversion Dam operations were modified and temperature control shutters were installed on Shasta Dam, but has declined since 2005 (Reclamation 2008; NMFS 2016). Winter-Run Chinook Salmon adult escapement data for the Sacramento River Basin from 1974 to 2016 are included in Figure 2.1-2 below (CDFW 2018). Preliminary data show a decline since 2012.

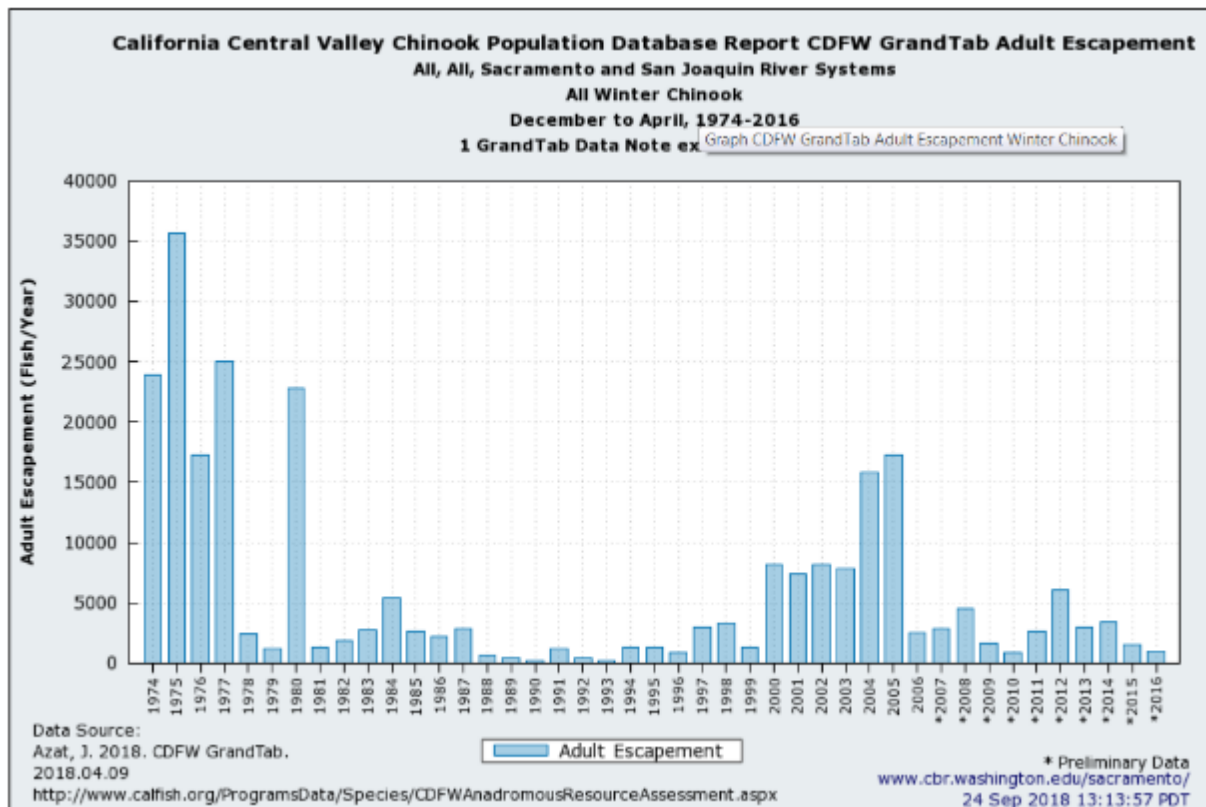


Figure 2.1-2. Winter-Run Chinook Salmon Adult Escapement (1974–2016) (CDFW 2018)

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). Phillis et al (2018) found with isotope data that 44 to 65 percent of surviving Winter-Run Chinook Salmon adults reared in non-natal habitats as juveniles. The lower reaches of the Sacramento River, the Delta, and San Francisco Bay serve as migration corridors for the downstream migration of juvenile and upstream migration of adult Winter-Run Chinook Salmon.

Until recent years, salmon passage was not allowed above the Coleman Hatchery barrier weir located on Battle Creek. No Winter-Run Chinook Salmon spawning has been observed in Battle Creek but Winter-Run Chinook Salmon were detected above the weir in 2006 (high flow year). All Winter-Run Chinook Salmon production currently occurs in the Sacramento River or Livingston Stone Fish Hatchery (CDFG 2004).

2.1.4 Limiting Factors, Threats, and Stressors

The major factor that limits the range of Winter-Run Chinook Salmon is the existence of dams, which have created barriers to upstream migration. Factors currently limiting abundance include the altered flow regime, which has led to changed water temperatures, reduced gravel mobilization, reduced riparian recruitment, etc; deteriorated habitat quality; entrainment in water diversions; predation pressure on juveniles; and loss of riparian and floodplain habitat. These factors are discussed below and also in the “Past and Present Impacts” section of Chapter 3, Environmental Baseline, Biological Assessment.

Warm water releases from Shasta Dam have been a significant stressor to Winter-Run Chinook Salmon, especially when releases were warmer than usual because of the recent extended drought in California from 2012 through 2015 (NMFS 2016). The optimal water temperature for egg incubation ranges from 46 degrees Fahrenheit (°F) to 56°F (7.8 degrees Celsius (°C) to 13.3°C), and a significant reduction in egg viability occurs in mean daily water temperatures above 57.5°F (14.2°C) (Seymour 1956, Boles 1988, USFWS 1999, EPA 2003, Richter and Kolmes 2005, Geist et al. 2006). New temperature modeling show higher sensitivity to increases in water temperature due to exponential increases in oxygen demand with rise in temperature during the final weeks of egg-embryo maturation before the alevin stage (Martin et al. 2016, Anderson 2018). Despite Reclamation's best efforts to maintain appropriate spawning temperatures, there was increased mortality during the 2012-2015 drought. Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to 5.9 percent and 4.2 percent egg-to-fry survival rates respectively, to the Red Bluff Diversion Dam.

Climate experts predict physical changes to ocean, river and stream environments along the West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated impacts on water temperature, hydrology, and ocean conditions are generally considered likely to have substantial effects on Chinook Salmon populations in the future (NMFS 2014). Global parameters, such as ocean conditions, have also demonstrated a marked effect on adult escapement (Lindley et al. 2009).

Impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) have deleterious impacts on natural in-river populations (Matala et al. 2012). These impacts are associated with hatchery fish spawning naturally (i.e., second generational). During recent years, when the hatchery program was scaled up in size and natural production faltered, hatchery fish made up the vast majority of winter Chinook that spawned both in the river and at LSNFH. The Winter-Run Chinook Salmon conservation program at LSNFH is controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 Winter-Run Chinook Salmon per year compared to the estimated natural production that passes the Red Bluff Diversion Dam, which is approximately 878,000 per year based on the 2012 to 2018 average (Voss, 2019), or 4.7 million per year based on the 2002 to 2010 average (Poytress and Carrillo 2011). Therefore, hatchery production can be up to approximately 20 percent of the total in-river juvenile production in any given year.

2.1.4.1 *Habitat Quality*

Construction of Keswick and Shasta Dam for agricultural, municipal, and industrial water supply has eliminated access to historical holding and spawning grounds above Keswick Dam, approximately 200 river miles (Yoshiyama et al. 1996). Rearing habitat quantity and quality has been reduced in the upper Sacramento River as a result of channel modification and levee construction (Lindley et al. 2009). Much of the historical floodplain habitat has been developed or converted, this has decreased shallow water habitat that has high residence time needed for food production (Jefferes et al. 2008; Katz et al. 2018; Ahearn et al. 2006).

More information on stressors of native fish, including physical, hydrologic, and biological alteration are described in the environmental baseline. Additional factors include other water quality parameters (e.g., dissolved oxygen), food quality and quantity, biotic interactions (e.g., predation and competition), altered hydrology in the Sacramento–San Joaquin Delta, loss of tidal marsh, commercial and/or recreational harvest, and predation from introduced species such as striped bass (NMFS 2014).

2.1.5 Water Operations Management

The Sacramento River system includes several major features and facilities that are relevant to temperature management: (1) Shasta Dam and Lake, and the installed Temperature Control Device (TCD); (2) interbasin transfers from the Trinity River Basin, which are conveyed through Whiskeytown Lake, the Clear Creek Tunnel and Carr Powerhouse, and the Spring Creek Tunnel; and (3) Keswick Reservoir, which regulates releases from Shasta Dam and Spring Creek Powerhouses, resulting in a stable flow regime for release from Keswick Dam.

Reclamation currently uses the Shasta TCD to improve temperatures while minimizing power loss. At Shasta Reservoir, Reclamation seeks to build cold water pool for Winter-Run Chinook Salmon spawning and incubation in the summer. Reclamation seeks to build storage through the fall, winter, and spring months. When higher releases from Shasta Dam are required in the fall through spring timeframe, this may reduce the summer cold water pool. Higher releases may be requested to avoid Winter-Run and Fall-Run Chinook Salmon redd dewatering, spring pulses for juvenile outmigration, or increased releases to meet Delta outflow or salinity requirements per D-1641. Usually, flows in the Sacramento River are kept high until the Winter-Run Chinook Salmon fry have emerged from the gravel. However, higher flows sometimes overlap the period in which Fall-Run Chinook Salmon begin to spawn, leading to Fall-Run Chinook Salmon spawning in shallow locations that may be out of water when Reclamation reduces flows for building storage. Once the Fall-Run Chinook Salmon begin spawning, fish agencies frequently want to maintain releases at the same level as where spawning occurred to avoid redd dewatering.

The Sacramento River Temperature Task Group (SRTTG) is a multiagency group, formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1, to assist with increasing and stabilizing Chinook populations in the Sacramento River. Annually, Reclamation develops operation plans for controlling temperatures within the Shasta and Trinity divisions of the CVP. These plans consider impacts on Winter-Run and other races of Chinook Salmon, and associated project operations. Meetings are held initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control. Once an operation plan for temperature control is recommended, Reclamation submits the report to the SWRCB, generally on or before June 1 each year. The SRTTG may continue to meet throughout the year or other groups may be formed to discuss temperature management.

Fish agencies generally seek to maintain a 56 degree compliance location as far downstream as possible for as long as possible. Maintaining cold water too far downstream risks prematurely using up the cold water pool and results in warmer-than-desired temperatures at the end of the temperature control season. Fish agencies have further requested that Reclamation operate to experimental water temperature control regimes. The primary examples are the 7 Daily Average Daily Maximum (DADM) () and the 53.5°F Daily Average Temperature (DAT) at the Clear Creek gage on the Sacramento River (CCR). The requested temperature control regimes may deplete cold water faster than the objective of 56°F at Balls Ferry according to D-90-5 and pose substantial operational challenges.

Reclamation and DWR coordinate regarding downstream requirements (Delta outflow, Delta salinity, turbidity, etc) under D-1641 via the COA. Reclamation and DWR split requirements between the CVP and SWP. After splitting requirements with the SWP, Reclamation plans how to meet the CVP share of the requirements via a combination of releases from Folsom Reservoir, releases from Shasta Reservoir, and/or reducing exports. The amount of water from each reservoir depends upon reservoir storage, channel capacity, fishery concerns, projected inflows, and projected end-of-September storage. Reclamation balances releases so that no one reservoir bears the full burden of meeting downstream requirements.

Congress authorized Shasta and Trinity Dams to work in an integrated fashion for “the principal purpose of increasing the supply of water available for irrigation and other beneficial uses” in the Central Valley. 69 Stat. 719. Exports from Trinity Reservoir helped decrease the demand on Shasta Reservoir for water supply and brought colder water directly into the Sacramento River system, preserving a larger cold water pool volume in Shasta Reservoir. Reclamation heavily relies on both reservoirs to meet multiple obligations for listed fish species in both basins. First, there are limitations on transbasin diversions from the Trinity Basin due to requirements in the Trinity River. The 2000 Trinity River Record of Decision (Trinity ROD) strictly limits Reclamation’s transbasin diversions to 55 percent of annual inflow on a 10-year average basis for the restoration and protection of the Trinity fishery, which restricts the amount of water authorized for exportation to the Central Valley. Pursuant to the Trinity ROD, the Trinity Reservoir now also provides flows for the Trinity River Restoration Program to improve conditions for the native fisheries on the Trinity River.

During the extraordinary conditions in 2014 and 2015, under extreme drought, as part of a coordinated response to improve Shasta Reservoir cold water pool management, a number of measures were taken on a temporary basis that included: (1) work with the State Board and water users to lower Wilkins Slough navigational flow requirements; (2) request that the State Board relax D-1641 Delta water quality requirements; (3) delay Sacramento River Settlement Contractor depletions, and transfer a volume of their water in the fall rather than increase depletions throughout the summer; (4) target slightly warmer temperatures during the Winter-Run Chinook Salmon holding period (before spawning occurs); and (5) install temporary improvements on the Shasta Dam TCD curtain (in 2015).

In 2017, Reclamation agreed to a long-term plan to provide fall augmentation flows for the Lower Klamath River. For the previous 15 years, and now under the 2017 long-term plan through 2030, Reclamation has released fall augmentation flows to help support fish health (this practice began following controversy and litigation over a large fish die off event that occurred in 2002 due to low flows).

2.1.6 Recovery and Management Actions

The following sections are actions that have been taken to benefit Winter-Run Chinook Salmon.

2.1.6.1 *Anadromous Fish Restoration Program*

Reclamation annually expends funding for the CVPIA Anadromous Fish Restoration Program (AFRP), CVPIA 3406(b)(1), to undertake reasonable measures to not less than double anadromous fish populations from the 1967-1991 time period and to mitigate other adverse environmental effects. Winter-Run actions are described in the Final Plan for the AFRP (2001).

2.1.6.2 *Anadromous Fish Screen Program*

Section 3406(b)(21) of the CVPIA authorized the Anadromous Fish Screen Program (AFSP) to assist the State of California on unscreened diversions. The AFRP screens or installs “fish protective devices” on diversions. The AFSP has developed guidelines to prioritize screening projects. Factors taken into account include location of the diversion in relation to areas used by anadromous fish for spawning and rearing, size of the diversion (or percent flow diverted in tributaries), season of diversion in relation to anadromous fish use of the stream or reach, and placement of the diversion. All but one of the diversions greater than 100 cubic feet per second (cfs) on the Sacramento River have fish screens.

2.1.6.3 *Anderson Cottonwood Irrigation District*

The Anderson Cottonwood Irrigation District (ACID) operates a diversion dam across the Sacramento River located 3.2 miles downstream from Keswick Dam. The ACID Diversion Dam was improved in 2001 and 2015 with the addition of new fish ladders and fish screens around the diversion. Since upstream passage was improved a substantial shift in Winter-Run Chinook Salmon spawning has occurred. In recent years, more than half of the Winter-Run Chinook Salmon redds have typically been observed above the ACID diversion dam (Killam 2008).

2.1.6.4 *Battle Creek Restoration Program*

The Battle Creek Salmon and Steelhead Restoration Project has a long history that includes research by various organizations and collaboration among many resource agencies and public interest groups. In 1999, a cooperative effort among Reclamation, USFWS, NMFS, CDFW, and the Pacific Gas and Electric Company (PG&E) led to the signing of a Memorandum of Understanding (MOU). The Battle Creek Salmon and Steelhead Restoration Project includes modifications to facilities and adjustments to operations for anadromous fish, including Winter-Run Chinook Salmon. Construction is anticipated to be complete in 2023.

2.1.6.5 *Spawning and Rearing Habitat Restoration*

Reclamation expends annual funding for the CVPIA under Section 3406(b)(13) Spawning and Rearing Habitat Program. The CVPIA (b)(13) program partners with other federal, state, and local agencies, water users, and other stakeholders to develop and implement a continuing program for the purpose of restoring and replenishing, as needed, salmonid spawning gravel lost due to the construction and operation of Central Valley Project dams and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River.

The upper Sacramento River between Keswick Dam and the Red Bluff Diversion Dam presents several opportunities for improving and restoring salmonid spawning and rearing habitats. Reclamation annually injects spawning gravel into reaches of the Sacramento River where the majority of Winter-Run Chinook Salmon spawn.

2.1.6.6 *Glenn Colusa Irrigation District Hamilton City Fish Screen*

Glenn Colusa Irrigation District (GCID) diverts a maximum of 3,000 cfs from the Sacramento River at the Hamilton City pump station. The peak demand occurs in the spring, often at the same time as the peak outmigration of juvenile salmon. Because GCID diverts up to 25 percent of the Sacramento River flow at Hamilton City, GCID pumping operations were identified as a significant impediment to the downstream juvenile salmon migration. In 2000, GCID and Reclamation completed a 620-foot-long fish screen extension and channel improvements to minimize entrainment of salmonids into GCID's facility.

2.1.6.7 *Livingston Stone National Fish Hatchery*

The USFWS manages a conservation hatchery program for Winter-Run Chinook Salmon at the LSNFH. This hatchery program supplements the natural population according to strict guidelines developed in conjunction with NMFS. Based on a review of available genetic and other information, this hatchery stock was considered part of the Sacramento River Winter-Run Chinook Salmon ESU in 2005 (70 FR 37160).

2.1.6.8 Red Bluff Diversion Dam

The Red Bluff Diversion Dam was decommissioned in 2013 providing unimpaired juvenile and adult fish passage, so that adult Winter-Run Chinook Salmon could migrate through the structure at a broader range of flows reaching spawning habitat upstream of that structure. This project was authorized by CVPIA 3406(b)(10).

2.1.6.9 Salmon Resiliency Strategy

The Sacramento Valley Salmon Resiliency Strategy, published in June 2017 by the State of California, is an approach to improving species viability and resiliency by implementing specific habitat restoration actions. Actions include: restoration on Battle Creek, Implement McCloud Reintroduction Pilot Plan, Provide Instream Flows to Support Chinook Salmon and Steelhead in Mill, Deer, Antelope, and Butte Creeks, Restore Fish Passage and Habitat in Upper Sacramento Tributaries, Restoration of Instream Habitats in Upper Sacramento River, Improve Fish Passage by Removing Sunset Pumps Rock Dam on the Feather River, Restore Off-Channel Rearing, Streambank, and Riparian Habitats and Migratory Conditions along Upper/Middle/Lower Reaches of the Sacramento River, Complete Fish Screen Construction on Major Diversions along the Sacramento River, Improve Sutter Bypass and Associated Infrastructure to Facilitate Adult fish Passage and Improved Stream Flow Monitoring, Improve Yolo Bypass Adult Fish Passage, Increase Juvenile Salmonid Access to Yolo Bypass, and Increase Duration and Frequency of Yolo Bypass Floodplain Inundation, Construct Permanent Georgiana Slough Non-Physical Barrier, Restore Tidal Habitat in the Delta, and other actions.

2.1.6.10 Shasta Temperature Control Device

Reclamation constructed the Shasta Temperature Control Device (TCD) under the CVPIA 3406(b)(6). Reclamation operates the Shasta TDC to conserve the available cold pool in the reservoir for spawning and egg incubation temperatures for Winter-Run Chinook Salmon. Reclamation manages releases to maintain suitable depths over Winter-Run Chinook Salmon redds to avoid dewatering when possible.

2.1.6.11 Whiskeytown Reservoir Spring Creek and Oak Bottom Temperature Curtains

Reclamation has replaced both the Spring-Creek and Oak Bottom temperature curtains in Whiskeytown Reservoir to improve temperature flexibility and build cold water pool temperature compliance for Clear Creek and Sacramento River.

2.1.6.12 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Most salmonid floodplain rearing habitat in the Sacramento Valley was altered or blocked from use by dams and levees. The Yolo Bypass is the largest remaining floodplain in the Sacramento Valley, but is only accessible when the Sacramento River exceeds the crest of the Fremont Weir during high flow events. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is a joint effort undertaken by DWR and Reclamation. The project largely focuses on infrastructure modifications to increase the number of juvenile salmonids that have access to floodplain habitat in the Yolo Bypass through Fremont Weir; and, to increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

2.1.6.13 California EcoRestore

California EcoRestore is an initiative to help coordinate and advance at least 30,000 acres of critical habitat restoration in the Sacramento–San Joaquin Delta (Delta) by 2020. The program includes a broad range of habitat restoration projects, including aquatic, sub-tidal, tidal, riparian, flood plain, and upland ecosystem.

Projects completed to date include the following:

- Fremont Weir Fish Passage Modification—This project widened and deepened the existing fish ladder at the Fremont Weir and the upstream and downstream adjoining channels were reconfigured to accommodate migratory fish passage. Existing earthen agricultural road crossings were replaced by permanent crossings that allow for the clear passage of migratory fish.
- Knights Landing Outfall Gates—A positive fish barrier, was constructed (with new concrete wing walls and installation of a metal picket weir) on the downstream side of the existing Knights Landing Outfall Gate in the Colusa Basin Drain. This project serves primarily as a fish passage improvement action that will prevent salmon entry into the Colusa Basin Drain where they become trapped with no access back to the Sacramento River.
- Wallace Weir—The project consisted of constructing a permanent earthen weir that was hardened to withstand winter floods to prevent adult salmon entry into the Colusa Basin Drain. A fish rescue facility was incorporated into the weir so fish that arrive at the Wallace Weir via the Yolo Bypass can be safely and effectively rescued and returned to the Sacramento River to resume their migration to upriver spawning grounds.
- Lindsey Slough—The project restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.
- Sherman Island—The project constructed levee setbacks in Mayberry Slough that will augment existing riparian vegetation and restore tidal wetland that will provide habitat for native species including salmonids.

2.1.6.14 Battle Creek Winter-Run Chinook Salmon Reintroduction Plan

The Battle Creek Winter-Run Chinook Salmon Reintroduction Plan is a key action in the NMFS Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon. Reintroduction of Winter-Run Chinook Salmon into North Fork Battle Creek is part of a larger strategy in the NMFS Recovery Plan to restore some of the spatial structure of the ESU by reintroducing populations to habitats from which they have been extirpated.

2.1.6.15 Flyway Farms Tidal Habitat Restoration Project

This project has restored seasonal wetland and cattle grazing land to sub-tidal, intertidal and seasonal wetlands to benefit native fish species. The project involves restoring and enhancing approximately 300 acres of tidal freshwater wetlands, and an additional 30 acres of seasonal wetlands, at the southern end of the Yolo Bypass. It is designed to maximize residency time and foodweb production by capturing and slowly draining water through the excavation of two breaches along the Yolo Bypass Toe Drain and interior channels to connect and enhance existing wetlands on site. The goal is to improve habitat conditions for salmonids by providing rearing habitats for out-migrating juveniles and migratory habitats for adults.

2.1.6.16 Shasta Dam Fish Passage Evaluation

The Shasta Dam Fish Passage Evaluation is an effort to determine the feasibility of reintroducing Winter-Run and Spring-Run Chinook Salmon and Steelhead to tributaries above Shasta Dam. The evaluation is part of Reclamation’s response to the June 4, 2009, NMFS *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

2.1.6.17 Harvest Management

NMFS’ current Winter-Run Chinook Salmon harvest management is set based on a 2012 RPA from the NMFS Winter-Run Chinook Salmon ocean harvest fishery consultation. During the consultation, the Pacific Fisheries Management Council expressed concern as initially no fishing was allowed below 500 forecasted Age 3 fish, and the rule didn’t account for drought. In response to these comments, NMFS proposed a new rule that continues to allow for harvest down to a forecasted population of 0 Age 3 Winter-Run Chinook Salmon (NMFS, March 2018).

Figure 2.1-3 shows the 2012 harvest control rule compared to the 2018 harvest control rule. The x-axis is the forecasted number of Age 3 Winter-Run Chinook Salmon. The y axis is the Impact Rate Cap, a metric of the ocean harvest.

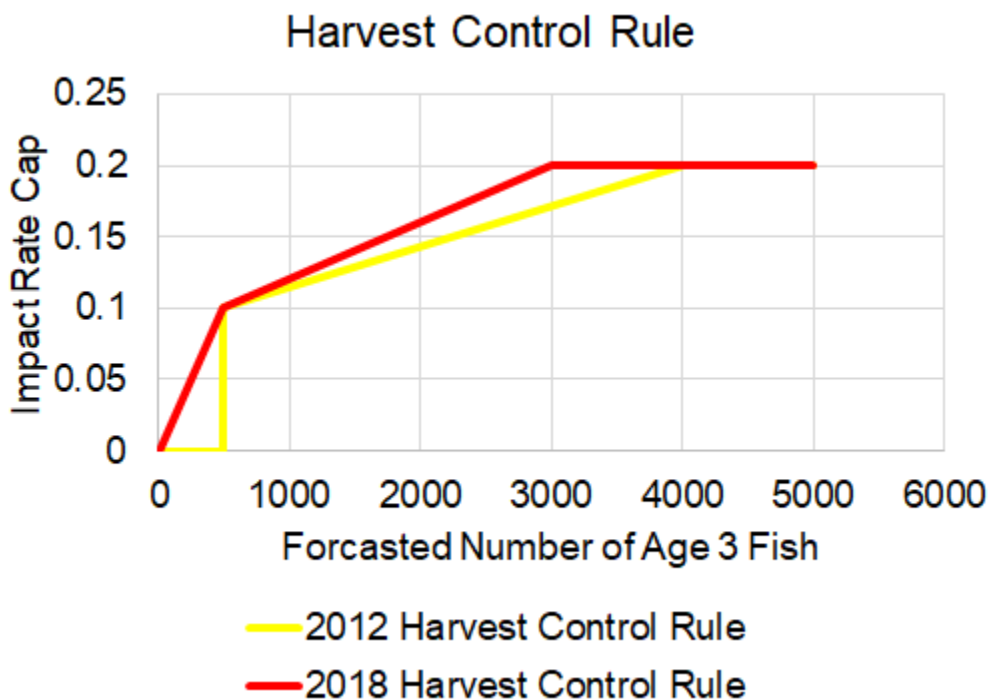


Figure 2.1-3. 2012 Harvest Control Rule.

Under the 2018 rules, NMFS has increased harvest pressures on Winter-Run Chinook Salmon.

2.1.7 Monitoring and Research Programs

Monitoring and research programs help provide information on Winter-Run Chinook Salmon migration, survival, and redd distribution. Since 2015, Reclamation has started Enhanced Acoustic Tag Salmonid Monitoring (EATSM). EATSM is part of the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) program, which improves monitoring by addressing vital population statistics rather than reliance upon indexes. In 2018, EATSM conducted studies on hatchery-origin Winter-Run Chinook Salmon movement (Figure 2.1-4), which represents fish arrivals per day at Tower Bridge in downtown Sacramento (DOSS 2018). The two studies shown represent 20.7 percent survival (in red) and 26.9 percent survival (in teal).

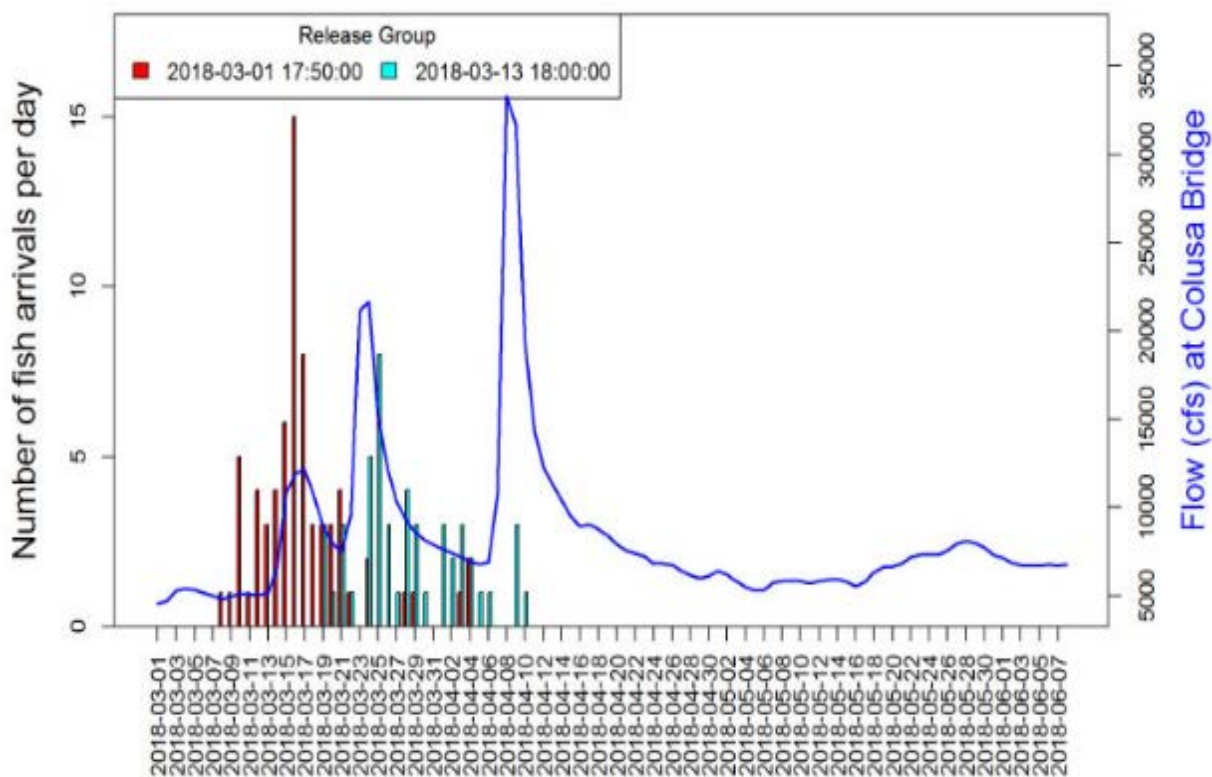


Figure 2.1-4. Tagged Hatchery Winter-Run Chinook Salmon Migration between Redding and Sacramento in 2018

CDFW annually conducts aerial redd surveys and carcass counts. Table 2.1-1 shows the distribution of Winter-Run Chinook Salmon redds from 2001 to 2018, a period after the ACID fish ladders were installed. For the period of 2001–2018, the furthest downstream observed Winter-Run Chinook Salmon redd was upstream of Tehama with over 98 percent of all observed redds occurring in the upper 20 river miles.

Surveys also help CDFW compile annual population estimates of Chinook Salmon. Information is entered into CDFW’s GrandTab and is accessible through www.calfish.org. Reclamation funds monitoring, evaluation, and web-based data services through the Central Valley Prediction and

Assessment of Salmon (SacPAS) tool online. This service also provides a publicly accessible reporting system of historical and current information (www.cbr.washington.edu/sacramento/).

Table 2.1-1. Winter-Run Chinook Spawning Distribution, 2001–2018

| Reach | Miles below Dam | 2001–2018 Distribution | Yearly Average | Percent Distribution |
|------------------------------------------|-----------------|------------------------|----------------|----------------------|
| Keswick to ACID Diversion Dam | 3 | 3,482 | 226 | 45 |
| ACID Diversion Dam to Highway 44 Bridge | 5.5 | 2,606 | 154 | 34 |
| Highway 44 Bridge to Airport Road Bridge | 19 | 1,566 | 95 | 20 |
| Airport Rd. Bridge to Balls Ferry Bridge | 27 | 75 | 4 | 1 |
| Balls Ferry Bridge to Battle Creek | 32 | 10 | 1 | 0 |
| Battle Creek to Jellys Ferry Bridge | 36 | 7 | 0 | 0 |
| Jellys Ferry Bridge to Bend Bridge | 45 | 10 | 1 | 0 |
| Bend Bridge to Red Bluff Diversion Dam | 60 | 0 | 0 | 0 |
| Red Bluff Diversion Dam to Tehama Bridge | 74 | 11 | 1 | 0 |
| Total | | 7,767 | 482 | 100 |

2.2 Winter-Run Chinook Salmon Critical Habitat

NMFS designated critical habitat for the Sacramento River Winter-Run Chinook Salmon ESU on June 16, 1993 (58 FR 33212). Designated critical habitat encompasses 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 Carquinez Bridge, including Honker, Grizzly, and Suisun Bays, and 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 (59 FR 440).

In the Sacramento River, critical habitat is the river water column, river bottom, and adjacent riparian zone and the water column and essential foraging habitat and food resources west of Chipps Island including the San Francisco Bay to the Golden Gate Bridge.

Critical habitat consists of physical and biological habitat features considered essential for the conservation of a species, which are referred to as Physical and Biological Features (PBFs). PBFs outlined in the designation of critical habitat (57 FR 36626) include the following:

1. Unimpeded 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 57.5oF for successful spawning, egg incubation, and fry development;
5. Habitat and prey that is free of contaminants;
6. Riparian habitat that provides for successful juvenile development and survival; and
7. Unimpeded passage of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean.

2.3 Chinook Salmon, Central Valley Spring-Run ESU

2.3.1 ESA Listing Status

The Central Valley Spring-Run Chinook Salmon ESU was listed as threatened under the ESA in 1999 because of the reduced range and small size of remaining Spring-Run Chinook Salmon populations (64 FR 50393). On June 28, 2005, NMFS published the final hatchery listing policy (70 FR 37204) and reaffirmed the threatened status of the ESU (70 FR 37160). The ESU consists of naturally spawned Spring-Run Chinook Salmon originating from the Sacramento River and its tributaries, and also from the Feather River Fish Hatchery (FRFH) Spring-Run Chinook Program (NMFS 2016b).

Based on a review of the available information, NMFS (2016b) recommends that the Central Valley Spring-Run Chinook Salmon ESU remain classified as a threatened species. NMFS' review also indicates that the biological status of the ESU has probably improved since the previous status review in 2010–2011 and that the ESU's extinction risk may have decreased. However, the ESU is still facing substantial risks (Williams et al. 2016). Spring-Run Chinook Salmon escapement data for the Sacramento River Basin (CDFW 2018c) indicate that Spring-Run Chinook Salmon populations have steadily declined in abundance from 2014 through 2017 since peaking in 2013. As part of the 5-year review, NMFS also re-evaluated the status of the FRFH stock and concluded that it should remain part of the Central Valley Spring-Run Chinook Salmon ESU.

2.3.2 General Life-History and Habitat Requirements

Adult Spring-Run Chinook Salmon enter freshwater as immature fish between mid-February and July and remain in deep cold pools in proximity to spawning areas until they are sexually mature and ready to spawn in late summer and early fall, depending on water temperatures (CDFG 1998; NMFS 2009).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Fry emerge from the gravel from November to March (Moyle 2002) and can have highly variable

emigration timing based on various environmental factors (NMFS 2009). Post-emergent fry inhabit calm, shallow waters with fine substrates and depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

Some juveniles begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for Spring-Run Chinook Salmon can extend from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998 as cited in NMFS 2009). Peak movement of yearling Spring-Run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and again in March and April for young-of-the-year juveniles (NMFS 2009).

During juvenile rearing and downstream movement, salmon prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. As described for Winter-Run Chinook Salmon, off-channel areas and floodplains can provide important rearing habitat. The greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem Sacramento River, which can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001a).

2.3.3 Historical and Current Distribution and Abundance

Spring-Run Chinook Salmon populations historically occupied the headwaters of all major river systems in the Central Valley up to any natural barrier (Yoshiyama et al. 1998; Reclamation 2008). The Sacramento River was used as a migratory corridor to spawning areas in upstream tributaries and headwater streams (CDFG 1998). The most complete historical record of Spring-Run Chinook migration timing and spawning is contained in reports to the U.S. Fish Commissioners of Baird Hatchery operations on the McCloud River (Stone 1893, 1895, 1896a, 1896b, 1896c, 1898; Williams 1893, 1894; Lambson 1899, 1900, 1901, 1902, 1904, all as cited in CDFG 1998). Spring-Run Chinook migration in the upper Sacramento River and tributaries extended from mid-March through the end of July with a peak in late May and early June. Baird Hatchery intercepted returning adults and spawned them from mid-August through late September. Peak spawning occurred during the first half of September. The average time between the end of Spring-Run spawning and the onset of Fall-Run spawning at Baird Hatchery was 32 days from 1888 through 1901.

Construction of the Shasta and Keswick Dams in 1945 and 1950, respectively, has blocked passage to areas of historic spawning habitat, limiting potential spawning habitat to areas downstream of the dams. The presence of dams on the Sacramento River has blocked upstream passage of Spring-Run Chinook Salmon to historically available spawning habitat and confined them to a much smaller area of the watershed. Current spawning is restricted to limited areas in mainstem reaches below the lowermost impassable dams and in a few select tributaries with reduced habitat availability. However, Spring-Run spawned and continue to spawn in rivers other than the Sacramento River. The Central Valley drainage as a whole is estimated to have supported annual runs of Spring-Run Chinook Salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Following construction of Shasta, Keswick, and Friant dams, annual runs were estimated to be no more than 26,000 fish in the 1950s and 1960s (CDFW GrandTab data; Yoshiyama et al. 1998). Before the construction of Friant Dam (completed in 1942), nearly 50,000 adults were counted in the San Joaquin River (Fry 1961). The San Joaquin populations were essentially extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Hallock and Van Woert 1959; Yoshiyama et al. 1998).

The Central Valley Spring-Run Chinook Salmon ESU has displayed broad fluctuations in adult abundance. Estimates of Spring-Run Chinook Salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather rivers because CDFW’s GrandTab does not distinguish between Fall-Run and Spring-Run Chinook Salmon in-river spawners, and not including the FRFH) have ranged from 1,105 in 2017 to 25,890 in 1982.

Since 1995, Spring-Run Chinook Salmon annual run size estimates typically have been dominated by Butte Creek returns. Of the three tributaries producing naturally spawned Spring-Run Chinook Salmon (Mill, Deer, and Butte creeks), Butte Creek has produced an average of two-thirds of the total production over the past 10 years (DWR and Reclamation 2017; CDFW 2017a). During recent years, Spring-Run Chinook Salmon escapement estimates (excluding in-river spawners in the Yuba and Feather rivers) have ranged from 23,696 in 2013 to 1,796 in 2017 throughout the tributaries to the Sacramento River surveyed (CDFW 2017a).

Spring-Run Chinook Salmon population estimates remain low. Spring-Run Chinook escapement was estimated to be 6,453 in 2016 and 1,105 in 2017 (Figure 2.3-1; Azat 2018). In addition, fish monitoring is conducted throughout the year at the Tracy Fish Collection Facility (TFCF) and the John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) (collectively referred to as the Delta fish facilities). During WY 2017, 26,551 wild juvenile Spring-Run and 963 hatchery Spring-Run were observed at the Delta fish facilities, and 9,487 wild juvenile Spring-Run and 1,010 hatchery Spring-Run were observed during WY 2018. Fish monitoring is also conducted at the Rock Slough Intake by the Contra Costa Water District (CCWD). No Spring-Run have been collected in CCWD’s Fish Monitoring Program at the Rock Slough Intake since 2008.

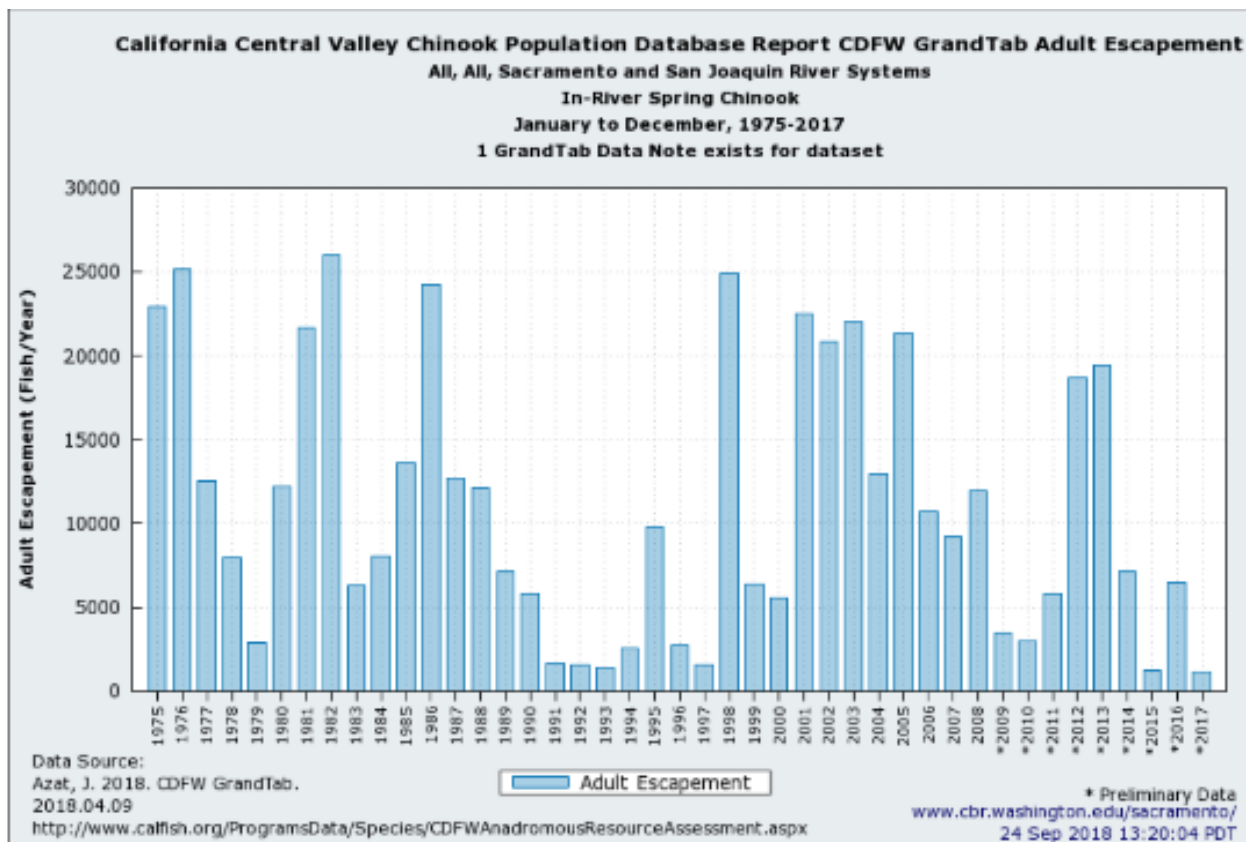


Figure 2.3-1. Estimates of Central Valley Spring-Run Chinook Salmon Escapement, 1975–2017

2.3.4 Limiting Factors, Threats, and Stressors

As discussed in the Winter-Run Chinook Salmon section and in Section 3.1, Past and Present Impacts, the habitat that remains for Spring-Run Chinook Salmon has been negatively impacted by inadequate flows and increased water temperatures from dam and water diversion operations on streams throughout the Sacramento River Basin including on Deer, Mill, and Antelope Creeks. Losses of suitable spawning gravel, the development of deep channels and levees, pollutants and siltation from urban development, mining, and water diversions are also stressors on this ESU (NMFS 2009; 2014).

The degradation and simplification of aquatic habitat in the Central Valley has greatly reduced the resiliency of Spring-Run Chinook Salmon to respond to additional stressors such as an extended drought and poor ocean conditions. Levee construction and maintenance projects have greatly simplified riverine habitat and have disconnected rivers from the floodplain (NMFS 2016b).

Climate change poses a further threat to the species with increasingly high water temperatures and changes to ocean conditions. Spring-Run Chinook Salmon may be particularly vulnerable as adults over-summer in freshwater streams before spawning in autumn. The Central Valley Spring-Run Chinook Salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia 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 (NMFS 2016b). Juveniles often rear in their natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures.

2.3.5 Water Operations Management

Spring-Run requirements do not typically control the operation of Shasta, Oroville, Folsom, or New Melones Dams. On Clear Creek, Reclamation has a requirement from its 2002 water right as well as the 2000 Reclamation / USFWS / CDFW agreement to provide 50 cfs flow year-round, increasing to 70 cfs in November and December of critical years and increasing to 100 cfs in November and December of normal years. In addition to these flows, Reclamation makes releases as part of the CVPIA b(2) and (b)(12) program. Reclamation's operations follow the CVPIA AFRP guidelines (USFWS 2001) which, for Clear Creek, are: "200 cfs October 1 to June 1 from Whiskeytown dam for Spring-Run, Fall-Run, and Late Fall-Run Salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; and release 150 cfs or less, from July through September to maintain less than 60°F temperatures in stream sections utilized by Spring-Run Chinook Salmon." Additionally, the less water available for the transbasin diversion, the greater potential impact to Clear Creek temperatures as adequate temperatures in Clear Creek are dependent to a large degree on the volume of water moving through Lewiston and Whiskeytown reservoirs.

2.3.6 Recovery and Management

The NMFS 2014 Recovery Plan for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and Central Valley Steelhead outlines actions to restore habitat, access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids.

Under the CVPIA, Reclamation has funded the Service to undertake a number of actions to improve Spring-Run including, but not limited to, the restoration of Butte Creek and passage improvements to

facilities on Mill Creek and Deer Creek. Spawning and rearing habitat improvements on the Upper Sacramento River also benefit Spring-Run. For more details concerning Spring-Run Chinook in Clear Creek, see the 2017 Clear Creek Technical Team Annual Report for the Coordinated Long-Term Operation Biological Opinion.

2.3.6.1 Clear Creek Restoration Program

Reclamation annually expends funding for the CVPIA, Section 3406(b)(12) Clear Creek Restoration Program. The goals of the Clear Creek Restoration Program are to (1) provide flows to allow sufficient spawning, incubation, rearing, and outmigration for Salmon and Steelhead; (2) restore the stream channel and associated instream habitat; and (3) determine impacts of restoration actions on anadromous fish and geomorphology. The program manages flows and temperatures through releases from Whiskeytown Dam on a year-round basis to support the different life stages of Salmon and Steelhead in Clear Creek. The amounts of water, considering timing, magnitude, and duration, and water temperature are controlled to meet this goal. The Clear Creek Restoration Program is working on restoration of a 2-mile section of Clear Creek floodplain and stream channel degraded by aggregate and gold mining, dams and diversions, and annually injects gravel to recharge and maintain the system (approximately 8,000 to 10,000 tons of gravel per year). The Clear Creek Restoration Program aims to create and maintain 347,288 square feet of usable spawning habitat in Clear Creek.

2.3.6.2 Ocean Management

All of California's Chinook Salmon stocks are impacted to some extent by ocean fisheries (NMFS, 2000). As NMFS (2000) states, "the lack of an annual estimate of ocean harvest rate for the Central Valley fall chinook stocks targeted by ocean fisheries makes assessment of fishery impacts on listed stocks difficult. While the harvest rates on listed ESUs are believed to be less than that occurring on Central Valley fall chinook, the lack of a harvest rate estimate for even the targeted Central Valley stocks requires the Pacific Fisheries Management Council and NMFS to address recovery of weak stocks through "adaptive management" strategies, in which fishing effort is either eliminated or reduced by somewhat judgemental amounts and the effect is then assessed by monitoring spawning escapement in subsequent years." The 2000 BO on ocean harvest's effect (the Pacific Coast Salmon Plan) on Spring-Run Chinook Salmon concluded that continued harvest was not likely to jeopardize the continued existence of Central Valley Spring-Run Chinook Salmon (NMFS 2000).

To address the lack of an annual estimate of ocean harvest rate, one approach would be to estimate age-specific ocean fishing mortality rates by using cohort reconstructions applied to tagged Feather River Hatchery salmon (Satterthwaite et al. 2018). Harvest models that predict how Spring-Run would be affected by fishing regulations could be developed from reference harvest rates (Satterthwaite et al. 2018). Data and monitoring needs to better guide management of Central Valley Spring-Run Chinook including genetic sampling of juvenile emigrants to improve juvenile production data (Satterthwaite et al. 2018). Increased tagging and sampling of Spring-Run is needed to directly estimate ocean fishing mortality rates.

2.3.7 Monitoring and Research Programs

2.3.7.1 San Joaquin River Restoration Program Experimental Population Management and Monitoring

The San Joaquin River Restoration Program (SJRRP) has conducted and is in the process of conducting a large number of Spring-Run monitoring and research programs. The SJRRP has released a combination of FRFH and San Joaquin River Conservation and Research Facility (SCARF) Spring-Run Chinook

Salmon juveniles to the San Joaquin River since 2014. All juvenile Spring-Run Chinook Salmon released are adipose fin-clipped and coded wire tagged. More information is available here: https://www.westcoast.fisheries.noaa.gov/central_valley/san_joaquin/san_joaquin_reint.html.

Because of previous release/reintroduction efforts, 2017 was the second year that adult Spring-Run Chinook Salmon had the potential to return to the San Joaquin River. However, due to an above average water year that prevented the placement of collection or counting stations, only limited monitoring occurred during the anticipated migration period. No unmarked Spring-Run Chinook (indicating wild origin) were seen in the lower reaches of the river.

UC Davis initiated a 2-year study in 2017 to calculate reach-specific survival and migration conditions for juvenile salmonids in the Lower San Joaquin River and south Delta. In March 2017, 700 individual SJRRP juveniles were tagged with acoustic JSATS tags and released in two evenly sized groups.

The SJRRP has established a parentage based tagging (PBT) program for the San Joaquin River Chinook Salmon populations. PBT involves the annual sampling and genotyping of adult Chinook Salmon returning to the Restoration Area; these data are being used to create a database of genotypes for future parentage assignment of their progeny. Genetic sampling of the San Joaquin River Fall-Run Chinook Salmon population began in 2013. As such, all adult Chinook Salmon returning to the Restoration Area in 2017/2018 were tissue sampled for genetic testing.

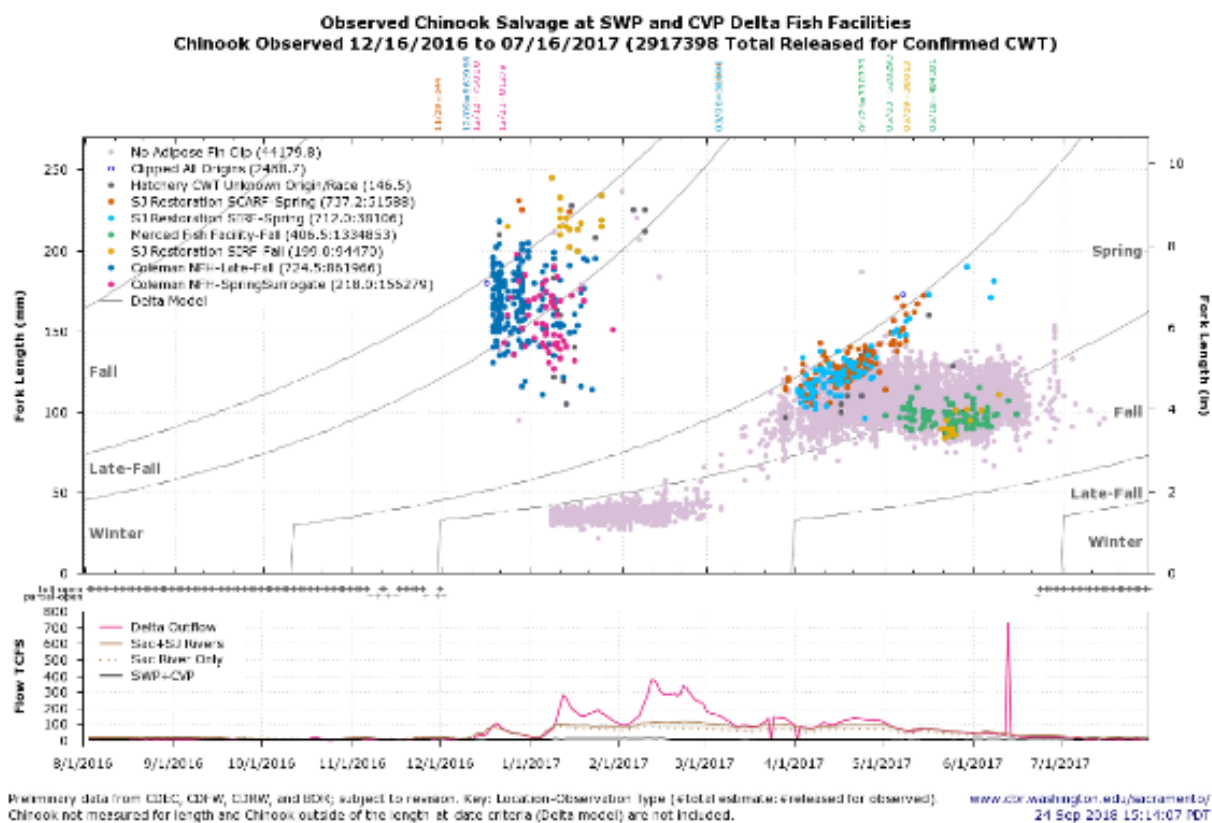


Figure 2.3-2. Observed Chinook Salvage at SWP and CVP Delta Fish Facilities during WY 2017

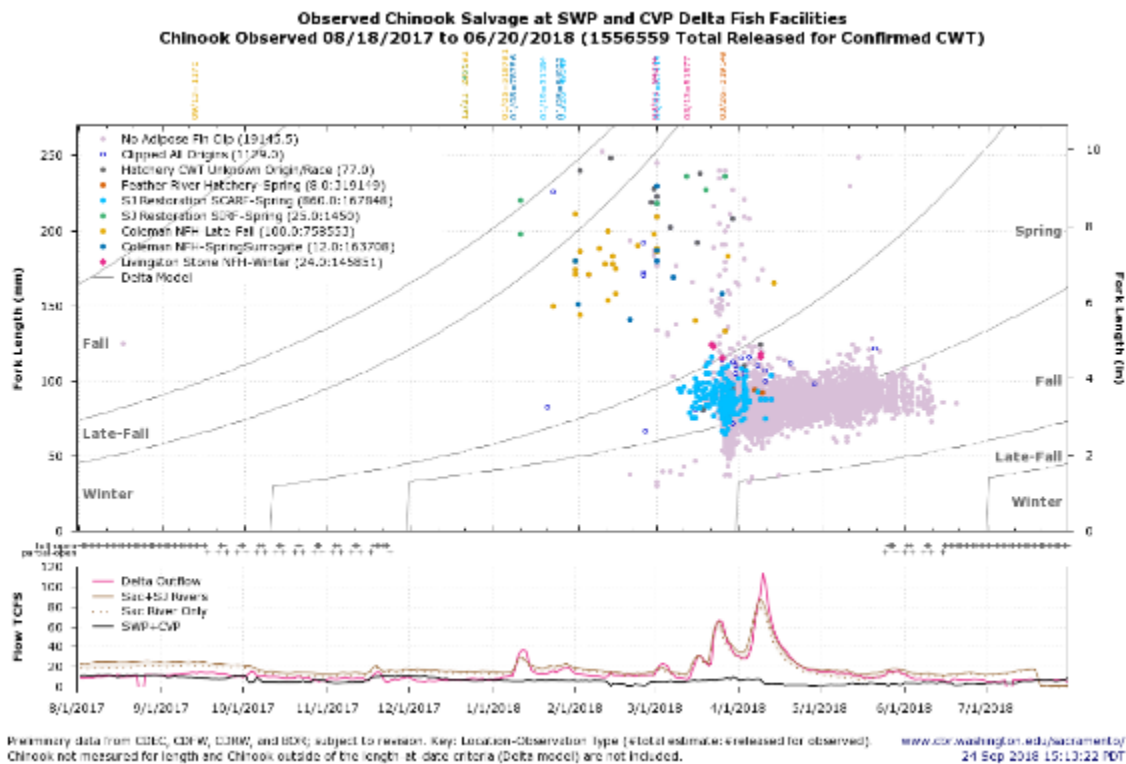


Figure 2.3-3. Observed Chinook Salvage at SWP and CVP Delta Fish Facilities during WY 2018

2.4 Spring-Run Chinook Critical Habitat

Critical habitat for the Central Valley Spring-Run Chinook Salmon was designated on September 2, 2005, and includes the mainstem Sacramento River from Chipps Island (RM 0) to Keswick Dam, and tributary reaches, including the Feather and Yuba rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and portions of the northern Delta (70 FR 52488).

Physical and Biological Features (PBFs) essential for the conservation of listed Chinook Salmon ESUs are those sites and habitat components that support one or more life stages and include:

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
2. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
3. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

4. Estuarine areas free of obstruction 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.
5. Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
6. Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

2.5 Central Valley Fall-Run and Late Fall-Run Chinook Salmon, Evolutional Significant Unit

2.5.1 ESA Listing Status

The Fall-Run and Late Fall-Run Chinook Salmon includes all spawning populations of Fall-Run and Late Fall-Run Chinook Salmon in the Sacramento and San Joaquin River basins and their tributaries east of Carquinez Strait, California (64 FR 50394). After reviewing the best available scientific and commercial information, NMFS on September 16, 1999, determined that listing Central Valley Fall-Run and Late Fall-Run Chinook Salmon was not warranted. On April 15, 2004, the Central Valley Fall-Run and Late Fall-Run Chinook Salmon ESU was identified by NMFS as a Species of Concern (69 FR 19975).

Freshwater Essential Fish Habitat (EFH) for Pacific Salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers et al. (1998). EFH includes not only the watersheds of the Sacramento and San Joaquin River basins but also the San Joaquin Delta (Delta), Suisun Bay, and the Lower Sacramento River.

2.5.2 General Life-History and Habitat Requirements

Chinook Salmon have evolved a broad array of life history patterns that allow them to take advantage of diverse riverine conditions throughout the year. These life history patterns generally fall into two main generalized freshwater life history types: stream-type and ocean-type (Healey 1991). Ocean-type Chinook Salmon like Fall-Run and Late-Fall-Run enter freshwater in late summer and fall and spawn soon after, and juveniles typically migrate to the ocean as young-of-the-year after several months or rearing.

Adult Fall-Run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Individuals spawn in the Sacramento River and eggs and alevins are in the gravel primarily between September and January, with a peak during October through December. Most individuals (83.4 percent) spawn upstream of Red Bluff Diversion Dam, although, unlike other races of Chinook salmon, a moderate percentage (16.6 percent) spawn below Red Bluff Diversion Dam (Table 2.5-1).

Table 2.5-1. The Temporal Occurrence of Adult and Juvenile Fall-Run Chinook Salmon at Locations in the Central Valley

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-----|----------|-----|-----|-------|-----|-----|-----|-----|-----|
| Adult | | | | | | | | | | | | |
| Delta ¹ | | | | | | | | | | | | |
| Sacramento River Basin ² | | | | | | | | | | | | |
| San Joaquin River ² | | | | | | | | | | | | |
| Juvenile | | | | | | | | | | | | |
| Sacramento River at Red Bluff ³ | | | | | | | | | | | | |
| Delta (beach seine) ⁴ | | | | | | | | | | | | |
| Mossdale (trawl) ⁴ | | | | | | | | | | | | |
| West Sacramento River (trawl) ⁴ | | | | | | | | | | | | |
| Chipps Island (trawl) ⁴ | | | | | | | | | | | | |
| Knights Landing (trap) ⁵ | | | | | | | | | | | | |
| Relative Abundance: | = High | | | = Medium | | | = Low | | | | | |
| <p>Note: Darker shades indicate months of greatest relative abundance.</p> <p>Sources:</p> <p>¹ State Water Project and Federal Water Project fish salvage data 1981–1988.</p> <p>² Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.</p> <p>³ Martin et al. 2001.</p> <p>⁴ U.S. Fish and Wildlife Service 2001b.</p> <p>⁵ Snider and Titus 2000.</p> | | | | | | | | | | | | |

Source: DWR and Reclamation 2016, p.11A–103

Table 2.5-2 shows the timing of the upstream presence of adult and juvenile life stages Late Fall-Run Chinook Salmon in the Sacramento River. The months included in this table represent the periods during which the majority (more than approximately 90 percent) of fish in a life stage are present. The life history characteristics of Late Fall–Run Chinook Salmon are not well understood. Late Fall–Run Chinook Salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between December and June, with a peak during January through March. Most adults (83.4 percent) spawn upstream of Red Bluff Diversion Dam, and roughly two thirds (67.6 percent) spawn just below Keswick Dam in the reach to the ACID Dam (Table 2.5-2).

Table 2.5-2. The Temporal Occurrence of Adult and Juvenile Late Fall-Run Chinook Salmon at Locations in the Central Valley

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Adult | | | | | | | | | | | | |
| Delta ¹ | | | | | | | | | | | | |
| Sacramento River Basin ² | | | | | | | | | | | | |
| Juvenile | | | | | | | | | | | | |
| Sacramento River at Red Bluff ³ | | | | | | | | | | | | |
| West Sacramento River (trawl) ⁴ | | | | | | | | | | | | |
| Delta (beach seine) ⁴ | | | | | | | | | | | | |
| Chippis Island (trawl) ⁴ | | | | | | | | | | | | |
| Knights Landing (trap) ⁵ | | | | | | | | | | | | |
| Relative Abundance: = High = Medium = Low | | | | | | | | | | | | |
| Note: Darker shades indicate months of greatest relative abundance. Sources: ¹ Moyle 2002. ² Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991. ³ Martin et al. 2001. ⁴ U.S. Fish and Wildlife Service 2001b. ⁵ Snider and Titus 2000. | | | | | | | | | | | | |

Source: DWR and Reclamation 2016, p.11A–104

In the Sacramento River, adult Fall-Run Chinook Salmon migrate upstream to spawn primarily during July through December, with a peak during August and September (Table 2.5-1). Adults that reach spawning grounds early in the season during July and August may hold before spawning (D. Swank, pers. comm.). Adult Late Fall-Run Chinook Salmon migrate upstream primarily during November through April (Table 2.5-2).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities to promote higher oxygen levels and eliminate fines in the substrate. Depending on ambient water temperature, embryos hatch in 40 to 60 days, and alevin (yolk-sac fry) remain in the gravel beds for an additional 4 to 6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding. Fall-Run Chinook Salmon fry (i.e., juveniles shorter than 2 inches long) in the Sacramento River generally emerge from December through March, with peak emergence occurring by the end of January. In general, Fall-Run Chinook Salmon fry abundance in the Delta increases following high winter flows. Most Fall-Run Chinook Salmon fry rear in fresh water from December through June, with emigration occurring from December through June and a peak from January through March (Table 2.5-1). Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A very small number (generally less than 5 percent) of Fall-Run juveniles spend over a year in fresh water and emigrate as yearling smolts the following November through April.

Late Fall–Run Chinook Salmon fry generally emerge from March through June. Late Fall–Run fry rear upstream until about July (Table 2.5-2) and in fresh water from April through the following April and emigrate as smolts from November through May.

2.5.3 Historical and Current Distribution and Abundance

Central Valley Fall-Run Chinook Salmon historically spawned in all major tributaries, as well as the mainstem of the Sacramento and San Joaquin Rivers. The historical distribution of Central Valley Late Fall–Run Chinook Salmon is not well understood, but is thought to be less extensive than that of Fall-Run. Late Fall–Run adults most likely spawned in the Upper Sacramento and McCloud Rivers in reaches now blocked by Shasta Dam, as well as in major tributaries with adequate cold water in summer. There is also some evidence they once spawned in the San Joaquin River in the Friant region and in other large San Joaquin tributaries (Yoshiyama et al. 1998).

Currently Fall-Run Chinook spawn below rim dams and barriers to migration in the Sacramento and San Joaquin Rivers and their tributaries. Some smaller streams that lack unpassable barriers have runs that extend into historical Fall-Run habitat. Late Fall–Run currently spawn almost exclusively in the Upper Sacramento River from Keswick Dam to ACID Dam.

Abundance of Central Valley Fall-Run and Late Fall–Run Chinook Salmon escapement before 1952 is not well documented. Production estimates of Fall-Run and Late–Fall Run Chinook Salmon on the San Joaquin River historically approached 300,000 adults and probably averaged approximately 150,000 adults (Reynolds et al. 1993.). Calkins et al. (1940) estimated Fall-Run and Late Fall–Run Chinook Salmon abundance at 55,595 adults in the Sacramento River basin from 1931 to 1939. Adult Fall-Run and Late Fall–Run Chinook Salmon escapement in the early 1960s, was estimated to be 327,000 in the Sacramento River basin (California Department of Fish and Game 1965). Estimates of Fall-Run and Late Fall–Run Chinook Salmon escapement in the mid-1960s, to the San Joaquin River basin was about 2,400 fish (Reynolds et al. 1993). Sacramento and San Joaquin Rivers in river Fall-Run estimates of escapement from 1975 to 2017 (Figure 2.5-1.). Fall-Run Chinook Salmon of hatchery origin are included in the Pacific Coast Salmon Fishery Management Plan and are included in an EFH type analysis (Pacific Fishery Management Council 2014). Hatchery Fall-Run Chinook Salmon in the Sacramento and San Joaquin Rivers have ranged from over 700,000 in 2005 to just over 20,000 in 2009 (Figure 2.5-2.). Sacramento and San Joaquin River Fall-Run Chinook have been described as primarily a hatchery stock with a smaller natural component. The San Joaquin River Fall-Run Chinook Salmon population also has hatchery and natural components. Huber and Carlson (2015) provide a synthesis of trends in release number, location, size, and timing of Fall-Run Chinook Salmon released from the five Central Valley hatcheries between 1946 and 2012. They found since the mid-1980s the proportion of hatchery Fall-Run Chinook Salmon juveniles released downstream of the Delta has varied from around 20 to 60 percent.

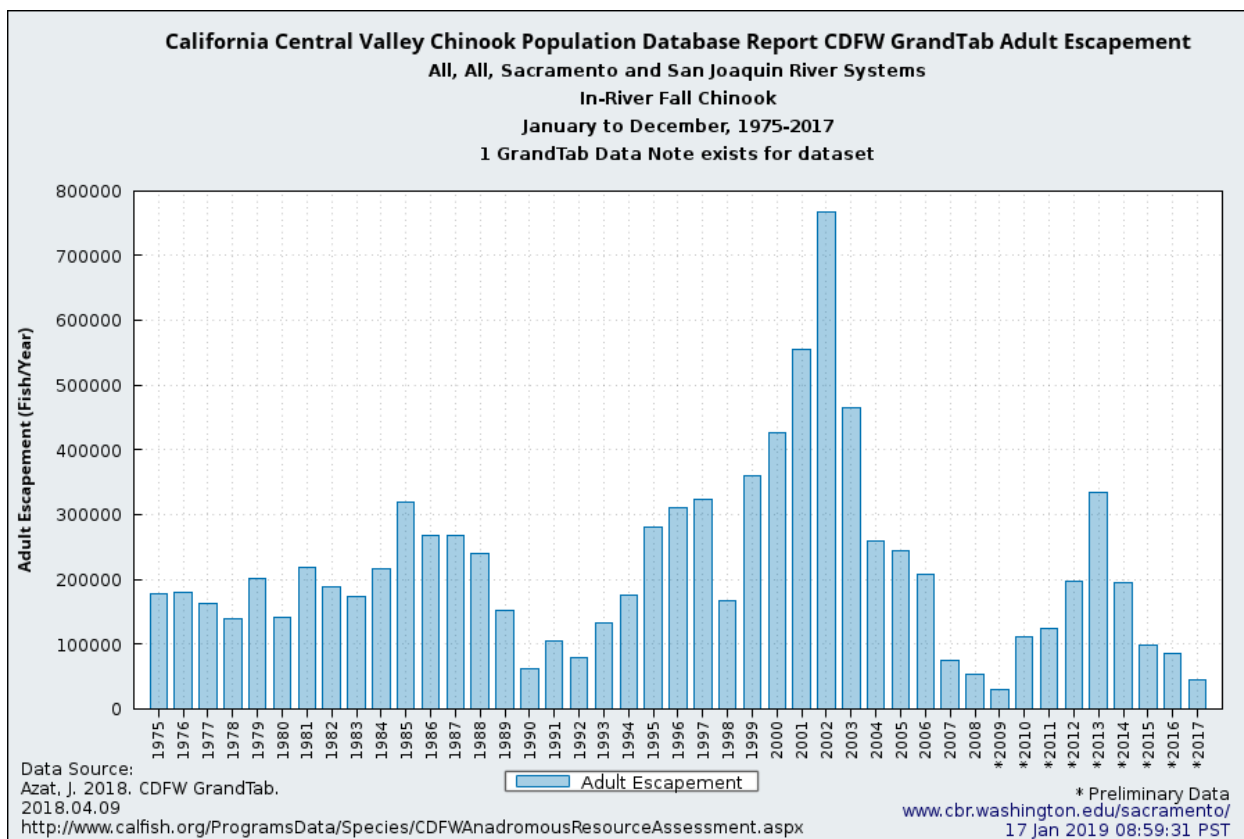


Figure 2.5-1. In-River Escapement Numbers of Fall-Run Chinook, Sacramento and San Joaquin River Systems

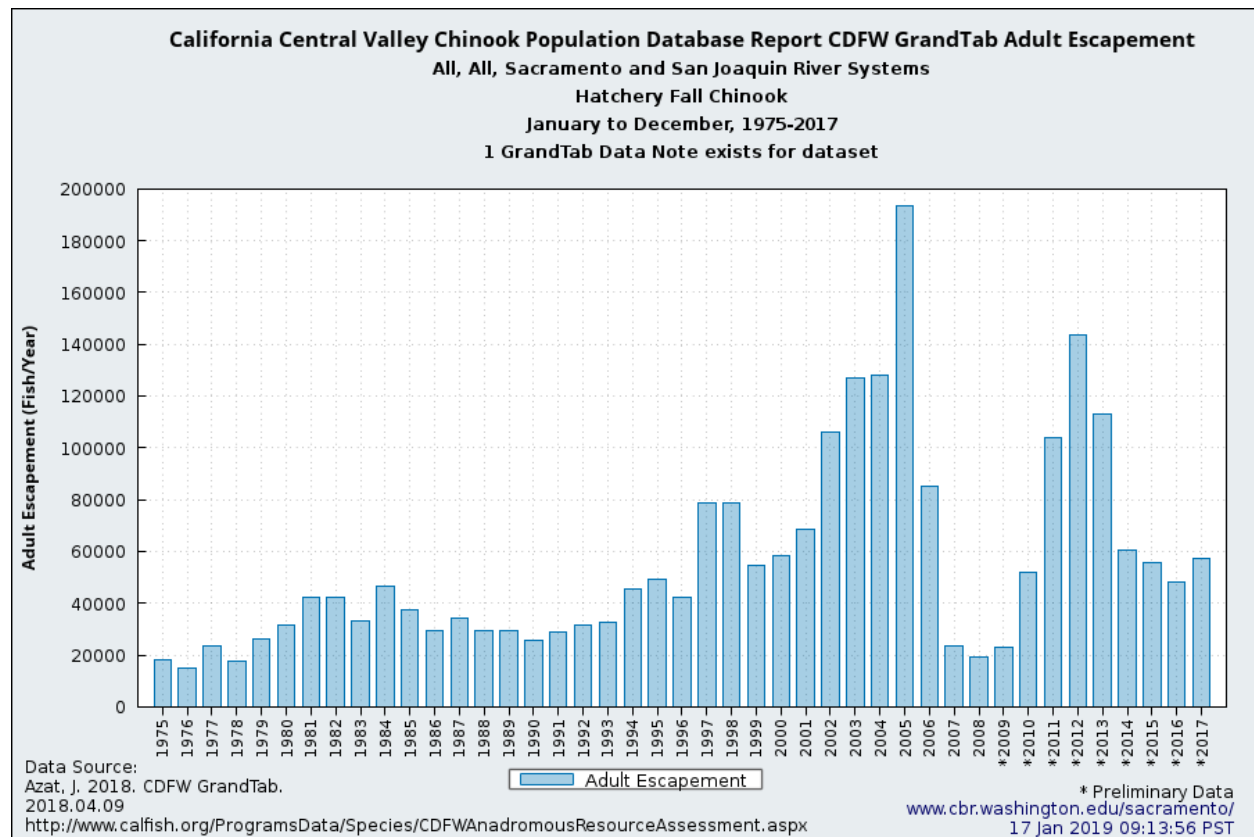


Figure 2.5-2. Hatchery Escapement Numbers of Fall-Run Chinook, Sacramento and San Joaquin River Systems

In the Sacramento and San Joaquin River from 1975 through 2017 adult escapement estimates for Late Fall–Run Chinook Salmon have ranged from several hundred adults to over 40,000 adults (Figure 2.5-3). Between 1971 and 1997, adult escapement showed a general trend of declining abundance. From 1990 through 2006, escapement increased substantially, but was also highly variable from year to year. Escapement estimates were lower than the previous 4 years in 2008 and 2009, but not on the magnitude that was observed for Fall-Run Chinook Salmon (California Department of Fish and Wildlife 2016). Sacramento River Late Fall–Run Chinook Salmon stock has hatchery and natural components from the Upper Sacramento River basin (Figure 2.5-4).

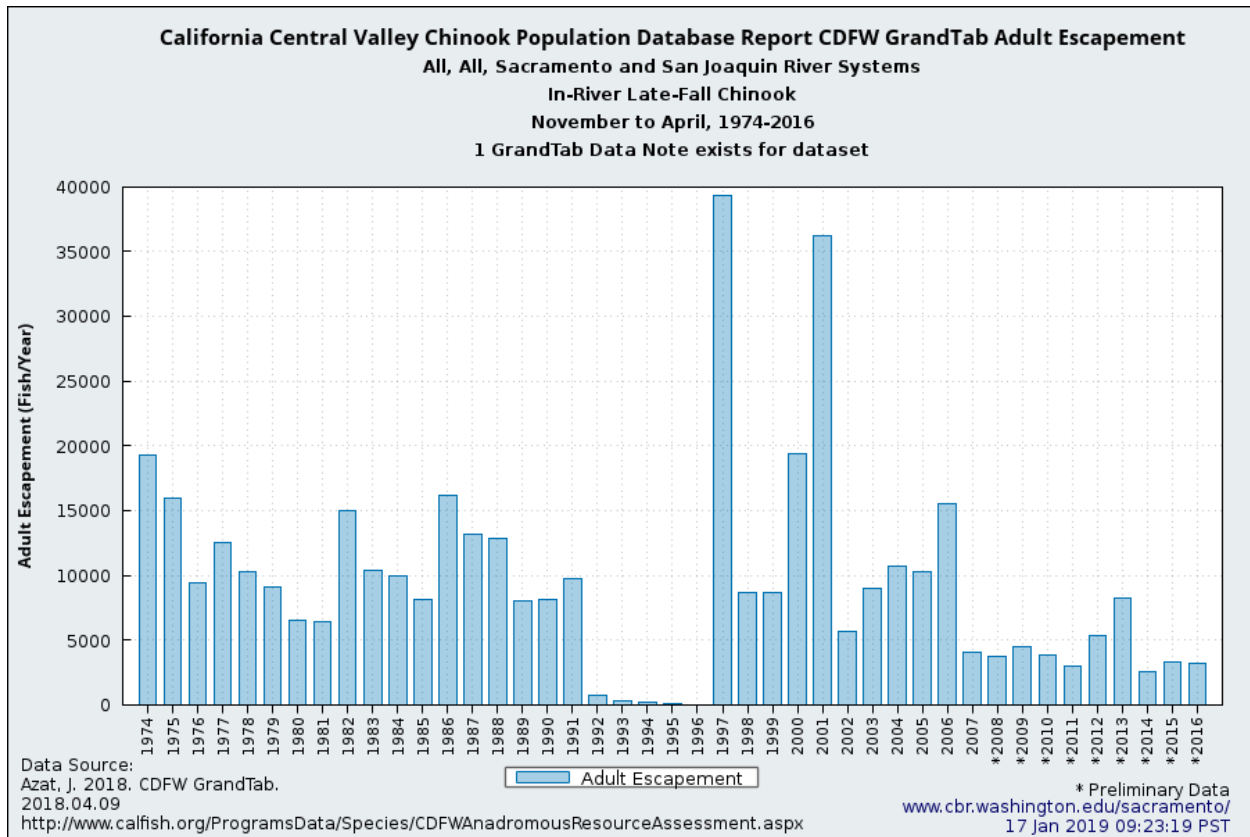


Figure 2.5-3. In-River Escapement Numbers of Late Fall-run Chinook, Sacramento and San Joaquin River Systems 1974–2017

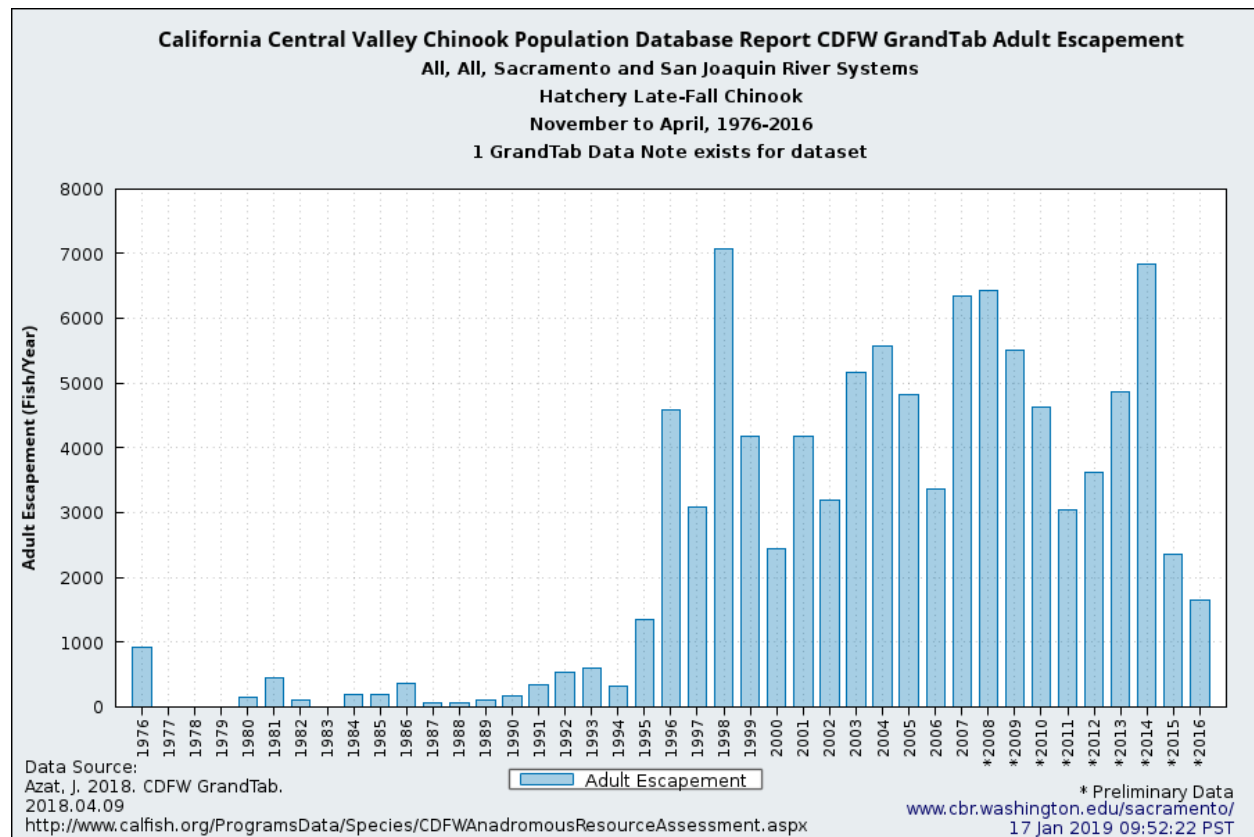


Figure 2.5-4. Hatchery Escapement Numbers of Late Fall-run Chinook, Sacramento and San Joaquin River Systems 1974–2017

2.5.4 Limiting Factors, Threats, and Stressors

The major factors that limit the range and abundance of Chinook Salmon are barriers to upstream migration, altered flow regime, high water temperature, habitat quality, entrainment in water diversions, loss of riparian and floodplain habitat, and ocean conditions.

Access to much or all of their historical spawning habitat was eliminated by high dams with no fish passage structures, although Fall-Run Chinook Salmon were less affected by these barriers than other Chinook races because much of their historical spawning habitat included the lower gradient reaches downstream of these dams (Reynolds et al. 1993; McEwan 2001). Changes in hydrologic patterns like the loss of spring peak flows and extended summer flows resulting from water and power operations have altered water temperatures and other habitat conditions for Fall-Run and Late Fall-Run Chinook (Williams 2006).

Migration and emigration corridors that previously contained high-value habitat types, such as dendritic channel systems, perched stream banks, floodplains and marshes, have been marginalized through channelization and leveed banks lined with riprap (Brandes and McLain 2001). Natural flow regimes have been modified by upstream reservoirs that capture water during high flow events, thus, dampening the hydrograph and lowering the extent and duration of floodplain inundations and other off-channel, flow-

dependent habitat used by emigrating juvenile Chinook salmon (70 FR 52488; Sommer et al. 2001; California Department of Water Resources 2005). Tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including Fall-Run Chinook Salmon. Studies have shown that these salmonids may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors on juvenile salmonids (Williams 2009). Similarly, channel margins provide valuable rearing and connectivity habitat along migration corridors, particularly for smaller juvenile fry, such as Fall-Run Chinook Salmon.

Predation on juvenile salmon by nonnative fish has been identified as an important threat to Fall-Run and Late Fall-Run Chinook Salmon in areas with high densities of nonnative fish that prey on outmigrating juvenile salmon (e.g., Smallmouth and Largemouth Bass, Striped Bass, and Catfish) (Lindley and Mohr 2003). Reduced habitat diversity (e.g., lack of cover) of channelized waterways in the rivers and Delta reduce refuge space for salmon from predators (Raleigh et al. 1984; Missildine et al. 2001; 70 FR 52488).

Climate experts predict physical changes to ocean, river, and stream environments along the West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated impacts on water temperature, hydrology, and ocean conditions are generally considered likely to have substantial effects on Chinook Salmon populations in the future (NMFS 2014). Global parameters, such as ocean conditions, have also demonstrated a marked effect on adult escapement (Lindley et al. 2009).

Impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) have deleterious impacts on natural in-river populations (Hindar et al. 1991; Ryman et al. 1994; Waples 1994; McLean et al. 2005; Ford et al. 2006).

2.5.5 Recovery and Management

The following sections describe recovery and management actions that have been taken to benefit Fall-Run and Late Fall-Run Chinook Salmon.

2.5.5.1 *Anadromous Fish Restoration Program*

Reclamation annually expends funding for the CVPIA AFRP (CVPIA 3406(b)(1)) to undertake reasonable measures to not less than double anadromous fish populations of the 1967 to 1991 period and to mitigate other adverse environmental effects. Fall-Run and Late Fall-Run conservation actions are described in the final plan for the AFRP (2001).

2.5.5.2 *Anadromous Fish Screen Program*

Section 3406(b)(21) of the CVPIA authorized the AFSP to assist the State of California on unscreened diversions. The AFRP screens or installs “fish protective devices” on diversions. The AFSP has developed guidelines to prioritize screening projects. Factors taken into account are location of the diversion in relation to areas used by anadromous fish for spawning and rearing, size of the diversion (or percent flow diverted in tributaries), season of diversion in relation to anadromous fish use of the stream or reach, and placement of the diversion. All but one of the diversions greater than 100 cfs on the Sacramento River have fish screens.

2.5.5.3 *Anderson Cottonwood Irrigation District*

The ACID operates a diversion dam across the Sacramento River located 5 miles downstream from Keswick Dam. The ACID Diversion Dam was improved in 2001 and 2015 with the addition of new fish ladders and fish screens around the diversion. (Killam 2008).

2.5.5.4 *Battle Creek Restoration Program*

The Battle Creek Salmon and Steelhead Restoration Project has a long history that includes research by various organizations and collaboration among many resource agencies and public interest groups. In 1999, a cooperative effort among Reclamation, USFWS, NMFS, CDFW, and PG&E led to the signing of a MOU. The Battle Creek Salmon and Steelhead Restoration Project includes modifications to facilities and adjustments to operations for anadromous fish. Construction is anticipated to be complete in 2021.

2.5.5.5 *Spawning and Rearing Habitat Restoration*

Reclamation expends annual funding for the CVPIA under Section 3406(b)(13) Spawning and Rearing Habitat Program. Federal, state, and local agencies, water users, and other stakeholders have partnered to develop and implement a continuing program for the purpose of restoring and replenishing, as needed, salmonid spawning gravel lost due to the construction and operation of CVP dams and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River.

The Upper Sacramento River between Keswick Dam and Red Bluff Diversion Dam presents several opportunities for improving and restoring salmonid spawning and rearing habitats.

2.5.5.6 *Glenn Colusa Irrigation District Hamilton City Fish Screen*

Glenn Colusa Irrigation District (GCID) diverts a maximum of 3,000 cfs from the Sacramento River at the Hamilton City pump station. The peak demand occurs in the spring, often at the same time as the peak outmigration of juvenile salmon. Because GCID diverts up to 25 percent of the Sacramento River flow at Hamilton City, GCID pumping operations were identified as a significant impediment to the downstream juvenile salmon migration. In 2000, GCID and Reclamation completed a 620-foot-long fish screen extension and channel improvements to minimize entrainment of salmonids into GCID's facility.

2.5.5.7 *Red Bluff Diversion Dam*

The Red Bluff Diversion Dam was decommissioned in 2013, providing unimpaired juvenile and adult fish passage so that adult Chinook salmon could migrate through the structure at a broader range of flows and reach spawning habitat upstream of the structure. This project was authorized by CVPIA 3406(b)(10).

2.5.5.8 *Shasta Temperature Control Device*

Reclamation constructed the TCD in under the CVPIA 3406(b)(6). Reclamation operates the Shasta Temperature Control Device to conserve the available cold pool in the reservoir for spawning and egg incubation temperatures for Chinook salmon. Reclamation manages releases to maintain suitable depths over Chinook salmon redds to avoid dewatering.

2.5.5.9 *Whiskeytown Reservoir Spring Creek and Oak Bottom Temperature Curtains*

Reclamation has replaced both the Spring-Creek and Oak Bottom temperature curtains in Whiskeytown Reservoir to improve temperature flexibility and build a cold water pool for Clear Creek and Sacramento River temperature compliance.

2.5.5.10 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*

Most salmonid floodplain rearing habitat in the Sacramento Valley was altered or blocked from use by dams and levees. The Yolo Bypass is the largest remaining floodplain in the Sacramento Valley, but is only accessible when the Sacramento River exceeds the crest of the Fremont Weir during high flow events. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is a joint effort undertaken by DWR and Reclamation. The project largely focuses on infrastructure modifications to increase the number of juvenile salmonids that have access to floodplain habitat in the Yolo Bypass through Fremont Weir and to increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

2.5.5.11 *California EcoRestore*

California EcoRestore is an initiative to help coordinate and advance at least 30,000 acres of critical habitat restoration in the Delta by 2020. The program includes a broad range of habitat restoration projects, including aquatic, subtidal, tidal, riparian, flood plain, and upland ecosystems. Projects completed to date include the following:

- Fremont Weir Fish Passage Modification—Fremont Weir Adult Fish Passage Modification Project widened and deepened the existing fish ladder at the Fremont Weir and the upstream and downstream adjoining channels were reconfigured to accommodate migratory fish passage. Existing earthen agricultural road crossings were replaced by permanent crossings that allow for the clear passage of migratory fish.
- Knights Landing Outfall Gates—A positive fish barrier was constructed (with new concrete wing walls and installation of a metal picket weir) on the downstream side of the existing Knights Landing Outfall Gate in the Colusa Basin Drain. This project serves primarily as a fish passage improvement action that will prevent salmon entry into the Colusa Basin Drain, where they become trapped with no access back to the Sacramento River.
- Wallace Weir—The project consisted of constructing a permanent earthen weir that was hardened to withstand winter floods to prevent adult salmon entry into the Colusa Basin Drain. A fish rescue facility was incorporated into the weir so fish that arrive at the Wallace Weir via the Yolo Bypass can be safely and effectively rescued and returned to the Sacramento River to resume their migration to upriver spawning grounds.
- Lindsey Slough—The project restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.
- Sherman Island—The project constructed levee setbacks in Mayberry Slough that will augment existing riparian vegetation and restore tidal wetland that will provide habitat for native species including salmonids.
- Sacramento River Temperature Task Group—The SRTTG is a multiagency group formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1 to assist with improving and stabilizing

Chinook population in the Sacramento River. Annually, Reclamation develops temperature operation plans for the Shasta and Trinity divisions of the CVP. These plans consider impacts on Winter-Run and other races of Chinook Salmon, and associated project operations. The SRTTG meets initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control.

2.5.5.12 Flyway Farms Tidal Habitat Restoration Project

Restored seasonal wetland and cattle grazing land to sub-tidal, intertidal and seasonal wetlands to benefit native fish species. Involves restoring and enhancing approximately 300 acres of tidal freshwater wetlands, and an additional 30 acres of seasonal wetlands, at the southern end of the Yolo Bypass. Designed to maximize residency time and food web production by capturing and slowly draining water through the excavation of two breaches along the Yolo Bypass Toe Drain and interior channels to connect and enhance existing wetlands on site. The goal is to improve habitat conditions for salmonids by providing rearing habitats for outmigrating juveniles and migratory habitats for adults.

2.5.5.13 Shasta Dam Fish Passage Evaluation

The Shasta Dam Fish Passage Evaluation is an effort to determine the feasibility of reintroducing Winter-run and Spring-Run Chinook Salmon and Steelhead to tributaries above Shasta Dam. The evaluation is part of Reclamation's response to the June 4, 2009, NMFS BO *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

2.5.6 Water Operations Management

2.5.6.1 Sacramento River

The Sacramento River system includes several major features and facilities that are relevant to temperature management: (1) Shasta Dam and Lake and the installed TCD; (2) interbasin transfers from the Trinity River Basin, which are conveyed through Whiskeytown Lake, the Clear Creek Tunnel and Carr Powerhouse, and the Spring Creek Tunnel; and (3) Keswick Reservoir, which regulates releases from Shasta Dam and Spring Creek Powerhouses, resulting in a stable flow regime for release from Keswick Dam.

Reclamation currently strives to meet Sacramento River storage and temperature requirements (NMFS RPA Actions I.2.1 through I.2.4), as well as holding the Sacramento River Temperature Task Group meetings, providing operations plans each year, and using the Shasta TCD to strive to meet temperature targets while minimizing power loss.

Measures taken in 2014 and 2015 as part of a coordinated drought response to improve Shasta Reservoir cold water pool management included: (1) working with the SWRCB and water users to lower Wilkins Slough navigational flow requirements; (2) requesting that the SWRCB relax D-1641 Delta water quality requirements; (3) delaying Sacramento River Settlement Contractor depletions and transferring a volume of their water in the fall rather than increase depletions throughout the summer; (4) targeting slightly warmer temperatures during the Sacramento River Winter-Run Chinook Salmon holding period (before spawning occurs); and (5) installing a Shasta Dam TCD curtain in 2015.

2.5.6.2 Clear Creek

Reclamation has a requirement from its 2002 water right as well as the 2000 Reclamation/USFWS/DFW agreement for 50 cfs year-round in all years, increasing to 70 cfs in November and December of critical years and increasing to 100 cfs in November and December of normal years.

Reclamation's operations on Clear Creek follow the CVPIA AFRP guidelines (USFWS 2001) of 200 cfs October 1 to June 1 from Whiskeytown dam for anadromous salmonids and their habitat. A flow of 150 cfs or less, from July through September to maintain 60°F temperatures in stream sections utilized by Spring-Run Chinook Salmon.

2.5.6.3 Stanislaus River

Reclamation operates the Stanislaus River separately from the other Central Valley Project reservoirs. While releases from New Melones Reservoir provide inflow to the Delta, Reclamation does not operate New Melones for Delta salinity, outflow, or export requirements. Reclamation operates New Melones Reservoir to meet instream flow objectives (see 2009 BO, Table 2E flows), dissolved oxygen standards as measured at Ripon, salinity objectives at Vernalis (as set in SWRBC D-1641) and Vernalis flow objectives as set in D-1641 and updated in the 2009 BO.

Prior to the 2009 BO Table 2E flows, instream releases on the Stanislaus River were set pursuant to the 1987 CDFG agreement. This agreement was intended to only be in place for 10 years while a specific set of fishery studies was completed to help inform the decision on what instream flows would be most beneficial. However, while studies have been completed, the agreement has never been updated. Each year Reclamation determines the annual volume of water available to be utilized for fishery releases and transmits that volume to the CDFW. CDFW is then responsible for determining the pattern of water release. Since the initiation of this agreement, the CDFW has routinely put 0 cfs as the required release during the summer months. Reclamation has a separate obligation to meet dissolved oxygen standards at Ripon during the summer months as required by Reclamation's water rights. DFW has always assumed that Reclamation will have to release approximately 300 cfs to meet the dissolved oxygen standards. This allowed CDFW to concentrate their fishery volume in other months. However, this was not the intent of the agreement and had the effect of stressing the reservoir resources, particularly in dry years. Since the BO, this has generally not been a problem because the 2009 NMFS BO Table 2E flows have generally been greater than those requested by CDFW. However, in some years or months, such as December 2018, the requested CDFW releases are higher than the Table 2E releases, reducing storage and affecting other authorized purposes of the reservoir.

2.5.6.4 American River

2.5.6.4.1 Flow

Flow releases from Folsom Reservoir are made for both flood control and to meet water quality objectives and demands in the Delta. This can result in rapid increases and decreases of flow during the winter and spring. As a result, dewatering and isolation of Steelhead redds has been documented (Hannon et al. 2003; Water Forum 2005; Hannon and Deason 2008). In addition to flow fluctuations, low flows also can negatively affect Lower American River Steelhead. At low flow levels, the availability of bar complexes and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover is limited.

Reclamation operates Folsom Dam and Reservoir to provide water for irrigation, M&I uses, hydroelectric power, recreation, water quality, flood control, and fish protection. Reclamation, operating under the SWRCB Decision 893 (D-893) adopted in 1958, allows flows at the mouth of the American River to fall as low as 250 cubic feet per second (cfs) from January through mid-September, with a minimum of 500 cfs required between September 15 and December 31. The D-893 decision is out-of-touch with modern biological, socioeconomic, and institutional conditions. For instance, it doesn't address the requirements of the CVPIA, the 1995 Bay-Delta Plan, or biological opinions issued to protect Central Valley Steelhead. Reclamation and the SWCB and many stakeholders (Water Forum) agreed that D-893 did not provide sufficient protections for Central Valley Steelhead in the Lower American River. Recently, Reclamation has operated the Folsom/Nimbus complex to more modern protective requirements and habitat management plans by providing flows that far exceed those required in D-893.

NMFS provided a reasonable and prudent alternative (RPA) in their 2017 amendment to the 2009 RPA. In this amended RPA, NMFS requires the action of implementing the flow schedule specified in the Water Forum Flow Management Standard. This flow schedule developed by the Water Forum, Reclamation, USFWS, NMFS, and CDFW addresses minimum flows needed for Central Valley Steelhead and Fall-Run Chinook Salmon in the Lower American River. Furthermore, Reclamation shall convene the American River Group (ARG), composed of representatives from Reclamation, NMFS, USFWS, CDFW and the Water Forum, to make recommendations for management within the constraints of the Flow Management Standard. Reclamation shall ensure that flow, water temperature, Steelhead spawning, and Steelhead rearing monitoring is conducted annually to help inform the ARG process and to evaluate take associated with flow fluctuations and warm water temperatures.

2.5.6.4.2 Temperature

Water temperatures in the Lower American River are influenced by proposed action operations. In the Lower American River water temperatures are a function of the timing, volume, and temperature of water releases from Folsom and Nimbus Dams. Once water is released, river distance and environmental heat flux influences the water temperature further as it moves through the Lower American River (Bartholow 2000).

In response, NMFS issued an RPA action to maintain suitable overwintering temperatures for juvenile Central Valley Steelhead in the Lower American River. In the action, Reclamation is to prepare a draft Operations Forecast and Temperature Management Plan based on forecasted conditions and submit the draft plan to NMFS for review by May 1 of each year. The information provided in the Operations Forecast will be used in the development of the Temperature Plan. Reclamation will use an iterative approach, varying proposed operations, with the objective to attain the temperature compliance point at Watt Avenue Bridge. Operation of Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam will be used to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31.

2.5.6.5 *Feather River*

DWR will operate Oroville Dam consistent with the applicable NMFS and USFWS biological opinions for the Oroville Complex (FERC Project #2100-134). During the summer, DWR typically releases water from Lake Oroville to meet instream flow requirements and to supplement non-project Delta inflows needed to meet D-1641 requirements. Releases also include water for local deliveries and south-of-Delta export at Banks Pumping Plant.

DWR balances the cumulative storage between Lake Oroville and San Luis Reservoirs so as to meet its flood control requirements, Sacramento–San Joaquin Delta requirements, and deliver water supplies to its contracted water agencies consistent with all environmental constraints. Lake Oroville may be operated to convey water through the Delta to San Luis Reservoir via Banks under different schedules depending on Delta conditions, reservoir storage volumes, and storage targets. Decisions as to when to move water from Lake Oroville to San Luis Reservoir are based on many real-time factors.

2.5.6.6 San Joaquin River

Reclamation operates the Friant Division for flood control, irrigation, M&I, and fish and wildlife purposes. Facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals. Friant Dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Gravelly Ford, provides Restoration Flow releases under Title X of Public Law 111-11, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals for water supply. Water is delivered to about a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal north to Madera and Chowchilla Irrigation Districts. A minimum of 5 cfs is required to pass the last holding contract diversion located about 40 miles downstream of Friant Dam near Gravelly Ford.

The SJRRP implements the San Joaquin River Restoration Settlement Act in Title X of Public Law 111-11. USFWS and NMFS issued programmatic biological opinions in 2012 that included project-level consultation for SJRRP flow releases. Programmatic ESA coverage is provided in both the USFWS and NMFS biological opinions for flow releases, 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.

The Stipulation of Settlement of NRDC vs. Rogers, is based on two goals: the Restoration Goal and the Water Management Goal. To achieve the Restoration Goal, the Settlement calls for, among other things, releases of water from Friant Dam to the confluence of the Merced River (referred to as Restoration Flows) according to the hydrographs in Settlement Exhibit B. To achieve the Water Management Goal, the Settlement calls for the development and implementation of a plan for recirculation, recapture, reuse, exchange, or transfer of Restoration Flows for the purpose of reducing or avoiding impacts on water deliveries to all of the Friant Contractors caused by Restoration Flows. Recapture of Restoration Flows must occur downstream of the Merced River confluence. Recapture can occur at Banta-Carbona, Patterson, or West Stanislaus Irrigation District facilities, or at Jones or Banks Pumping Plants. Recapture of Restoration Flows in the Sacramento–San Joaquin Delta under this proposed action would average 33 TAF and range from about 17 TAF in a critical-high year to about 44 TAF in a normal-wet year. If Voluntary Agreements are approved, up to 50 percent of the February through June volume could be dedicated to Delta Outflow, up to an annual maximum of 50 TAF.

2.5.6.7 Additional Programmatic Actions

2.5.6.7.1 Lower SJR Spawning and Rearing Habitat

Reclamation may create a regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. This stretch of the San Joaquin River is cut off from its floodplain due to an extensive levee system, with two notable exceptions at Dos Rios Ranch (1,600 acres) and the San Joaquin River National Wildlife Refuge (2,200 acres). In recent years, there has been growing interest in multi-benefit floodplain habitat restoration projects in the Central Valley that can provide increased flood protection for urban and agricultural lands, improved riparian corridors for

terrestrial plants and wildlife, and enhanced floodplain habitat for fish. The resulting restoration could include thousands of acres of interconnected (or closely spaced) floodplain areas with coordinated and/or collaborative funding and management. 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.

2.5.6.7.2 Delta

The main CVP and SWP facilities in the Delta provide for the export of water to the San Joaquin Valley and Southern California. The major CVP features are the Delta Cross Channel (DCC), Contra Costa Canal, Jones Pumping Plant, TFCF, Delta-Mendota Canal/California Aqueduct Intertie (Intertie), and Delta-Mendota Canal (DMC). The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCWD diversion facilities use CVP water resources, and other water rights, to serve CCWD customers directly and to operate CCWD's Los Vaqueros Project. The Jones Pumping Plant diverts water from the Delta to the head of the DMC. The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, Clifton Court Forebay (CCF), Skinner Fish Facility, and Barker Slough Pumping Plant.

2.5.6.7.2.1 Banks Pumping Plant

DWR plans to continue implementation of projects to reduce mortality of ESA-listed fish species in response to the NMFS letter dated April 9, 2015, requiring that DWR immediately implement interim measures to improve predator control until an acceptable alternative can be implemented. These interim measures that could be implemented include: electro-shocking and relocating predators; controlling aquatic weeds; developing a fishing incentives or reward program for predators; and operational changes when listed species are present.

2.5.6.7.3 Agricultural Barriers

DWR proposes to continue to install three agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year when necessary. The barriers are installed between April and July and removed in November. Barriers would include at least one culvert open to allow for fish migration when water temperatures are less than 22°C.

2.5.6.7.3.1 Delta Cross Channel

The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When DCC 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 the Banks and Jones Pumping Plants. Reclamation operates the DCC in the open position to (1) improve the movement of 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 are often periodically closed to protect outmigrating salmonids from entering the interior Delta and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage.

Reclamation proposes to operate the DCC gates to reduce juvenile salmonid entrainment risk beyond the actions described in D-1641, consistent with Delta water quality requirements 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 4-13 to determine whether to

close the DCC gates and for how long. From December 1 to May 20, the DCC gates will be closed, unless Reclamation determines that it can avoid D-1641 water quality exceedances by opening the DCC gates for up to 5 days for up to two events within this period. If there is a conflict between water quality and species in December and January due to drought, Reclamation and DWR propose to coordinate with USFWS and NMFS through the Delta Monitoring Working Group. From May 21 to June 15, Reclamation will close the DCC gates for 14 days during this period, consistent with D-1641. Reclamation and DWR's risk assessment will consider the Knights Landing rotary screw trap (RST), 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 DCC operations. If the risk assessment determines that survival, route entrainment, or behavior changes to create a new adverse effect not considered under this proposed action, Reclamation will not open the DCC.

2.5.6.7.3.2 Tracy Fish Collection Facility

Reclamation proposes to screen fish from Jones Pumping Plant with the TFCF. The TFCF 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.

Reclamation proposes to sample fish passing through the facility for no less than 30 minutes every 2 hours. Reclamation proposes to sample fish for 10 minutes every 2 hours when large amounts of fish are present, or under conditions of excessive debris or aquatic weed loading. Reclamation proposes to continue tissue sampling and genetic analysis of all salvaged juvenile salmonids. During periods of OMR management, older fish of juvenile size will be genetically analyzed within 48 hours.

Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an 8 ppt salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge.

2.5.6.7.3.3 Skinner Fish Facility

The Skinner Fish Facility has behavioral barriers to keep fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash rack. Smaller fish are diverted from the intake channel into bypasses by a series of behavioral barriers (metal louvers), while the main flow of water continues through the louvers and toward the pumps. These fish pass through a secondary system of louvers or screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks. The sampling frequency at TFCF will be maintained at Skinner Fish Facility.

2.5.7 Monitoring and Research Programs

Monitoring and research programs help provide information on Fall-Run and Late Fall-Run Chinook Salmon migration, survival, redd distribution. Since 2015, Reclamation has started Enhanced Acoustic Tag Salmonid Monitoring (EATSM). EATSM is part of the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) program, which improves monitoring by addressing vital population statistics rather than reliance upon old indexes. CDFW annually conducts aerial redd surveys and has gone through the process of digitizing recorded Fall-Run and Late Fall-Run Chinook Salmon redds in the upper Sacramento from 1990 to 2014.

Surveys also help CDFW compile annual population estimates of Chinook salmon. Information is entered into CDFW's GrandTab and is easily accessible through www.calfish.org. Reclamation funds monitoring, evaluation, and web-based data services through the Central Valley Prediction and Assessment of Salmon (SacPAS) tool online. This service also provides a publicly accessible reporting system of historical and current information (www.cbr.washington.edu/sacramento/).

2.5.7.1 *Monitoring Programs for Chinook Salmon*

Table 2.5-3 Summary of Chinook Salmon (SRWC) Monitoring Surveys, Protocols, and Precisions

| Life Stage | Location | Agency | Protocol | Level of Precision | Protocol Citation |
|----------------------|--------------------------|-----------|---------------------------------------------------------------------|----------------------------------|-----------------------|
| Upper River | | | | | |
| Adults | Upper river | CDFW | Carcass mark–recapture; McCormick Jolly Seber | Abundance 90% CI 10% | Bergman et al. 2012 |
| Juveniles | RBDD | USFWS | Mark–recapture; gear efficiencies | Abundance 90% CI 35% | Poytress et al. 2014 |
| Middle River | | | | | |
| Juveniles | GCID | GCID | RST | Counts reported | |
| | Tisdale | CDFW | RST | Counts reported | |
| | Knights Landing | CDFW | RST | Counts reported | |
| | Yolo Bypass | DWR | RST; Beach seines | Counts reported | |
| Tidal Estuary | | | | | |
| Juveniles | Sacramento | USFWS | Kodiak trawl | Counts reported | Honey et al. 2004 |
| | Delta | USFWS | Beach seines | Counts reported | Honey et al. 2004 |
| | Chippis Island | USFWS | Mid-water trawl | Abundance CV 20--40% | Pyper et al. 2013 |
| | Fish Protective Facility | USBR/CDWR | Salvage; Loss estimate | Expanded counts per water volume | |
| Ocean | | | | | |
| Adults | Ocean fishery | NMFS | CWT recoveries; Cohort reconstruction | Not estimated for impact rates | O'Farrell et al. 2012 |
| Multiple regions | | | | | |
| Hatchery juveniles | Multiple regions | NMFS | Reach-specific survival and movement rates; JSAT Acoustic Telemetry | Errors vary by reach | Michel et al. 2015 |
| Adult migration | Flood bypasses | CDFW | Strandings and rescues | Counts reported | Purdy et al. 2015 |

2.5.7.2 *Fall-Run and Late Fall-Run Essential Fish Habitat*

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. In 1999, the Pacific Fishery Management Council (PFMC) identified EFH for Central Valley Chinook Salmon stocks to include the Sacramento and San Joaquin Rivers and their tributaries as

EFH. EFH includes not only the watersheds of the Sacramento and San Joaquin River basins but also the San Joaquin Delta (Delta) hydrologic unit, Suisun Bay hydrologic unit, and the Lower Sacramento hydrologic unit. Freshwater EFH for Chinook Salmon consists of four major habitat functions:

1. Spawning and incubation
2. Juvenile rearing
3. Juvenile migration corridors
4. Adult migration corridors and adult holding habitat

Projected impacts associated with the proposed action are expected to eliminate, diminish, and/or disrupt these EFH habitat functions for Fall-Run and Late Fall-Run Chinook Salmon at many sites within the action area.

2.6 Steelhead, California Central Valley DPS

2.6.1 ESA Listing Status

The California Central Valley Steelhead DPS was originally listed as threatened under the ESA on March 19, 1998 (63FR 13347), and the listing was reaffirmed on January 5, 2006 (71 FR 834) and updated April 14, 2014 (79 FR 20802). The DPS includes all naturally spawned populations of Steelhead in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries. The DPS includes all naturally spawned Steelhead populations below natural and man-made impassable barriers in the Sacramento and San Joaquin Rivers and their tributaries (63 FR 13347). Steelhead in two artificial propagation programs, the Coleman National Fish Hatchery (CNFH) and FRFH Steelhead hatchery programs, are considered to be part of the DPS. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the DPS (71 FR 834).

In May 2016, NMFS completed a 5-year status review of the Central Valley Steelhead DPS. Based upon a review of available information, NMFS (2016c) recommended that the Central Valley Steelhead DPS remain classified as a threatened species. However, NMFS also indicated that the biological status of the DPS has declined since the previous status review in 2011. NMFS indicated that natural production of Steelhead continues to decline and is now at very low levels (NMFS 2016c). 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. Due to this declining trend, NMFS suggests that the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016c).

Based on new genetic evidence described by Pearse and Garza (2015), NMFS recommended that Steelhead originating from the Mokelumne River Hatchery be added to the Central Valley Steelhead DPS (just as FRFH fish are considered to be a native Central Valley stock and are listed as part of the DPS). NMFS also recommended that the status of the DPS should be monitored and Hatchery and Genetic Management Plans should mandate that all Central Valley Steelhead hatcheries collect a full set of biological data, including scale samples, length, weight, sex, origin, and state of maturity, from a subset of all returning fish (NMFS 2016c) Hatcheries also should be required to conduct studies of smolt survival using modern tagging methods such as PIT tags and/or acoustic tags.

2.6.2 General Life-History and Habitat Requirements

Steelhead have a complex suite of life history traits, including the capability to be anadromous or to be resident (i.e., rainbow trout). Spawning and rearing habitat for Steelhead is usually characterized as perennial streams with clear, cool to cold, fast flowing water with a high dissolved oxygen content and abundant gravels and riffles. The preferred flow velocity is in the range of one to three feet per second (Raleigh et al. 1986). Steelhead use various mixtures of sand-gravel and gravel-cobble substrate for spawning, but optimal spawning substrate reportedly ranges from 0.25 to 4.0 inches in diameter (Reiser and Bjornn 1979). Optimal water temperatures for Steelhead adult immigration are reported to range from 46°F to 52°F (NMFS 2002; SWRCB 2003). Optimal conditions for Steelhead spawning and embryo incubation reportedly occur at water temperatures 52°F (NMFS 2002; SWRCB 2003). Water temperatures between 45°F and 65°F have been reported as preferred for fry and juvenile Steelhead rearing (NMFS 2002). Upper lethal temperatures for adult Pacific salmonids are in the range of 75°F to 77°F for continuous long-term exposure (Brett et al. 1982). NMFS (2002) reported 65°F as the upper water temperature limit preferred for the growth and development of Sacramento and American river juvenile Steelhead. Steelhead successfully undergo the smolt transformation at water temperatures between 43.7°F to 52.3°F (Myrick and Cech 2001).

Adult Steelhead immigration into Central Valley streams typically begins in August, continues into March or April (McEwan 2001; NMFS 2014), and generally peaks during January and February (Moyle 2002), but adult Steelhead immigration can potentially occur during all months of the year (NMFS 2009). Steelhead spawning generally occurs from December through April, with peaks from January through March, in small streams and tributaries (NMFS 2009).

Eggs usually hatch within 4 weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another 4 to 6 weeks (CDFG 1996). After fry emerge, they inhabit shallow areas along the stream margin and prefer areas with cobble substrates, then use a greater variety of habitats as they grow and develop (CDFG 1996). Habitat use is affected by the presence of predators and juvenile Steelhead survival increases when cover, such as wood debris and large cobble, is available (Mitro and Zale 2002). The preferred range of water depths for spawning Steelhead has been observed most frequently between 0.3 and 4.9 feet (Moyle 2002). The reported preferred water velocity for Steelhead spawning is 1.5 to 2.0 feet per second (USFWS 1995).

Juvenile Central Valley Steelhead typically migrate to the ocean after spending 1 to 3 years in freshwater (CDFG 1996). Steelhead fry and fingerlings rear and migrate downstream in the Sacramento River during most months of the year, but the peak period of emigration is January to June (Hallock et al. 1961; McEwan 2001). Based on CDFW sampling at Knights Landing, juvenile Steelhead emigration occurs primarily from January through April, with peaks during January and February (NMFS analysis of 1998-2011 CDFW data.). Because of their varied freshwater residence times Steelhead fry and fingerlings can be rearing and migrating in the Sacramento River year-round (McEwan 2001).

2.6.3 Historical and Current Distribution and Abundance

Historically, Central Valley steelhead were distributed from the upper Sacramento and Pit river systems (upper Sacramento, McCloud, Pit and Fall rivers) south to the Kings River (and possibly Kern river systems in wet years) and in both east- and west- side tributaries of the Sacramento River and east-side tributaries of the San Joaquin River (McEwan 2001). Presently, Central Valley Steelhead are found in the Sacramento River downstream of Keswick Dam and in the major tributary rivers and creeks in the Sacramento River watershed. Zimmerman et al. (2009) found Steelhead present in three tributaries to the San Joaquin River (Stanislaus, Tuolumne, and Merced rivers) as well as in the Calaveras Rivers, and a

hatchery supported Steelhead population occurs in the the Mokelumne River. The populations in the Feather and American Rivers are supported primarily by the Feather and Nimbus hatcheries. Other major Steelhead populations in the Sacramento River watershed are found in Battle, Mill, Deer, Clear and Butte Creeks. Steelhead also occur in many tributaries to the Sacramento River including Stony and Thomes Creeks (McEwan 2001), as well as intermittent streams in the Redding area.

In the 1950s, Central Valley Steelhead populations numbered approximately 40,000 fish, while during the mid-1960s, the Steelhead population was estimated at 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). McEwan and Jackson (1996) estimated the annual run size for Central Valley Steelhead to be less than 10,000 fish by the early 1990s. Since 2015, Steelhead population estimates continue to demonstrate significant variation as reflected by the hatchery returns for Feather River Hatchery (Figure 2.6-1), Nimbus Hatchery (Figure 2.6-2), Mokelumne River Hatchery (Figure 2.6-3), and CNFH (Figure 2.6-4). Steelhead returns have been lower than average ($n = 1,480$) on the American River during recent years with a return of 756 in 2016, 1,032 in 2017, and 513 in 2018. Furthermore, Steelhead redd counts on the American River have been lower than average ($n = 122$) with 53 redds counted in 2015, 10 in 2017, and 63 counted in 2018 (Figure 2.6-5).

Monitoring efforts throughout the Central Valley inform Central Valley Steelhead abundance and distribution. During WY 2018, Steelhead catches in the Sacramento River drainage totaled: 5 at Tisdale weir; 3 at Knights Landing; none in the Sacramento beach seines; 4 in the Sacramento trawls; 12 in the Chipps Island trawls; 9,298 at Red Bluff Diversion Dam (Figure 2.6-6). In the San Joaquin River drainage, steelhead catches totaled: 11 adults (6 with adipose fin clips) at the Stanislaus weir; no juveniles at the Caswell rotary screw trap (RST); no adults at the Tuolumne weir (juvenile catch at the Tuolumne RST was not reported); and 8 smolts in the Mossdale trawls (USFWS 2018a; Stanislaus Operations Group 2018; Turlock Irrigation District and Modesto Irrigation District 2018). During WY 2017, Steelhead catches in the Sacramento River drainage totaled: 3 at Tisdale weir; 10 at Knights Landing; none in the Sacramento beach seines; 13 in the Sacramento trawls; 16 in the Chipps Island trawls; and 22,961 at Red Bluff Diversion Dam (Figure 2.6-7). In the San Joaquin River drainage, steelhead catches totaled: 26 adults (14 with adipose fin clips) at the Stanislaus weir; one adult at the Tuolumne weir; none at the Tuolumne RST (juvenile catch at the Stanislaus RST was not reported); and none in the Mossdale trawls (USFWS 2018a; Stanislaus Operations Group 2017; Turlock Irrigation District and Modesto Irrigation District 2017). During WY 2017, 65 wild juvenile and 43 hatchery Steelhead were observed at the Delta fish facilities, and 1,118 wild juvenile and 732 hatchery Steelhead were observed during WY 2018 (Figures 2.6-8 and 2.6-9). Steelhead have not been observed in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2012.

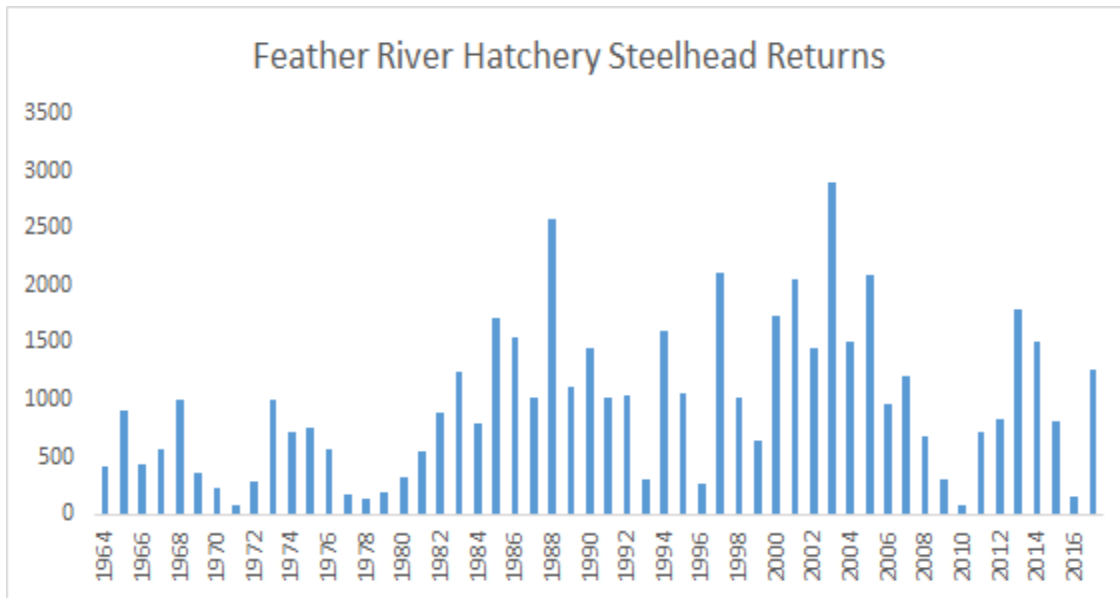


Figure 2.6-1. Steelhead Returns to the Feather River Hatchery, 1956–2017

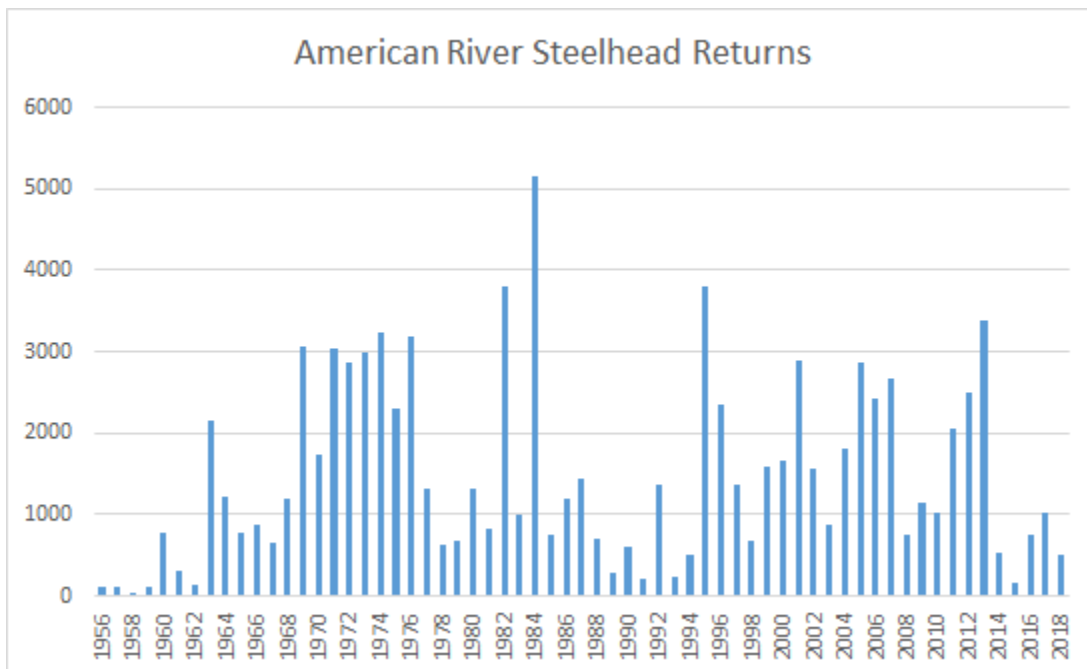


Figure 2.6-2. Steelhead Returns to the Nimbus Hatchery, 1956–2018

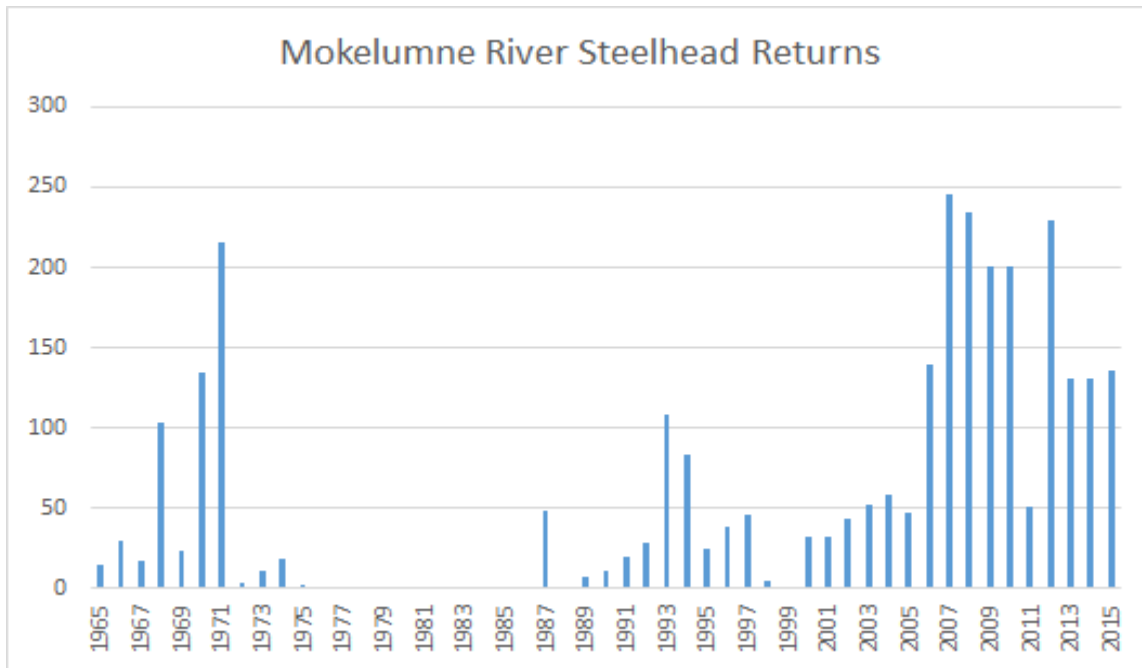


Figure 2.6-3. Steelhead Returns to the Mokelumne River, 1965–2015

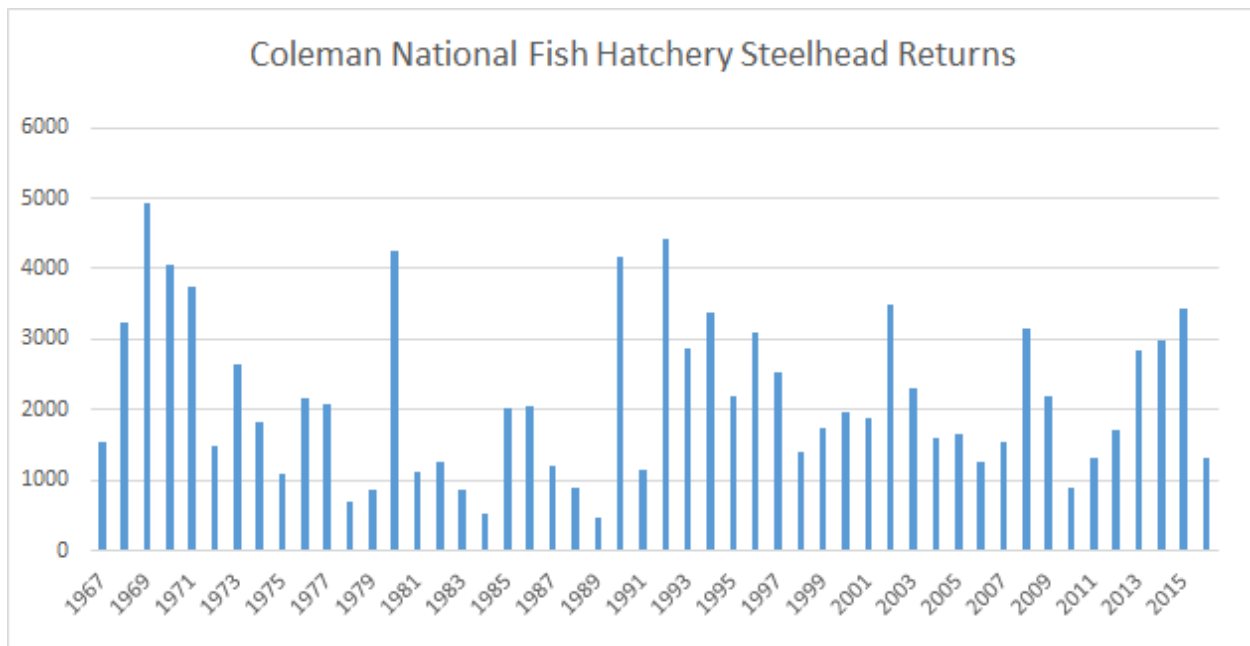


Figure 2.6-4. Steelhead Returns to Coleman National Fish Hatchery, 1967–2016

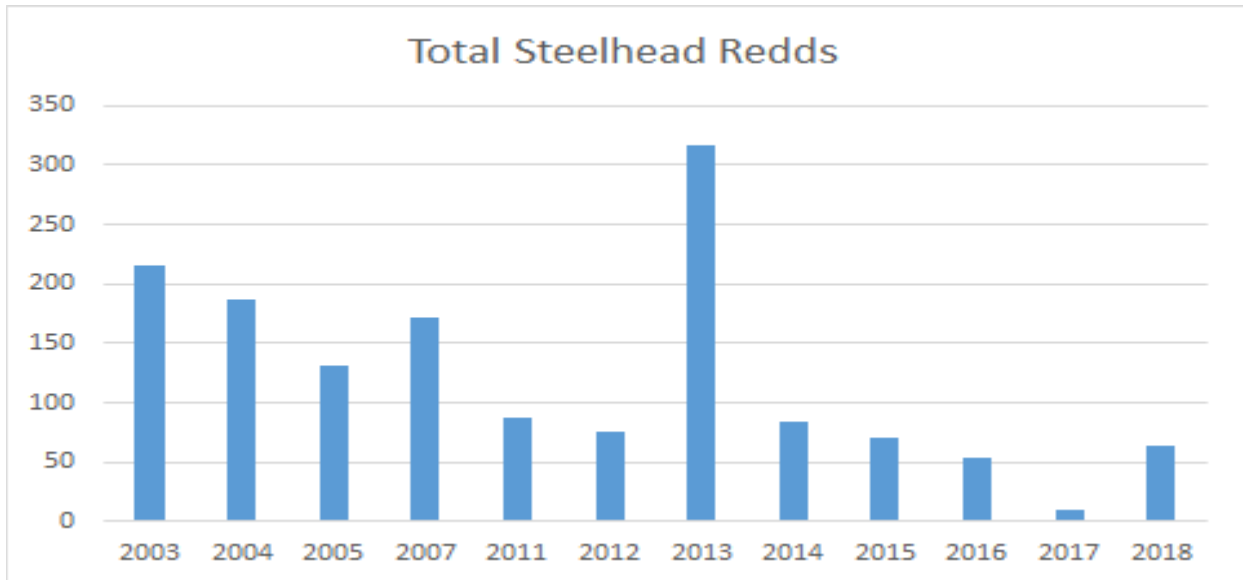


Figure 2.6-5. Total Steelhead Redds on the American River, 2003–2005, 2007, 2011–2018

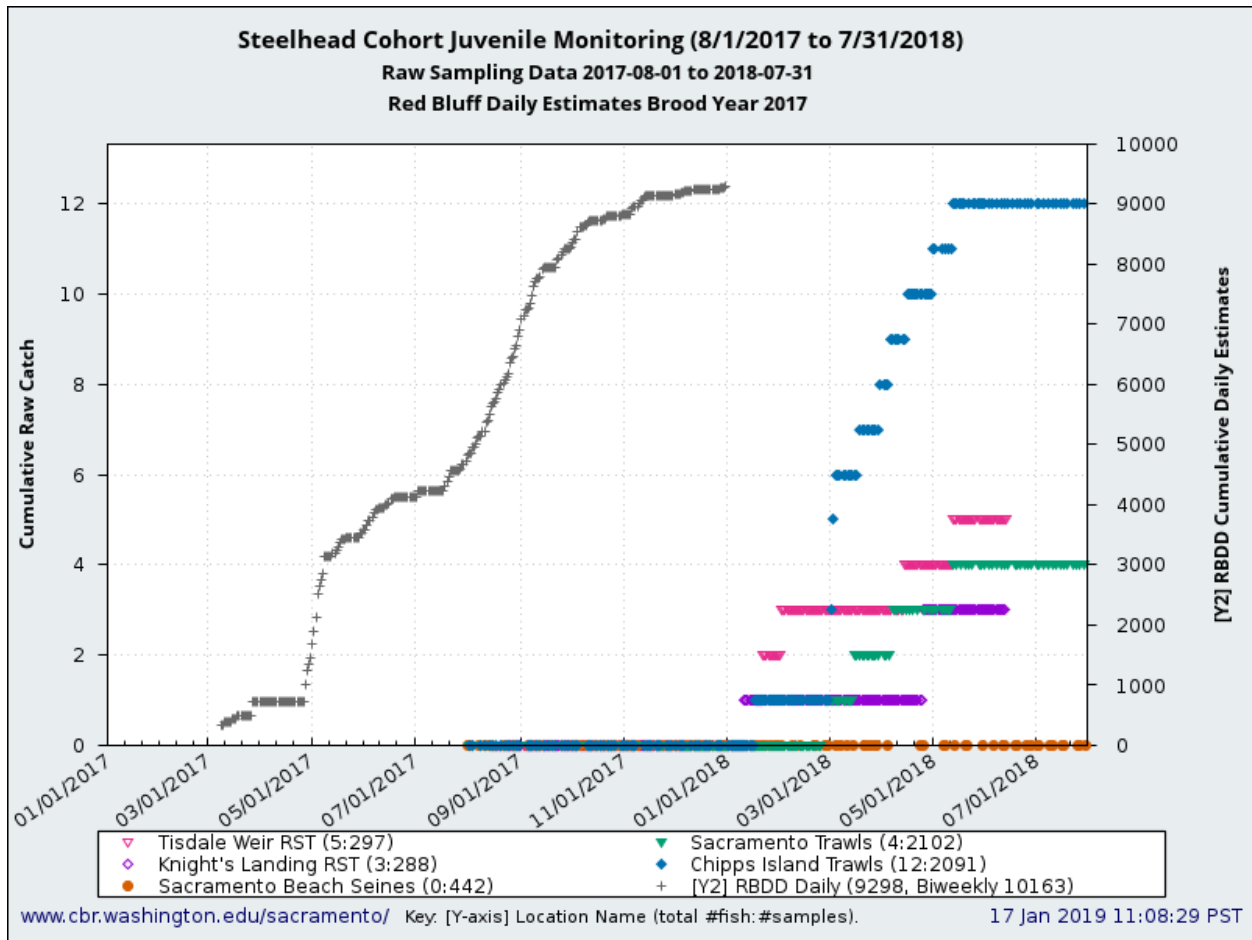


Figure 2.6-6. Juvenile Central Valley Steelhead Monitoring at Tisdale, Knights Landing, Sacramento Beach Seines, Sacramento Trawl, Chipps Island Trawl, and Red Bluff Diversion Dam for WY 2018

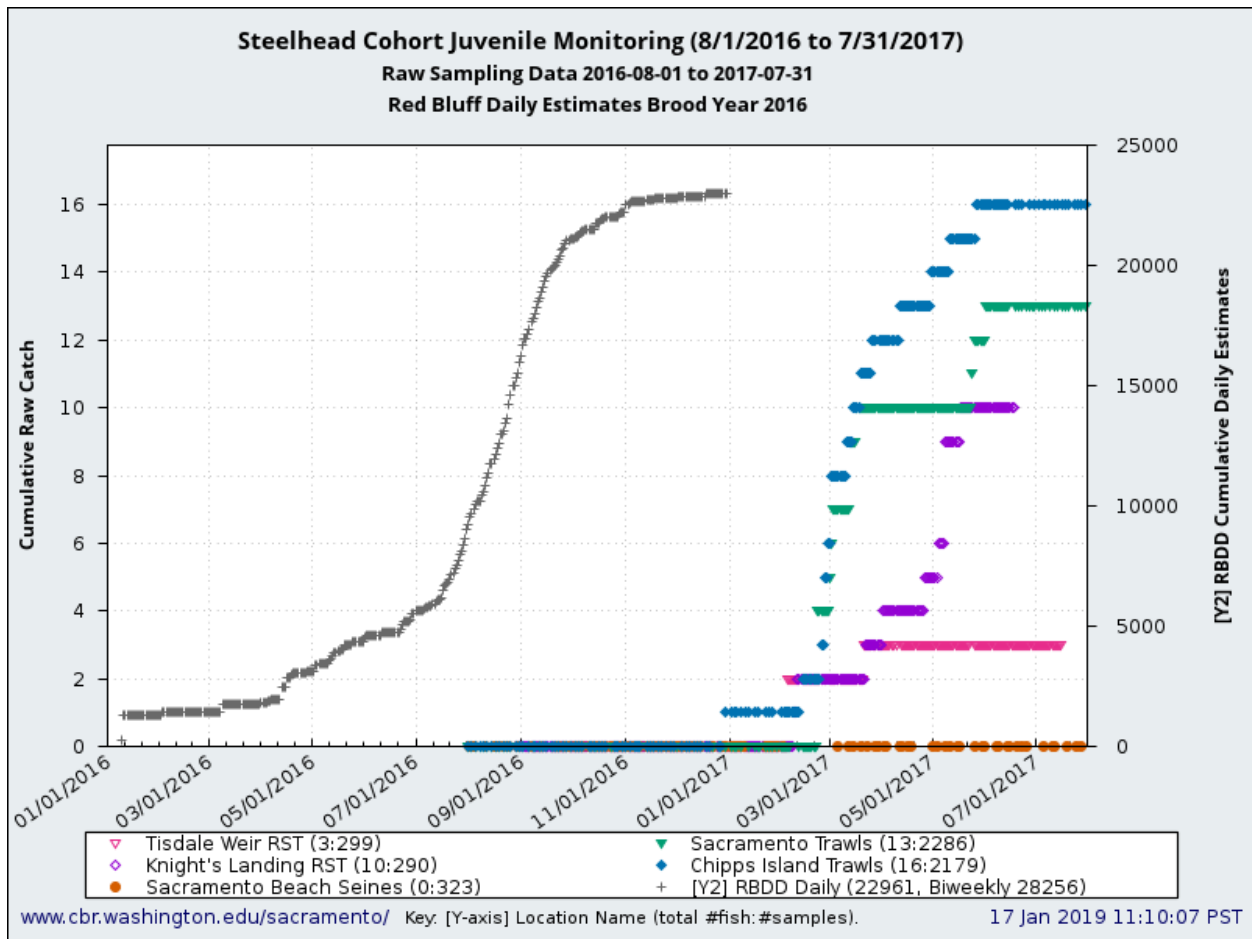


Figure 2.6-7. Juvenile Central Valley Steelhead Monitoring at Tisdale, Knights Landing, Sacramento Beach Seines, Sacramento Trawl, Chipps Island Trawl, and Red Bluff Diversion Dam for WY 2017

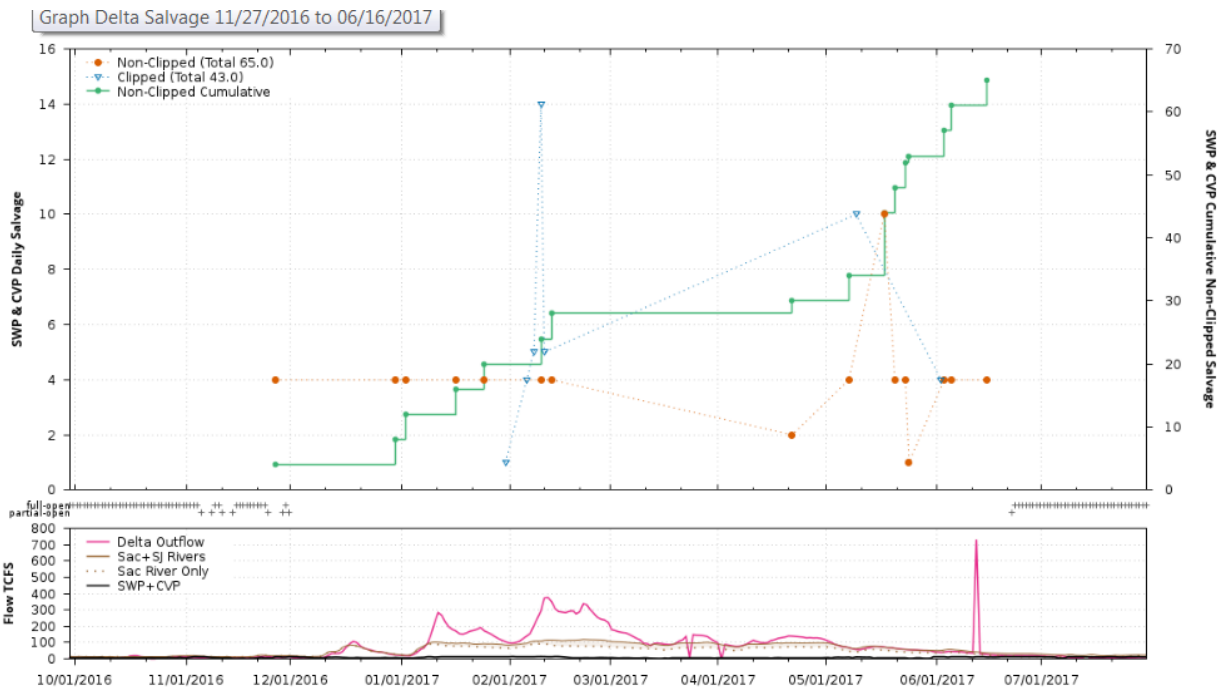
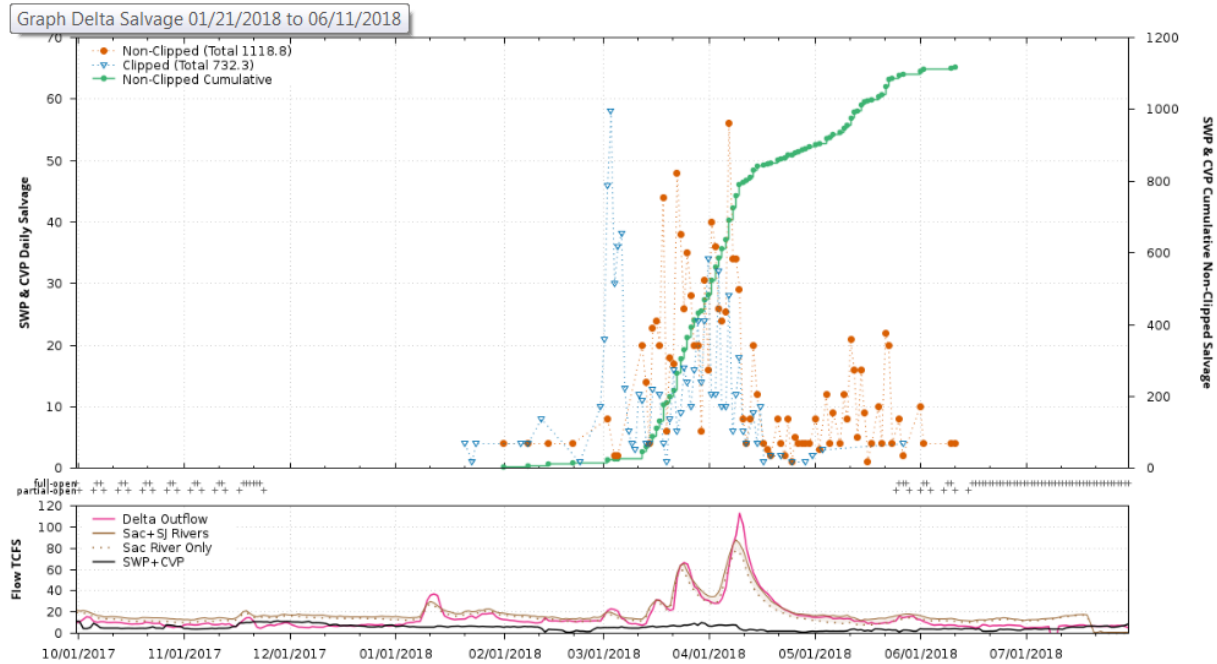


Figure 2.6-8. Central Valley Steelhead Salvage at the Delta Fish Facilities during WY 2017



7 preliminary data from CDEC, CDFW, CDRW, and BOR; subject to revision.
www.cdr.washington.edu/sacramento/

17 Jan 2019 11:02:28 PST

Figure 2.6-9. Central Valley Steelhead Salvage at the Delta fish facilities during WY 2018

2.6.4 Limiting Factors, Threats, and Stressors

As with the other salmonid species described above and further discussed in Section 3.1, high water temperatures in remaining rearing areas, effects from hatcheries and the rearing of out of basin stocks, limited quantity and quality of rearing habitat, ocean conditions, and predation and entrainment into diversions at the CVP and SWP pumping facilities all affect the species. Degradation of the remaining accessible habitat through reducing flow variability, blocking coarse sediment recruitment, operation of outdated fish screens, ladders and diversion dams, simplified habitat due to levee construction and maintenance and disconnection of off-channel habitat, water delivery and hydroelectric operation on both the Sacramento and Feather Rivers affect natural flow regimes.

Future increasing temperatures and altered precipitation patterns due to climate change will also pose stressors on Central Valley Steelhead. These factors are the same for Steelhead as those described previously for Chinook Salmon.

Figure 2.6-10 below shows water year type average flows on the American River along with timing of the fish species in the American River.

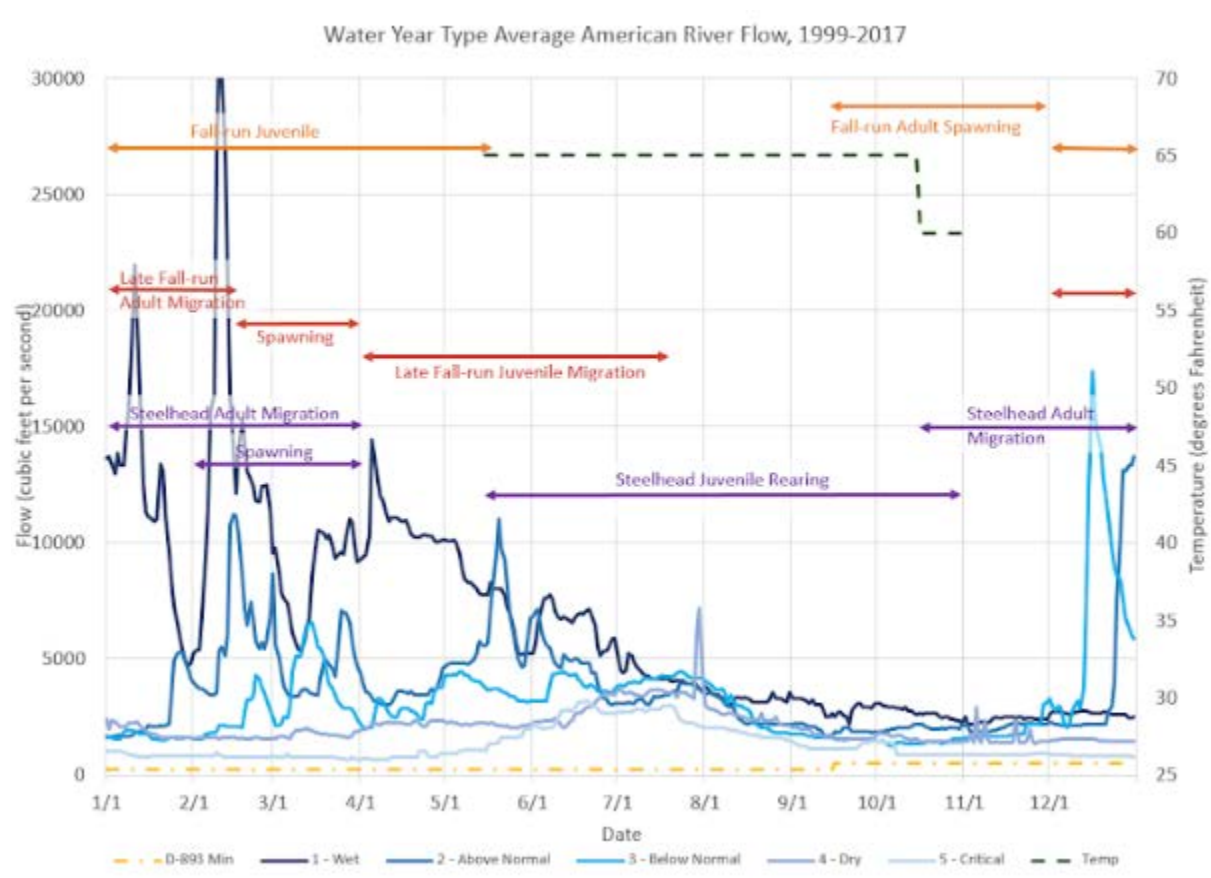


Figure 2.6-10. Water Year Type Average American River Flow, 1999–2017

2.6.5 Recovery and Management

As discussed above in Section 5.1.6, the NMFS 2014 Recovery Plan for Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and Central Valley Steelhead outlines actions to restore habitat, access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids. Many of the Recovery and Management Action for Winter-Run and Spring-Run Chinook Salmon also benefit Steelhead.

2.6.6 Water Operations Management

2.6.6.1 *Upper Sacramento River*

Water Operations Management for the upper Sacramento River for Central Valley Steelhead would be the same as those in Winter-Run Chinook species account.

2.6.6.2 *American River*

Reclamation operates Folsom Dam and Reservoir to provide water for irrigation, municipal and industrial uses, hydroelectric power, recreation, water quality, flood control, and fish protection. Reclamation operation under SWRCB Decision 893 (D-893) adopted in 1958 allows flows at the mouth of the American River to fall as low as 250 cfs from January through mid-September, with a minimum of 500 cfs required between September 15 and December 31. The D-893 decision does not address the requirements of the CVPIA, the 1995 Bay Delta Plan, or biological opinions issued to protect Central Valley Steelhead.

Reclamation's 2008 Biological Assessment proposed implementing the Water Forum Flow Management Standard. This flow schedule, developed by the Water Forum, Reclamation, USFWS, NMFS, and CDFW, addresses minimum flows for Central Valley Steelhead and Fall-Run Chinook in the Lower American River.

Reclamation convenes the American River Group (ARG), comprised of representatives from Reclamation, NMFS, USFWS, CDFW and the Water Forum, to make recommendations for management within the constraints of the Flow Management Standard. Reclamation ensures that flow, water temperature, Steelhead spawning, and Steelhead rearing monitoring is conducted annually in order to help inform the ARG process and to evaluate take associated with flow fluctuations and warm water temperatures.

Flow releases from Folsom Reservoir are made for both flood control and to meet water quality objectives and demands in the Delta. This can result in rapid increases and decreases of flow during the winter and spring. Dewatering and isolation of Steelhead redds has been documented (Hannon *et al.* 2003, Water Forum 2005, Hannon and Deason 2008) as a result. In addition to flow fluctuations, low flows also can negatively affect lower American River Steelhead. At low flow levels, the availability of bar complexes and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover is limited.

Water temperatures in the lower American River are influenced by the timing, volume, and temperature of water releases from Folsom and Nimbus dams. Once released, river distance and environmental heat flux influences the water temperature further as it moves through the Lower American River (Bartholow 2000). The NMFS RPA Action II.2 requires suitable over summering temperatures for juvenile CV Steelhead in the Lower American River. In the RPA, Reclamation is to prepare a draft Operations

Forecast and Temperature Management Plan based on forecasted conditions and submit the draft Plan to NMFS for review by May 1 of each year. The information provided in the Operations Forecast will be used in the development of the Temperature Plan. Reclamation uses an iterative approach, varying proposed operations, with the objective to attain the temperature compliance point at Watt Avenue Bridge. Operation of Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam are used to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31.

2.6.6.3 Clear Creek

Pursuant to its 2002 water right and the 2000 Reclamation / USFWS / DFW agreement, Reclamation provides 50 cfs flow in Clear Creek year-round in all years, increasing to 70 cfs in November and December of critical years and increasing to 100 cfs in November and December of normal years.

In addition to these flows, Reclamation makes releases as part of the CVPIA b(2) program. Reclamation's operations follow the CVPIA AFRP guidelines (USFWS 2001) which, for Clear Creek, are 200 cfs October 1 to June 1 from Whiskeytown dam for Spring-Run, Fall-Run, and Late Fall-Run salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; and [to] release 150 cfs or less, from July through September to maintain less than 60°F temperatures in stream sections utilized by Spring-Run Chinook Salmon. As Reclamation operates for water temperature in Clear Creek, the less water available for the transbasin diversion, the greater potential impact to Clear Creek temperatures as adequate temperatures in Clear Creek are dependent to a large degree on the volume of water moving through Lewiston and Whiskeytown reservoirs.

2.6.6.4 Stanislaus River

Reclamation operates the Stanislaus River separately from the other Central Valley Project reservoirs. While releases from New Melones Reservoir provide inflow to the Delta, Reclamation does not operate New Melones for Delta salinity, outflow, or export requirements. Reclamation operates New Melones Reservoir to meet the instream flow objectives set in Appendix 2-E (2-E) of the 2009 NMFS Biological Opinion, dissolved oxygen standards as measured at Ripon, salinity objectives at Vernalis (as set in SWRBC D-1641) and Vernalis flow objectives as set in D-1641, as appropriate, and updated in the 2009 NMFS Biological Opinion.

Prior to publication of 2-E, instream releases on the Stanislaus river were set pursuant to the 1987 CDFG agreement. This agreement was intended to last 10 years while a specific set of fishery studies was completed to help inform the decision on what instream flows would be most beneficial. While studies have been completed, the agreement has never been updated. Each year Reclamation determines the annual volume of water available to be used for fishery releases and transmits that volume to CDFW, who is then responsible for determining a requested release pattern. Since the initiation of this agreement, CDFW has routinely requested a 0 cfs release during the summer months. Reclamation has a separate obligation to meet dissolved oxygen standards at Ripon during the summer months as required by Reclamation's water rights. CDFW has routinely assumed that Reclamation would release approximately 300 cfs to meet the dissolved oxygen standards. This allowed CDFW to concentrate their fishery volume in other months. However, this was not the intent of the agreement and had the effect of stressing the reservoir resources, particularly in dry years. Since the 2009 biological opinion, the 2-E flows have generally been greater than those requested by CDFW. However, in some years or months, such as December 2018, the requested CDFW releases are higher than the 2-E releases, reducing storage and impacting other authorized purposes of the reservoir and storage for subsequent years.

2.6.7 Monitoring and Research Programs

The Central Valley Steelhead Monitoring Program (CVSMP), a pilot study, began implementing monitoring projects on the Sacramento River and select tributaries to help identify Central Valley Steelhead populations. The CVSMP projects include (1) Mainstem Sacramento River Mark-Recapture; (2) Upper Sacramento River Tributary Escapement Monitoring; (3) Sacramento River Tributary Mark-Recapture Monitoring; and (4) Hatchery Broodstock and Angler Harvest Sampling. These projects began July 2015 under contract with Pacific States Marine Fisheries Commission (PSMFC). The objective of the CVSMP pilot study was to evaluate the efficacy and success of these monitoring projects in order to expand these techniques throughout the Sacramento and San Joaquin watersheds.

Reclamation performed a 6-year Steelhead telemetry study on the Stanislaus River and currently working to continue an acoustic tagging study on the San Joaquin River to determine entrainment of SJR origin Steelhead into 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 is 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 trout.

2.7 Steelhead, Central Valley Critical Habitat

Critical habitat for the Central Valley Steelhead DPS was designated in 2005 and includes all river reaches accessible to Steelhead in the Sacramento and San Joaquin rivers and their tributaries, the Delta, and the Yolo Bypass (70 FR 52488). A 2016 status review found that the DPS continues to be at a high risk of extinction (NMFS 2016c). In the Sacramento and San Joaquin Rivers and tributaries, critical habitat includes the river water column, river bottom, and adjacent riparian zone and including the water column and essential foraging habitat and food resources west of Chipps Island including San Francisco Bay to the Golden Gate Bridge.

Critical habitat consists of PBFs considered essential for the conservation of a species. PBFs outlined in the designation of critical habitat (70 FR 52488) are:

1. Unimpeded access from the Pacific Ocean to appropriate spawning areas in the Sacramento and San Joaquin River and their tributaries
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 prey free of contaminants
6. Riparian habitat that provides for successful juvenile development and survival
7. Unimpeded passage of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean

2.8 Steelhead, Central California Coast DPS

2.8.1 ESA Listing

The Central California Coast (CCC) Steelhead DPS was listed as threatened under the ESA on January 5, 2006 (71 FR 834). The CCC Steelhead DPS includes all naturally spawned Steelhead populations below natural and human-made impassable barriers in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco, San Pablo, and Suisun bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. Tributary streams to Suisun Marsh include Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough, excluding the Sacramento-San Joaquin River Basin, as well as two artificial propagation programs (NMFS 2009).

2.8.2 General Life-History and Habitat Requirements

Steelhead return to their natal streams to spawn typically as 2- to 4-year-old adults. Adults generally migrate upstream from November through March to spawn, but may extend into April (NMFS 2011) (Table 2.8-1). Spawning occurs between January and April. Time of incubation and hatching varies with region, habitat, water temperature, and spawning season. CCC Steelhead incubation occurs between January and May. Alevins emerge from their redds following yolk sac absorption and are ready to feed as fry or juveniles. Following emergence, fry live in small schools in shallow water along streambanks. The diet of juvenile Steelhead includes emergent aquatic insects, aquatic insect larvae, snails, amphipods, opossum shrimp, and small fish (Moyle 2002). Steelhead usually do not eat when migrating upstream and often lose body weight. As Steelhead grow, they establish individual feeding territories; juveniles typically rear for 1 to 2 years (and up to 4 years) in streams before emigration as smolts (NMFS 1996). Steelhead may remain in the ocean from 1 to 4 years, growing rapidly as they feed in the highly productive currents along the continental shelf (Barnhart 1986).

Table 2.8-1. Timeline of Steelhead Life Stages

| Life Stage | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Spawning | • | • | • | • | | | | | | | | |
| Migration | • | • | • | • | | | | | | | • | • |
| Incubation | • | • | • | • | • | | | | | | | |
| Rearing | • | • | • | • | • | • | • | • | • | • | • | • |
| Source: NMFS 2011 | | | | | | | | | | | | |

2.8.3 Historical and Current Distribution and Abundance

Historically, approximately 70 populations of Steelhead existed in the CCC Steelhead DPS (Spence et al. 2008; Spence et al. 2012): 37 independent or potentially independent and 33 dependent. While historical and present data on abundance are limited, CCC Steelhead populations are substantially reduced from

historical levels. CDFG (1965) estimated a total of 94,000 adult Steelhead spawned in the rivers and streams of this DPS during the mid-1960s, including 50,000 fish in the Russian River—the largest population within the DPS. Near the end of the 20th Century, the Steelhead population in the Russian River was believed to have declined substantially and local CDFG biologists estimated the wild run population in the Russian River Watershed was between 1,700-7,000 fish (McEwan and Jackson 1996). Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with individual run size estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of approximately 500 fish or less (62 FR 43937). Some loss of genetic diversity has been documented and attributed to previous out-of-basin transfers of hatchery stock as well as local hatchery production (Bjorkstedt et al. 2005, Good et al. 2005). In particular, for streams that are tributary to San Francisco Bay, reduced population sizes and habitat fragmentation caused by intense urbanization and water resource development have also led to a loss of genetic diversity in these populations.

CCC Steelhead have experienced significant declines in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. Independent populations that historically provided enough Steelhead immigrants to support nearby dependent populations may no longer be able to do so, placing these dependent populations at increased risk of extirpation. However, because CCC Steelhead remain present in most streams throughout the DPS, roughly approximating the known historical range, CCC Steelhead may possess a resilience that is likely to slow their decline relative to other salmonid DPSs or ESUs in worse condition. Their iteroparous life history and variation in time spent in streams and the ocean have helped the Steelhead populations respond to different pressures on their population (Busby et al. 1996).

The 2005 status review concluded the CCC Steelhead DPS remains “likely to become endangered in the foreseeable future” (Good et al. 2005). In its most recent 5-year review of the DPS, NMFS determined that the DPS should remain listed as threatened (NMFS 2016; Williams et al. 2016).

2.8.4 Limiting Factors, Threats and Stressors

Limiting factors affecting Central Coast Steelhead include degradation of habitat through water quality, water quantity, wetland loss, timber harvest, agriculture including marijuana-related diversion dams, urbanization, and impaired passage; illegal harvest; predation; invasive species; drought and climate change; and the existing small population size.

In addition, the 2012-2015 drought has revealed that during low storage levels, Coyote Valley Dam is known to release highly turbid water for extended periods well after turbidity levels in reservoir inflows and unregulated tributaries have diminished (NMFS 2008a). Turbid flows result in degraded salmonid spawning and rearing habitat (Everest 1969), and may impair food availability for juvenile salmonids by reducing habitat diversity for benthic invertebrates and eliminating certain guilds of invertebrates from the food chain. Similarly, extended periods of warm, turbid, and reduced flow releases have been noted at dams in the San Francisco Bay Area during periods of low storage (Leicester and Smith 2014).

Freshwater poaching or unintentional take of CCC Steelhead may occur. Where current abundance is below the “high risk” threshold (as described in Spence et al. 2008), losing adult fish to poaching could significantly impact population productivity and genetic diversity.

Many populations of CCC Steelhead have declined in abundance to levels that are well below low-risk abundance targets, and several are, if not already extirpated, likely below the high-risk depensation thresholds specified by Spence et al. (2008). Recently the largest donor population in the Russian River has declined, increasing the risk. As natural populations get smaller, stochastic processes may cause

alterations in genetics, breeding structure, and population dynamics. Even though recent data suggests some CCC Steelhead populations are doing better than others, all populations remain at severely depressed levels, suggesting stochastic processes continue to remain a high threat to the species (NMFS 2016).

2.8.5 Water Operations Management

Operations of the Suisun Marsh Salinity Control Gates and other infrastructure in Suisun Marsh could affect CCC Steelhead by blocking or allowing access to Suisun Creek, where a population of California Central Coast Steelhead exists.

2.8.6 Recovery and Management

Recovery actions for CCC Steelhead include over 7000 actions ranging from increasing the quality and extent of estuarine habitat to requesting that the SWRCB review and/or modify water use based on the needs of Steelhead and authorized diverters (NMFS Recovery Plan, October 2016).

2.8.7 Monitoring and Research Programs

Reclamation does not currently conduct research or monitoring on CCC Steelhead.

2.9 Steelhead, Central Valley California Coast Critical Habitat

CCC Steelhead critical habitat was designated September 2, 2005. Five watersheds with CCC Steelhead are in the San Francisco-San Pablo Suisun Bay estuarine complex which provides rearing and migratory habitat for this ESU.

2.10 North American Green Sturgeon, Southern DPS

2.10.1 ESA Listing Status

NMFS listed the southern DPS of North American Green Sturgeon as threatened in 2006 (71 FR 17757). In 2015, NMFS issued an updated status review in which the threatened status was confirmed (NMFS 2015). Green Sturgeon are known to spawn in the Sacramento and Klamath Rivers in California, and the Rogue River in Oregon (Moyle et al. 1992; Adams et al. 2002). Genetic analyses indicates that the Sacramento, Klamath, and Rogue Rivers support two distinct reproducing populations identified as southern and northern DPS Green Sturgeon (Israel et al. 2004). The threatened southern DPS is limited to a single reproducing population in the Sacramento River (71 FR 17757). The Northern DPS includes sturgeon from the Klamath and Rogue Rivers and is considered by NMFS a Species of Concern.

2.10.2 General Life-History and Habitat Requirements

Green Sturgeon are anadromous, with larval and juvenile life stages residing in natal rivers and subadult and adult life stages residing in estuarine and coastal marine waters before returning to freshwater to spawn. Green Sturgeon are long lived, reaching maturity at about age 15 and typically spawning every 3 to 4 years (NMFS 2015). Adult Green Sturgeon enter San Francisco Bay in late winter through early spring and migrate to spawning areas in the Sacramento River primarily from late February through April.

Spawning primarily occurs April through late July although late summer and early fall spawning may also occur based on the presence of larvae in the fall (Heublein et al. 2017). Elevated water flow appears to be an important cue in triggering migration and subsequent spawning of adult Green Sturgeon (Benson et al. 2007; Erickson and Webb 2007; Heublein et al. 2009). Spawning of Southern DPS Green Sturgeon primarily occurs in the mainstem Sacramento River although a spawning event was documented in 2011 in the lower Feather River at the Thermalito Afterbay Outlet (Seesholtz 2012).

Green Sturgeon spawn in deep pools in large, turbulent, freshwater river mainstems (Moyle et al. 2002). Green Sturgeon eggs are generally broadcast eggs over large gravel and cobble substrates where they adhere or settle into crevices (Van Eenennaam et al. 2001; Poytress et al. 2011). Substrates in spawning pools range from small to medium-sized sand to boulders and bedrock (Klimley et al. 2015a; Poytress et al. 2015; Wyman et al. 2018). Water temperature is an important factor for Green Sturgeon spawning and egg viability. Temperatures in the upper Sacramento River during the spawning period have ranged from 10.1°C to 17.6°C (Poytress et al. 2012). Wyman et al. (2017) studied the physical variables selected by adult Green Sturgeon during their spawning period using a two-dimensional model to integrate fish locations, physical habitat characteristics, discharge, bathymetry, and simulated velocity and depth. Results indicated that Green Sturgeon prefer spawning habitats with velocities between 1.0 and 1.1 meters per second, depths of 8 to 9 meters, and gravel and sand substrate (Wyman et al. 2017). After spawning, adults spend variable lengths of time in the river and estuaries before returning to the ocean (Heublein et al. 2017b). Outmigration may occur in late spring or summer (possibly in response to elevated flows) but most adults appear to remain in spawning and holding areas through the summer and leave in the fall (Benson et al. 2007; Heublein et al. 2009).

Development and survival of Green Sturgeon embryos is temperature dependent. Laboratory studies of Northern DPS Green Sturgeon indicate that eggs hatch after 144 to 192 hours when incubated at a temperature of $15.7 \pm 0.2^\circ\text{C}$ (Deng et al. 2002). Based on exposure of eggs to water temperatures ranging from 11°C to 26°C, Van Eenennaam et al. (2005) found that optimal water temperatures for development generally range from 14°C to 17°C. Water temperatures above 17°C resulted in increased rates of deformities and mortality risk, with total mortality occurring at temperatures of 23°C and above (Van Eenennaam et al. 2005).

After hatching, Green Sturgeon larvae possess limited swimming ability and generally seek refuge in low-velocity habitat, suggesting that complex habitat such as large cobble substrate is critical for this life stage (Kynard et al. 2005). Larvae transition from endogenous to exogenous feeding at approximately 15 days after hatching and initiate downstream migration at approximately 18 days (Gisbert et al. 2001, Poytress et al. 2011). Laboratory studies of nDPS Green Sturgeon indicate that optimal water temperatures for growth of larvae generally range from 17°C to 20°C when food is not limiting. Metamorphosis of Green Sturgeon larvae to juveniles occurs at approximately 45 days post-hatch at lengths of 62 to 94 mm (Deng et al. 2002).

Little is known about rearing, migratory behavior, and general emigration patterns of juvenile Southern DPS Green Sturgeon. Based on captures of juveniles in the Sacramento River near Red Bluff, it is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017a). The lack of juveniles less than 200 mm FL in Delta capture records further supports extended upriver rearing of juveniles before entering the estuary (CDFG 2002), as well as the lack of catch in the 20-mm survey reported in Dege and Brown (2004). Growth of juvenile nDPS Green Sturgeon is rapid as they move downstream, reaching up to 300 mm TL in the first year and more than 600 mm TL in years 2 and 3 (Nakamoto et al. 1995). Laboratory studies of nDPS Green Sturgeon indicate that optimal bioenergetic performance (growth, metabolic rate, temperature preference, and swimming

performance) occurs at 15°C to 19°C (Mayfield and Cech 2004). Estuarine residence appears to be variable with some entering the ocean in their first year and others remaining in the Delta for 2 to 3 years (Heublein et al. 2017a).

After Green Sturgeon enter the ocean, they appear to make northerly migrations within nearshore waters along the west coast and congregate in non-natal coastal bays and estuaries during the late summer and early fall (Lindley et al. 2008; 2011; Huff et al, 2012).

Feeding data recorded for adult Green Sturgeon indicate that they consume benthic invertebrates such as shrimp, mollusks, amphipods, and small fish (Moyle et al. 1992).

2.10.3 Historical and Current Distribution and Abundance

North American Green Sturgeon are long-lived, wide ranging, and the most marine-oriented species of the sturgeon family. Green Sturgeon spend the majority of their lives in coastal waters between northern Baja California and the Aleutian Islands, Alaska (Moyle et al. 1992). They are known to spawn in the Sacramento and Klamath Rivers in California, and the Rogue River in Oregon (Moyle et al. 1992; Adams et al. 2002). The actual historical and current spawning distribution is unclear because Green Sturgeon make non-spawning movements into coastal lagoons and bays, and because their original spawning distribution may have been reduced because of migration barriers, flow regulation, and other anthropogenic effects (Mora et al. 2009). Based on surveys of sites where adult Green Sturgeon aggregate in the upper Sacramento River in 2010-2015, the total number of adults in the Southern DPS was estimated to be $2,106 \pm 1,246-2,966$ (Mora 2018).

Based on data from acoustic tags, adult Green Sturgeon currently migrate upstream as far as the mouth of Cow Creek near Bend Bridge on the Sacramento River (NMFS 2009). Spawning occurs from Hamilton City (rkm 332.5) to Cow Creek (rkm 451) based on adult distribution (Heublein et al. 2009; Klimley et al. 2015a; Mora et al. 2018). Egg mat sampling confirmed spawning between Hamilton City and Inks Creek (rkm 426) (Poytress et al. 2015). Green Sturgeon spawning also has been documented in the Feather (Seesholtz et al. 2015) and Yuba Rivers (Beccio 2018). Records of Green Sturgeon in the San Joaquin River and its tributaries are rare and limited to information from angler report cards. However, Anderson et al. (2018) recently confirmed an adult Green Sturgeon holding in a deep pool near Knights Ferry in the Stanislaus River.

Based on records of spawning distribution and captures of larval Green Sturgeon, the distribution of larvae is estimated to extend at least 100 km downstream from spawning habitats on the Sacramento and Feather rivers in high flow years (NMFS 2018). Captures of larvae in traps at the Red Bluff Diversion Dam during 2003-2012 (27.3 mm average median TL) occurred primarily from May through August, with peak counts typically occurring in June and July, while captures of juveniles occurred sporadically from August through November (Poytress et al. 2014). Current information indicates that juvenile Green Sturgeon rear for up to 3 years in the Sacramento River, Delta, and San Francisco Bay before entering the ocean, but there is little information on residence times, movements, and emigration patterns of juveniles following metamorphosis in the Sacramento River. The lack of juveniles less than 200 mm FL in Delta capture records suggests extended upriver rearing of juveniles before entering the estuary (CDFG 2002).

2.10.4 Limiting Factors, Threats, and Stressors

The principal factor in the decline of the Southern DPS of Green Sturgeon is the reduction in historical spawning habitat (NMFS 2015). The population also is threatened by elevated water temperatures in

spawning areas, entrainment and stranding in water and flood diversions, indirect effects of invasive species, potential poaching, and exposure to contaminants (NMFS 2015).

Fish passage barriers such as dams, weirs, and other flood control structures block or impede Green Sturgeon migration. Adams et al. (2007) hypothesized that significant amounts of historically-utilized Green Sturgeon spawning habitat may be blocked by Shasta Dam and Oroville Dam on the Feather River. According to habitat and observance monitoring and statistics by Mora et al (2009), Shasta Dam and reservoir blocks access to reaches of the Pit, McCloud and Little Shasta rivers that contain apparently suitable habitat for Green Sturgeon. Similarly, Oroville Dam and reservoir block some areas of suitable habitat on the middle fork of the Feather River, and Daguerre Point Dam blocks some habitat on the Yuba River (Mora et al. 2009). Other potential migration barriers include the Sacramento Deep Water Channel Locks, Fremont Weir, Sutter Bypass, the DCC in the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River.

Quality of the remaining spawning habitat is also of concern in terms of water flow and temperature in the Sacramento, Yuba, and Feather Rivers. Comparative analyses of historic and contemporary hydrologic and thermal regimes indicate that habitats in all of these rivers are different than they were before dam construction (NMFS 2015).

Flood bypass systems along the Sacramento River pose a challenge to Southern DPS Green Sturgeon during spawning migrations. Green Sturgeon are particularly affected at the Yolo and Sutter Bypasses and by Tisdale and Fremont Weirs (Thomas et al. 2013). Reclamation and DWR are working on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project which will improve Sturgeon passage at the Yolo Bypass and Fremont Weir. Green Sturgeon mature late, live long, and do not reproduce every year, which makes the population susceptible to loss of even a small number of reproductive females. In long-lived species with delayed reproductive maturity, including Sturgeon, population growth rate is most sensitive to adult survival (Heppell 2007). Therefore, stranding of even a few reproductive individuals at flood control structures could have a large impact on the population.

Population impacts also arise from bycatch in fisheries, poaching, and small population size. Climate change could result in elevated water temperatures that would be detrimental to the reproductive success of the Green Sturgeon population if water temperatures in remaining spawning areas became elevated above that suitable for egg incubation and hatching success.

2.10.5 Water Operations Management

Reclamation does not currently manage for Green Sturgeon. However, many operational changes made for Chinook Salmon or Steelhead also benefit Green Sturgeon. Removal of the Red Bluff Diversion Dam in 2013 adds additional spawning habitat for Green Sturgeon in the upper Sacramento River.

2.10.6 Recovery and Management

Heublein et al. (2017) developed a conceptual model to support management and recovery of Sturgeon species in the San Francisco Estuary watershed. Additionally, NMFS issued a final recovery plan for the southern DPS of North American Green Sturgeon in 2018. Reduction of potential spawning habitat, severe threats to the single remaining spawning population coupled with the inability to alleviate these threats using current conservation measures, and the continued observance of declining numbers of juveniles collected in the past two decades threaten the species (NMFS 2015).

Fishing regulations and conservation measures represent a reduction in risk to Green Sturgeon. Recent implementation of Sturgeon fishing restrictions in Oregon and Washington and protective efforts put in place on the Klamath, Trinity, and Eel Rivers in the 1970s, 1980s, and 1990s may offer protection to the Southern DPS.

The retention of Green Sturgeon is prohibited along the west coast of North America. California also revised its regulations to provide additional protection for Green Sturgeon. Effective March 1, 2010, Sturgeon fishing was prohibited year-round in the mainstem Sacramento River from Highway 162 to Keswick Dam to protect spawning adults (NMFS 2015).

One of the most important conservation actions that has occurred in the last 10 years is the permanent removal of the gates of the Red Bluff Diversion Dam, where originally, the dam was closed year-round (NMFS 2015) and prevented Sturgeon passage. Further conservation efforts include floodplain and river restoration; riparian habitat protection; fish screening and passage projects; environmental water acquisitions; and contaminant studies conducted under the CVPIA, the Anadromous Fish Restoration Program, and the California Bay-Delta Program for the conservation of the southern DPS Green Sturgeon and other anadromous fishes.

Rescue of stranded individuals trapped behind weir structures can have a positive impact on this slow-reproducing species, but does not offer a viable long-term solution to maintaining the population. Thomas et al. (2013) present a modeling analysis indicating that rescue of the animals is important for population viability, but also note that fish passage improvement (rather than continued rescue) is a more appropriate long-term goal for mitigating this threat.

2.10.7 Monitoring and Research Programs

Research needs for Green Sturgeon in the Sacramento-San Joaquin Watershed are described in Klimley et al. (2015) and Heublein et al. (2017). Additionally, priority monitoring programs are described in the NMFS (*Acipenser medirostris*) (2018).

During July 2018, CDFW and University of California Davis began a 3-year monitoring study to investigate rearing and migratory behavior of Green Sturgeon in the lower Sacramento River (CDFW 2018). Results indicate that Green Sturgeon recruitment may be low during critically dry years.

Reclamation funds the USFWS to establish a Green Sturgeon monitoring program in the upper Sacramento River. Large numbers of larvae ($n=4,881$; greater than the long-average) and juveniles ($n=26$) were observed at the Red Bluff fish monitoring RSTs between May 28 and November 17, 2017. Eighty-five juveniles ranging in size from 72 to 322 mm mean = 176 mm) were collected in benthic trawl during 2017. Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic tags were implanted into 45 of these fish. All juveniles were sampled between downtown Red Bluff and below Woodson Bridge over an approximately 60 river kilometer reach. A strong correlation was observed between movement and flow events (i.e., discharge or turbidity). Approximately 83 percent of Sturgeon movement detected during 2017 occurred from November 15 to November 22, 2017 while flows were increasing (Poytress personal communication 2017).

Sampling tools that are less invasive are especially useful for monitoring ESA-listed species. Environmental DNA (eDNA) is a quick, inexpensive method that could be used to efficiently monitor distribution of fish. Green Sturgeon have been identified using eDNA techniques in the Sacramento River (Bergman et al. 2016).

Research on physiological processes are important for informing temperature ranges for survival and targeting future restoration sites. Poletto et al. (2018) studied the effects of temperature and food availability on the growth of larval Green Sturgeon. The study indicated that larval sturgeon that reared and the greatest temperature tests exhibited optimal condition when fed optimally; however, when food was restricted larval sturgeon condition was the poorest at the greatest temperature tested (Poletto et al. 2018). Sardella and Kultz (2014) assessed Green Sturgeon ability to tolerate salinity fluctuations. They found that Sturgeon can acclimate to changes in salinity; however, these salinity fluctuations result in cellular stress (Sardella and Kultz 2014).

2.11 Green Sturgeon Critical Habitat

On October 9, 2009, NMFS designated critical habitat for the southern DPS of North American Green Sturgeon. In the Central Valley, critical habitat for Green Sturgeon includes the Sacramento River downstream of Keswick Dam, the Feather River downstream of Fish Barrier Dam, the Yuba River downstream of Daguerre Point Dam, a portion of the lower American River, the Sutter and Yolo bypasses, the Sacramento–San Joaquin Delta, and the San Francisco Estuary (74 FR 52300). Critical habitat also includes marine waters (out to the 60-fathom depth bathymetry line, relative to Mean Low Low Water) and several coastal bays and estuaries extending from Monterey Bay, California northward to the Strait of Juan de Fuca, Washington (74 FR 52300).

NMFS has outlined specific PBFs essential for the conservation of the Southern DPS in freshwater riverine systems, estuarine areas, and coastal marine areas (74 FR 52300):

Freshwater riverine systems:

1. Food resources—Abundant prey items for larval, juvenile, subadult, and adult life stages.
2. Substrate type or size - 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 flow conditions), and subadults and adults (e.g., substrates for holding and spawning).
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 Southern DPS fish 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 (≥ 5 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 Southern DPS fish 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.

Nearshore coastal marine areas:

1. Migratory corridor—A migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats
2. Water quality—Nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (e.g., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult Green Sturgeon.
3. Food resources—Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes

2.12 Killer Whale, Southern Resident DPS

2.12.1 ESA Listing Status

The Southern Resident DPS of Killer Whales was listed as endangered under the Endangered Species Act on November 18, 2005 (70 FR 69903). Their range in the Northeastern Pacific Ocean overlaps with other whale populations classified as transient, resident, and offshore populations. The Southern Resident population consists of three pods designated J, K and L, each containing 22, 18 and 34 members, respectively (Center for Whale Research 2018). These pods generally spend late spring, summer and fall in inland waterways of Washington State and British Columbia. They are also known to travel as far south as central California and as far north as the Queen Charlotte Islands. Winter and early spring movements are largely unknown for this DPS.

On August 2, 2012, National Marine Fisheries Service (NMFS) received a petition to delist the Southern Resident Killer Whale DPS under ESA submitted by the Pacific Legal Foundation on behalf of the Center for Environmental Science Accuracy and Reliability, Empresas Del Bosque, and Coburn Ranch (Pacific Legal Foundation 2012). The petitioners claimed that there is no scientific basis for the designation of the unnamed North Pacific Resident subspecies of which the Southern Resident Killer Whales are a purported

DPS. Therefore, because NMFS is without authority to list a DPS of a subspecies, the listing of the Southern Resident Killer Whale DPS is illegal and NMFS should delist the DPS.

On November 27, 2012, NMFS indicated that the petition to delist the DPS was warranted and they would initiate a status review to determine whether delisting is warranted and to examine the application of the DPS policy (77 FR 70733).

On August 5, 2013, NMFS determined that the delisting of Southern Resident Killer Whale DPS was not warranted because, after a legal and scientific review, they found that there was no new information leading to a different conclusion from that reached in the 2005 rulemaking, and the weight of evidence continues to support their conclusion that the North Pacific Resident Killer Whales represent a taxonomic subspecies (78 FR 47277).

On April 25, 2014, NMFS accepted a petition from the Center for Biological Diversity to review the critical habitat designation for the Southern Resident Killer Whale DPS. The petition requested that NMFS revise the critical habitat designation to include inhabited Pacific Ocean marine waters along the West Coast of the United States that constitute essential foraging and wintering areas (79 FR 22933).

On February 23, 2015, National Oceanic and Atmospheric Administration (NOAA) Fisheries announced a 12-month finding on a petition to revise the Critical Habitat Designation for the Southern Resident Killer Whale DPS was warranted (80 FR 9682).

2.12.2 General Life-History and Habitat Requirements

Wild female Southern Resident Killer Whales give birth to their first surviving calf between the ages of 12 and 16 years (mean = about 14.9 years) (Olesiuk et al. 1990; Matkin et al. 2003). Females produce an average of 5.4 surviving calves during a reproductive life span lasting about 25 years (Olesiuk et al. 1990). Males become sexually mature at body lengths ranging from 5.2-6.4 meters, which corresponds to between the ages of 10 to 17.5 years (mean = about 15 years) (Christensen 1984; Perrin and Reilly 1984; Olesiuk et al. 1990), and are presumed to remain sexually active throughout their adult lives (Olesiuk et al. 1990).

Most mating of Southern Resident Killer Whales in the North Pacific is believed to occur from May to October (Olesiuk et al. 1990); however, conceptions apparently happen year-round because births of calves are reported in all months. The mean interval between viable calves is 4 years (Bain 1990). Mothers and offspring maintain highly stable social bonds throughout their lives and this natal relationship is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990; Baird and Whitehead 2000).

As the oceans' apex predator, Killer Whales feed on a great diversity of prey. More than 120 species of fishes, invertebrates, sea turtles, sea birds and marine mammals have been recorded in the species' diet (Ford and Ellis 2006). Most published information on Southern Resident Killer Whale prey originates from studies (Ford et al. 1998; Ford and Ellis 2005) in British Columbia, including southeastern Vancouver Island. These studies focused primarily on Northern Residents and included a relatively small number of observations for Southern Residents. Of the 487 records of apparent fish predation events from 1974 to 2004, only 68 (14 percent) observations came from Southern Residents. The study recorded surface observations from predation events and also analyzed the stomach contents from stranded Killer Whales. Southern Resident Killer Whales are known to consume 22 species of fish and one species of squid (Ford et al. 1998, 2000; Saulitis et al. 2000; Ford and Ellis 2005). In recent years, additional data have been collected on Southern Resident Killer Whales in parts of Puget Sound (Hanson et al. 2010). In

addition to collections of scales from observed predation events, fecal samples have also been collected for analysis.

Ford and Ellis (2005) found that salmon represent over 96 percent of the prey consumed during the spring, summer, and fall. Chinook Salmon were selected over other species, comprising over 70 percent of the identified salmonids taken. This preference occurred despite the much lower abundance of Chinook in the study area in comparison to other salmonids, and is probably related to the species' large size, high fat and energy content, and year-round occurrence in the area. Other salmonids eaten in smaller amounts include Chum (22 percent of the diet), pink (3 percent), Coho (2 percent), Sockeye (less than 1 percent), and Steelhead (less than 1 percent) (Ford and Ellis 2005). This work suggested an overall preference of these whales for Chinook during the summer and fall, but also revealed extensive feeding on Chum Salmon in the fall.

Ford et al. (2016) confirmed the importance of Chinook Salmon to Southern Residents in the summer months using DNA sequencing from whale feces. Ford et al. found that more than 90 percent of the whales' inferred diet consisted of salmonids; almost 80 percent was Chinook Salmon. Bellinger et al. (2015) estimated that Central Valley Chinook Salmon made up about 22 percent of the Chinook Salmon sampled off the Oregon coast and about 50 percent of those sampled off the California coast (south to Big Sur). While this apex predator certainly eats a variety of other species as well, Central Valley Chinook Salmon (all runs) can be estimated to make up approximately 40 percent of the Killer Whale diet when Killer Whales are off the California coast, and 18 percent of the Killer Whale diet when the Killer Whales are off the Oregon coast.

The Southern Resident population of Killer Whales is thought to move with the seasonal abundance of salmonids returning to natal rivers to spawn from early summer through fall. There are correlations between the occurrence of Southern Residents and commercial and sport salmon fishery catches in U.S. waters off southeastern Vancouver Island and in Puget Sound (Heimlich-Boran 1986). This population of Killer Whales is commonly found off southeastern Vancouver Island and in Puget Sound, Washington, from late spring to late fall (Ford 2006; Osborne 1999). The winter distribution of Southern Resident Killer Whales is poorly known. Several of the Southern Resident pods have been observed off the mouth of the Columbia River and in Monterey Bay, California, associated with local concentrations of Chinook Salmon (Wiles 2004; Balcomb 2006).

2.12.3 Historical and Current Distribution and Abundance

Southern Resident Killer Whales are found 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 the Queen Charlotte Islands, British Columbia (Figure 2.12-1). Southern Resident Killer Whales spend considerable time from late spring to early autumn in inland waterways of Washington and British Columbia, such as the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; table 4-10). Typically, J, K, and L Pods are increasingly present in May or June and spend considerable time in the core area of Georgia Basin and Puget Sound until at least September. During this time, the pods (particularly K and L) make frequent trips from inland waters to the outer coasts of Washington and southern Vancouver Island, which typically last a few days (Ford et al. 2000).

Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000). However, recent sightings of members of K and L Pods in Oregon and in California as far south as Monterey Bay, have considerably extended the southern limit of their known range (NMFS 2008b, 2014b, 2016). The historical abundance of Southern Residents was estimated based on genetic data to have ranged from 140 to 200 individuals

(Krahn et al. 2002; NMFS 2008). The population was depleted by live captures for aquarium programs during the 1960s and 1970s (Balcomb et al. 1982; Olesiuk et al. 1990). Following a steep decline of 20 percent between 1996 and 2001 (from 97 whales to 78) (Krahn et al. 2002, 2004), the population was listed as endangered in the United States and Canada. The population rebounded to 98 whales by 2005 and was 82 whales as of September 2013 (Center for Whale Research 2013). As of July 1, 2018, the total population of Southern Resident Killer Whales was 74, with J Pod having 22 individuals, K Pod having 18, and L Pod having 34, representing the lowest population in 34 years (Center for Whale Research 2018). Because the population is small and the probability of quasi-extinction is sufficiently likely, NMFS (2008) has determined that representation from all three pods is necessary to meet biological criteria for Southern Resident Killer Whale downlisting and recovery.

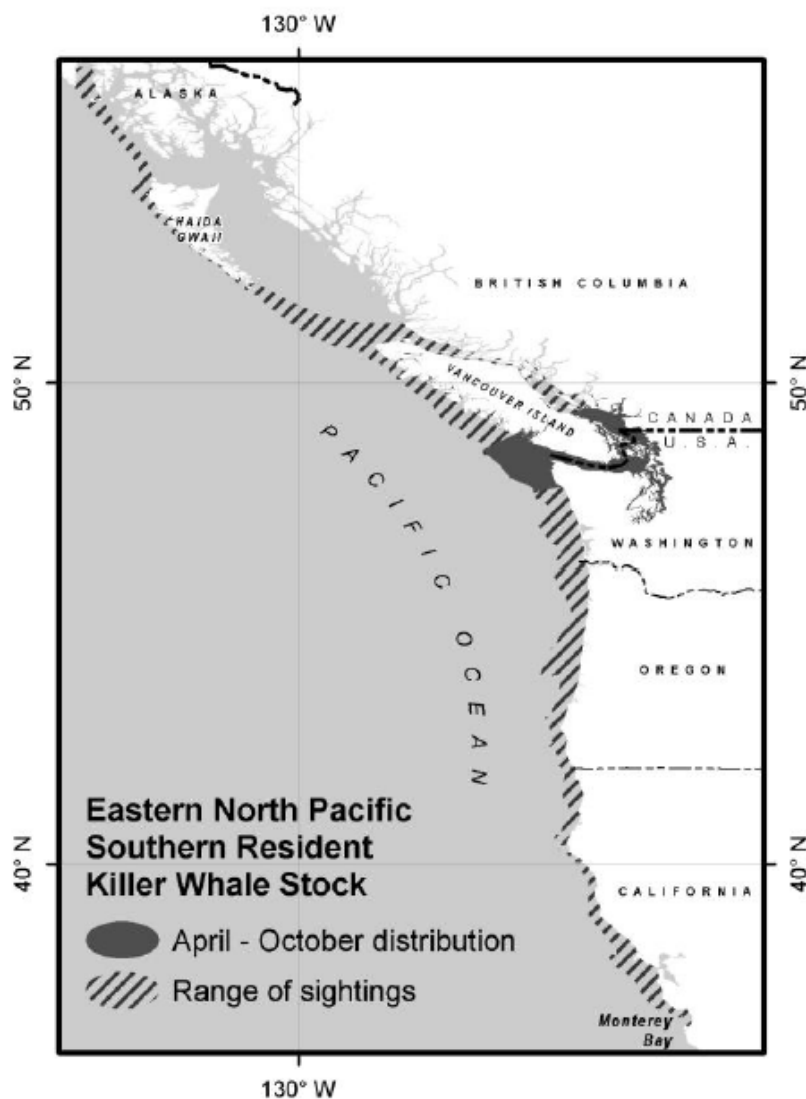


Figure 2.12-1. Southern Killer Whale Range off the Pacific West Coast

Most of the coastal sightings have occurred within 10 miles of shore (NMFS 2006), and there is no evidence that Southern Residents travel more than about 31 miles offshore (Ford et al. 2005). Although new evidence shows that Southern Residents range spans the coastal waters of Washington, Oregon, and

California during the winter months (Michael J. Ford, NMFS 2013). A tracking study found that Southern Residents traveled extensively between Cape Flattery, Washington, and Point Reyes, California, from December 2012 to March 2013. Whales during this period generally confined their offshore movements to the continental shelf and slope, ranging to a maximum distance of 76 km offshore (Michael J. Ford, NMFS). Southern Resident Killer Whales live in highly cohesive matrilineal groups consisting of older females and one or two generations of their offspring of both sexes (Bigg et al. 1990; Baird and Whitehead 2000). Matrilineal groups tend to associate consistently in pods that travel together most of the time. Pods that share a common range and frequently associate form a community, for example, the Southern Resident community (Bigg et al. 1990; Parsons et al. 2009). The Southern Resident Killer Whale community is considered a single population. Different Southern Resident pods frequently intermingle for brief periods, likely for socialization and breeding (Hauser et al. 2007).

Increased sightings in the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts. Most sightings along the outer coast from 1975 to the present have been in the period of January through April. Given that Southern Resident Killer Whales occur during winter months as far south as Monterey Bay and that Central Valley Chinook Salmon compose a large percentage of the Chinook Salmon available south of the Columbia River, it is reasonable to expect that the whales could be affected by a change in the availability of Central Valley Chinook Salmon (USBR 2016).

2.12.4 Limiting Factors, Threats, and Stressors

As discussed in the original listing notice (70 FR 69903), the three main human-caused factors that have affected the Southern Resident Killer Whale population and may continue to impede the recovery of this species are contaminants, vessel traffic, and reductions in prey availability. Reductions in prey availability are caused by a large number of factors, including entrainment, predators, and climate change.

Exposure to contaminants may result in harm to the species. The presence of high levels of persistent organic pollutants, such as polychlorinated biphenyls (PCBs) and DDT, have been documented in Southern Resident Killer Whales (Ross et al. 2000; Ylitalo et al. 2001; and Herman et al. 2005). Many organochlorines are highly fat soluble (lipophilic) and accumulate in the fatty tissues of animals (Ross et al. 2000.). Some are highly persistent in the environment and resistant to metabolic degradation. These and other chemical compounds have the ability to induce immune suppression, impair reproduction, and produce other adverse physiological effects, as observed in studies of other marine mammals. High levels of “newly emerging” contaminants that may have similar negative effects, such as flame retardants, have been documented in Killer Whales, and are also becoming more prevalent in the marine environment (Rayne et al. 2004). Although contaminants enter marine waters and sediments from numerous sources, these chemical compounds enter Killer Whales through their prey. Because of their long life span, position at the top of the food chain, and their blubber stores, Killer Whales are capable of accumulating high concentrations of contaminants (Ylitalo et al. 2001; Grant and Ross 2002).

Commercial shipping, whale watching, ferry operations, and recreational boat traffic have increased in recent decades. Several studies have linked vessels with short-term behavioral changes in Northern and Southern Resident Killer Whales (Kruse 1991; Williams et al. 2002; Foote et al. 2004). Although the potential impacts from vessels and the sounds they generate are poorly understood, these activities may affect foraging efficiency, communication, and/or energy expenditure through their physical presence, increased underwater sound level, or both. Collisions with vessels are another potential source of serious injury and mortality and have been recorded, although rarely, for both Southern and Northern Resident Killer Whales.

Healthy Killer Whale populations are dependent on adequate prey levels. Reductions in prey availability may force whales to spend more time foraging and might lead to reduced reproductive rates and higher mortality rates. The Southern Resident Killer Whale prey base is composed primarily of salmonids, particularly Chinook Salmon between late spring and early fall (Ford and Ellis 2005; Hanson et al. 2010). Salmon populations available as prey to Southern Resident Killer Whale have declined because of degradation in aquatic ecosystems from modern land use changes, harvest, and hatchery practices, and 27 ESUs of Salmon and Steelhead in Washington, Oregon, Idaho, and California have been listed as threatened or endangered under the ESA (NMFS 2008). Reductions in prey availability may increase the amount of time whales must spend foraging, reduce reproductive output, and lead to higher mortality.

Chinook Salmon stocks that are important to Southern Resident Killer Whales have been identified by NOAA Fisheries and Washington Department of Fish and Wildlife. A framework was developed by including three factors that contribute to the identification of priority Chinook Salmon populations: (1) observed part of Southern Resident Killer Whale diet, (2) consumed during reduced body condition or diversified Southern Resident Killer Whale diet, and (3) degree of spatial and temporal overlap (NOAA/WDFW 2018). These three factors were evaluated and scored (zero to five) to develop the priority list of Chinook Salmon populations (see details in Chapter 5, Effects Analysis).

2.12.5 Water Operations Management

While neither the CVP nor SWP operate for Killer Whales, occasional modifications to operations are made for Fall-Run Chinook Salmon, the commercial fishery of importance as prey to Southern Resident Killer Whales in California. For example, when cold water pool considerations are minimal, Reclamation keeps Keswick Dam releases high in the fall to avoid dewatering the last Fall-Run Chinook Salmon redds.

2.12.6 Recovery and Management

The final *Recovery Plan for Southern Resident Killer Whales* (*Orcinus orca*) was issued in January 2008 (NMFS 2008). The ultimate goal of the recovery plan is to achieve the recovery of the Southern Resident Killer Whale DPS and its ecosystem to a level sufficient to warrant its removal from the Federal List of Endangered and Threatened Wildlife and Plants under the ESA. The intermediate goal is to reclassify the DPS from endangered to threatened. The recovery plan also provides a recovery program that includes a set of specific management, research, and monitoring actions intended to reduce threats and restore the population to long-term sustainability.

Because NMFS determined that the Southern Resident stock was below its optimum sustainable population, the DPS was designated as “depleted” under the Marine Mammal Protection Act (MMPA) in 2003 (68 FR 31980) and a Proposed Conservation Plan was announced in 2005 (70 FR 57565). The plan provides a strategy to conserve and restore Southern Resident Killer Whales so that they are no longer considered depleted under the MMPA.

The following conservation measures were included in the final recovery plan for the DPS’s ESA listing (NMFS 2008):

- Support salmon restoration efforts in the region including habitat, harvest, and hatchery management considerations and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base.
- Clean up existing contaminated sites, minimize continuing inputs of contaminants harmful to Killer Whales, and monitor emerging contaminants.

- Continue evaluating and improving guidelines for vessel activity near Southern Residents and evaluate the need for regulations or protected areas.
- Prevent oil spills and improve response preparation to minimize effects on Southern Residents and their habitat in the event of a spill.
- Continue agency coordination and use of existing MMPA mechanisms to minimize potential impacts from anthropogenic sound.
- Enhance public awareness, educate the public on actions they can participate in to conserve Killer Whales, and improve reporting of Southern Resident sightings and strandings.
- Improve responses to live and dead Killer Whales to implement rescues, conduct health assessments, and determine causes of death to learn more about threats and guide overall conservation efforts.
- Coordinate monitoring, research, enforcement, and complementary recovery planning with international, federal, and state partners.
- Conduct research to facilitate and enhance conservation efforts. Continue the annual census to monitor trends in the population, identify individual animals, and track demographic parameters

2.12.7 Monitoring and Research Programs

Many programs are conduct monitoring and research with Southern Resident Killer Whales. These are a few of the programs:

- NMFS—Northwest Fisheries Science Center—Marine Mammal Ecology Team conducts research to understand the factors that may limit this population including studies about their taxonomy, behavior, ecology, health, and human-caused impacts.
(https://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_monitoring_research.html)
- The Center for Whale Research has been collecting detailed demographic data on the Southern Resident Killer Whale population, recording all observed births and deaths and also conducted an aerial observation study (Center for Whale Research 2018)
- The National Marine Fisheries Service Southwest Fisheries Science Center and SR3: SeaLife Response, Rehabilitation and Research utilize photogrammetry to make quantitative measurements (particularly aerial photographs) of length, growth and body condition/nutritional status and to describe the abundance and structure of pods
(https://www.westcoast.fisheries.noaa.gov/stories/2018/25_09252018_give_whales_space.html)
- The University of Washington—Center for Conservation Biology conducts research by acquiring scat samples to extract and assay DNA stress, reproductive and nutritional hormones, as well as toxicants (<http://conservationbiology.uw.edu/research-programs/killer-whales/>)
- The National Fish and Wildlife Foundation - Killer Whale Research and Conservation Program supports projects to help study and protect Killer Whales in the wild
(<https://www.nfwf.org/killerwhales/Pages/home.aspx>)

2.13 Killer Whale Critical Habitat

Critical habitat for the Southern Resident DPS was designated under the Endangered Species Act on November 29, 2006 (71 FR 69054). The critical habitat designation encompasses the Summer Core Area in Haro Strait and the waters around the San Juan Islands, the Strait of Juan de Fuca and all of Puget Sound (Figure 2.13-1), but does not include any areas in California.

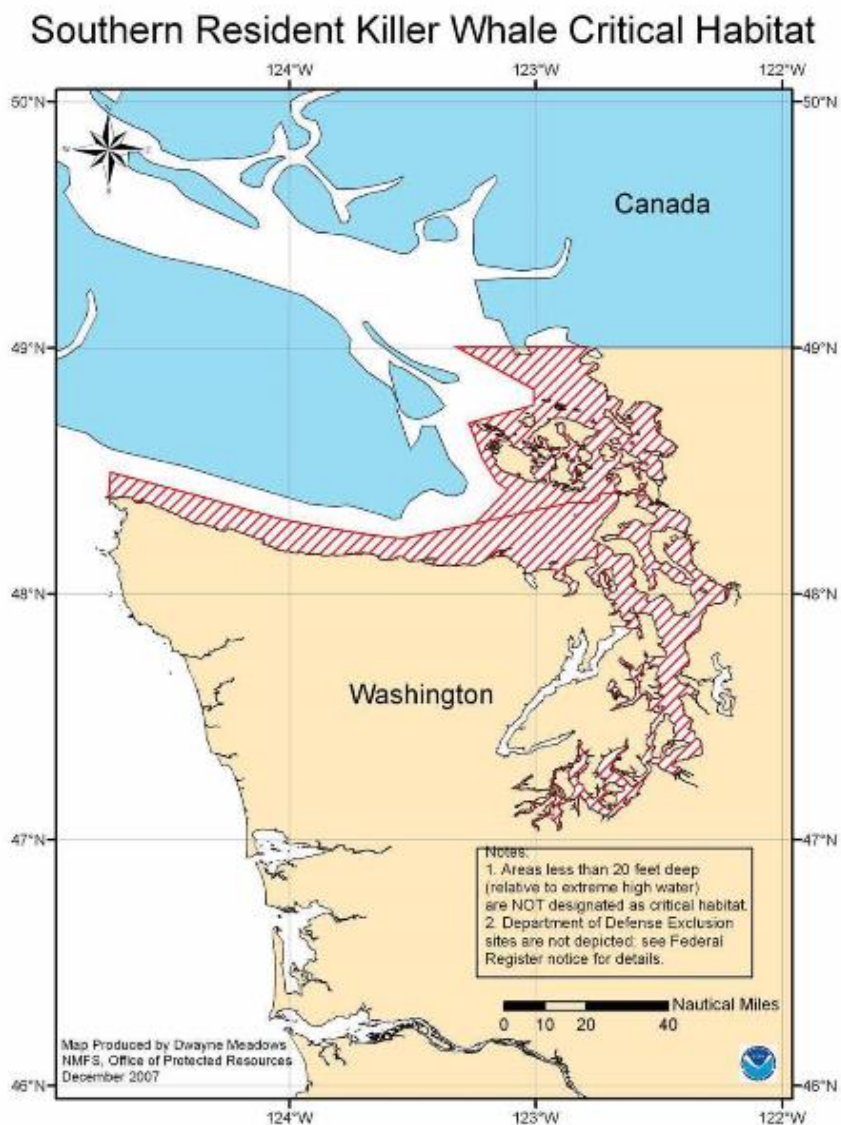


Figure 2.13-1. Southern Killer Whale Designated Critical Habitat

The critical habitat designation identified the following primary constituent elements considered essential for the conservation of the ESU.

1. Water quality to support growth and development;

2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
3. Passage conditions to allow for migration, resting, and foraging.

The Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include the addition of the Pacific Ocean region between Cape Flattery, WA, and Point Reyes, CA, extending approximately 47 miles (76 km) offshore. Based on new information, NOAA Fisheries intends to proceed with the petitioned action to revise critical habitat for Southern Resident Killer Whales (80 FR 9682).

2.14 Delta Smelt

2.14.1 ESA Listing

The USFWS proposed to list the Delta Smelt (*Hypomesus transpacificus*) as threatened with proposed critical habitat on October 3, 1991 (USFWS 1991). The USFWS listed the Delta Smelt as threatened on March 5, 1993 (USFWS 1993), and designated critical habitat for the species on December 19, 1994 (USFWS 1994). The Delta Smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (USFWS 1996). A 5-year status review of the Delta Smelt was completed on March 31, 2004 (USFWS 2004). The 2004 review concluded that Delta Smelt remained a threatened species. A subsequent 5-year status review recommended uplisting Delta Smelt from threatened to endangered status (USFWS 2010a). A 12-month finding on a petition to reclassify the Delta Smelt as an endangered species was completed on April 7, 2010 (USFWS 2010b). After reviewing all available scientific and commercial information, the USFWS determined that reclassifying the Delta Smelt from threatened to endangered was warranted but was precluded by other higher priority listing actions (USFWS 2010c). The USFWS annually reviews the status and uplisting recommendation for Delta Smelt during its Candidate Notice of Review (CNOR) process. Each year, the CNOR has recommended the uplisting from threatened to endangered. Electronic copies of these documents are available at http://ecos.fws.gov/docs/five_year_review/doc3570.pdf and <http://www.gpo.gov/fdsys/pkg/FR-2013-11-22/pdf/2013-27391.pdf> (USFWS 2010a; USFWS 2010b; USFWS 2012b).

2.14.2 General Life History and Habitat Requirements

The Delta Smelt is endemic to the San Francisco Bay–Delta where it primarily occupies open-water habitats in Suisun Bay and marsh and the Sacramento–San Joaquin Delta. The Delta Smelt is primarily an annual species, meaning that it completes its life cycle in 1 year, which typically occurs from April to the following April plus or minus 1 or 2 months. In captivity, Delta Smelt can survive to spawn at 2 years of age (Lindberg et al. 2013), but this appears to be rare in the wild (Bennett 2005; Damon et al. 2016), where very few individuals reach lengths over 3.5 inches (90 mm).

Delta Smelt spawning likely occurs at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005). Although preferred spawning substrate is unknown, spawning habits of Delta Smelt's closest relative, the Surf Smelt (*Hypomesus pretiosus*), as well as unpublished experimental trials, suggest that sand or small pebbles may be the preferred substrate (Bennett 2005). Hatching success peaks at temperatures of 15°C to 16°C (59°F to 61°F) and decreases at cooler and warmer temperatures. Hatching success nears 0 percent as water temperatures exceed 20°C (68°F) (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of

March to May, but ripe female Delta Smelt have been observed as early as January and larvae have been collected as late as July. Delta Smelt spawn in the estuary and have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. Freshwater flow affects how much of the estuary is available for Delta Smelt to spawn (Hobbs et al. 2007), but water temperature controls how long Delta Smelt can spawn each season.

Although adult Delta Smelt can spawn more than once, mortality is high during the spawning season and most adults die by May (Polansky et al. 2018). The egg stage averages about 10 days before the embryos hatch into larvae. The larval stage averages about 30 days. Metamorphosing “post-larvae” appear in monitoring surveys from April into July of most years. By July, most Delta Smelt have reached the juvenile life stage. Delta Smelt collected during the fall are called “subadults,” a stage which lasts until winter when fish disperse toward spawning habitats. This winter dispersal usually precedes sexual maturity (Sommer et al. 2011).

Most Delta Smelt complete their entire life cycle within or immediately upstream of the estuary’s low-salinity zone. The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 parts per thousand (ppt) (Kimmerer 2004). The 0.5 to 6 ppt and similar salinity ranges reported by various authors were chosen based on analyses of historical peaks in phytoplankton and zooplankton abundance, but recent physiological and molecular biological research has indicated that the salinities typical of the low-salinity zone are also within the tolerance range (0 to 18 ppt) for Delta Smelt (Komoroske et al. 2016). Komoroske et al. (2016) also found that acclimating to salinities outside the low-salinity zone (LSZ) could impose energetic costs that constrain the species’ ability to exploit these habitats. The low-salinity zone is a dynamic habitat with size and location responding rapidly to changes in tidal and river flows. By local convention the location of the low-salinity zone is described as “X2” in terms of the distance from the 2 ppt isohaline to the Golden Gate Bridge. 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.

Delta Smelt mainly occupy an arc of habitat in the north Delta, including Liberty Island and the adjacent reach of the Sacramento Deepwater Shipping Channel (Sommer and Mejia 2013), Cache Slough to its confluence with the Sacramento River, and the Sacramento River from that confluence downstream to Chipps Island, Honker Bay, and the eastern part of Montezuma Slough (see Figure 2.14-5). The reasons Delta Smelt are believed to permanently occupy this part of the estuary are the year-round presence of fresh- to low-salinity water that is comparatively turbid and of a tolerable water temperature. These appropriate water quality conditions overlap an underwater landscape featuring variation in depth, tidal current velocities, edge habitats, and food production (Sweetnam 1999; Nobriga et al. 2008; Feyrer et al. 2011; Murphy and Hamilton 2013; Hammock et al. 2015; Bever et al. 2016). Field observations are increasingly supported by laboratory research on the physiological response of Delta Smelt to variation in salinity, turbidity, water temperature, and environmental variables associated with changes in climate, freshwater flow, and estuarine bathymetry (Hasenbein et al. 2014, 2016; Komoroske et al. 2014, 2016).

2.14.3 Historical and Current Distribution

The 2018 (WY 2019) CDFW Fall Midwater Trawl (FMWT) Index was zero, the lowest on record. The CDFW Spring Kodiak Trawl (SKT) monitors the adult spawning stock of Delta Smelt and serves as an indication for the relative number and distribution of spawners in the system. The 2018 SKT Abundance Index was 2.1, the second lowest on record. All CDFW relative abundance indices show a declining trend since the early 2000s (Figure 2.14-1).

In 2016, the USFWS began calculating an absolute abundance estimate using January and February SKT catch data, which have been available since 2002. This calculation was modified in 2017 and resulting estimates and ranges are shown in Figure 2.14-1.

The 2018 absolute abundance estimate is the second lowest; however the confidence intervals overlap so strongly that it cannot be stated that 2018 actually had higher adult abundance than 2016. The January through February 2016 point estimates are the lowest since the SKT survey began in 2002 and suggest Delta Smelt experienced increased natural mortality during the extreme drought conditions occurring during 2013–2015. While the estimate may have increased slightly in 2017, it appears to have decreased again in 2018. The continued low spawning stock of Delta Smelt relative to historical numbers suggests the population would continue to be vulnerable to stochastic events and operational changes occurring in response until successive years of increased population growth results in a substantial increase in abundance.

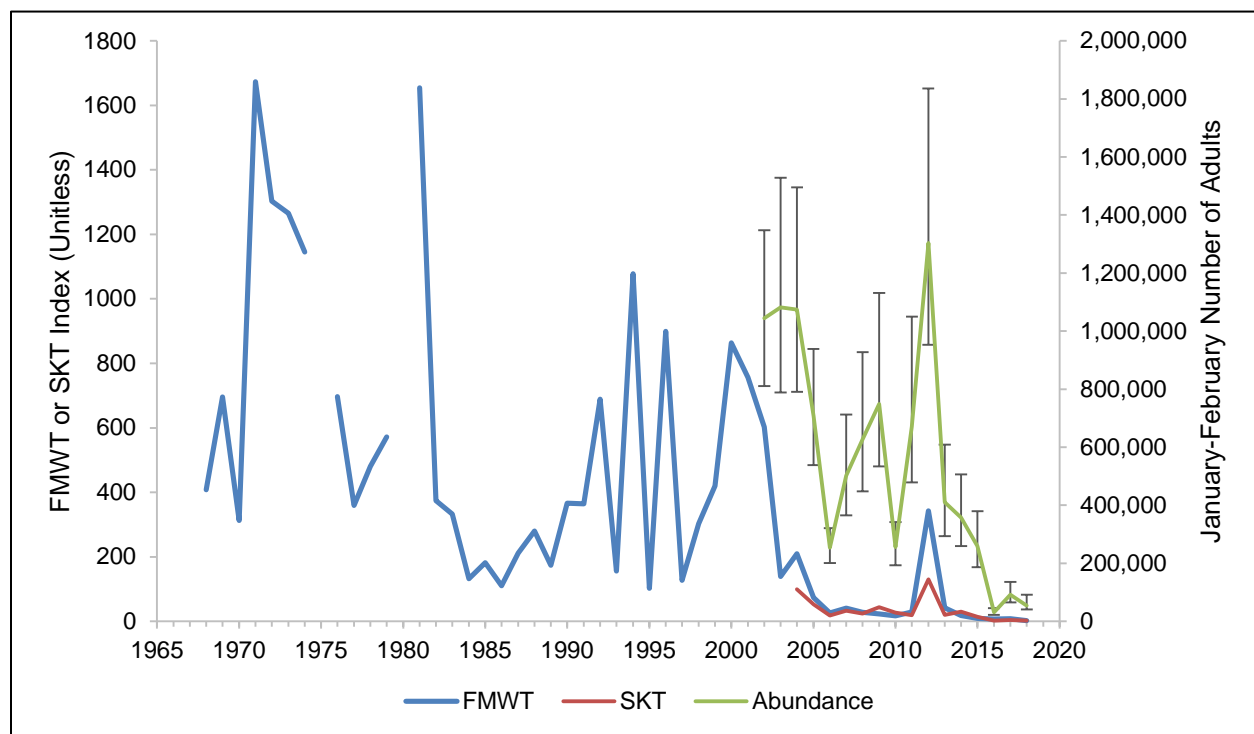


Figure 2.14-1. Fall Midwater Trawl Index, Spring Kodiak Trawl Index, and January-February Spring Kodiak Trawl Abundance Estimate (With 95% Confidence Interval), Water Years 2002-2018.

In addition to these abundance estimates, the CDFW conducts four fish surveys from which it develops indices of Delta Smelt’s relative abundance. Each survey has variable capture efficiency (Mitchell et al. 2017), and in each, the frequency of zero catches of Delta Smelt is very high, largely due to the species’ rarity (Latour 2016; Polansky et al. 2018).

The Towntnet Survey (TNS) and FMWT abundance indices for Delta Smelt have documented the species’ long-term decline, while the newer 20-mm and SKT abundance indices have generally confirmed the recent portions of the trends implied by the older surveys (Figures 2.14-2 and 2.14-3). During the period of record, Delta Smelt relative abundance has declined from peak levels observed during the 1970s. The

TNS and FMWT abundance indices both declined rapidly during the early 1980s, increased somewhat during the 1990s, and then collapsed in the early 2000s. Since 2005, the TNS and the FMWT have produced indices that reflect less year to year variation than their 20-mm and SKT analogs, but overall, the trends in both sets of indices are similar. During the past decade, the index has continued to decrease and currently reflects 0.5 percent of the relative abundance recorded in 1970–1971.

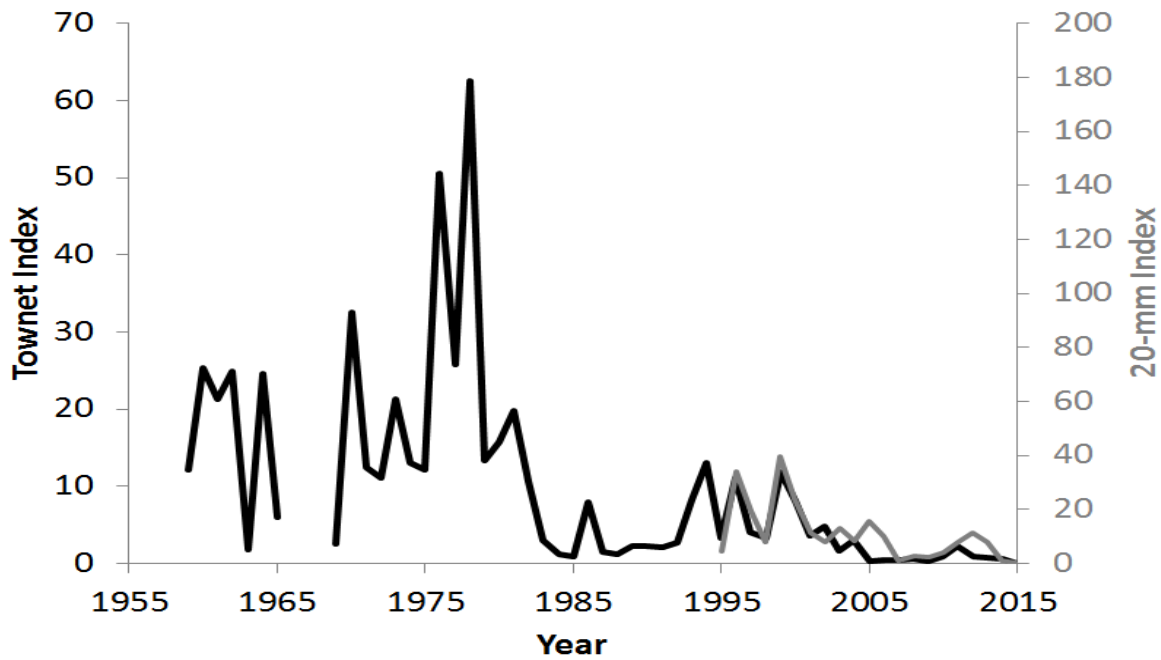


Figure 2.14-2. Time Series of the CDFW's Summer TNS (black line; primary y-axis) and 20-mm Survey (gray line; secondary y-axis) Abundance Indices for Delta Smelt

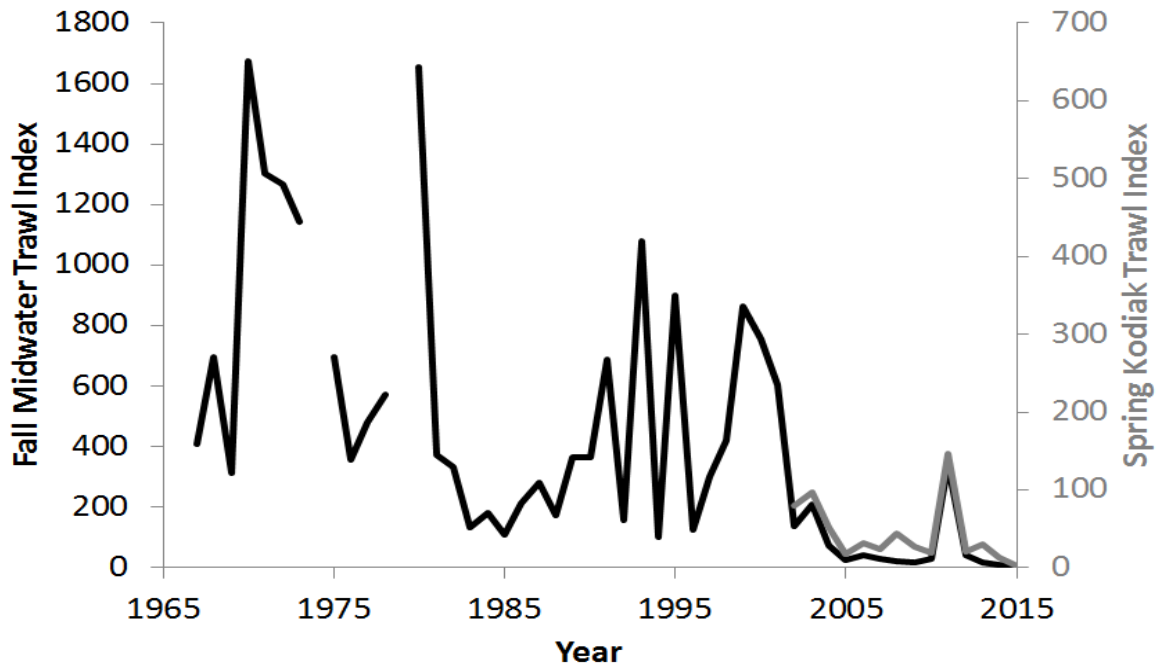


Figure 2.14-3. Time Series of the CDFW's FMWT (black line; primary y-axis) and SKT (gray line; secondary y-axis) Abundance Indices for Delta Smelt

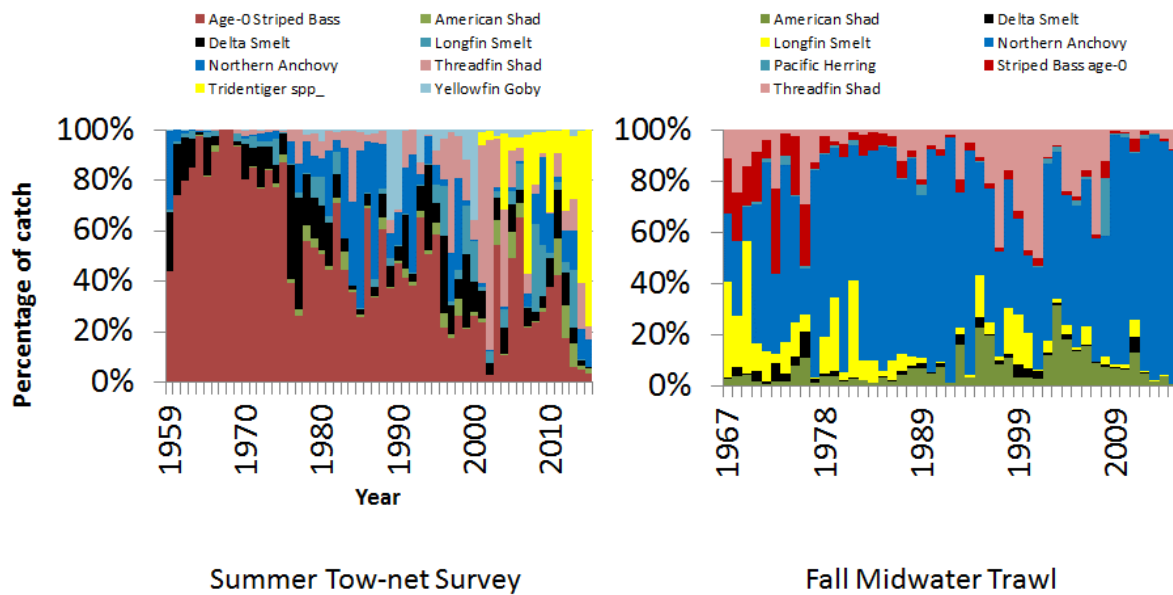


Figure 2.14-4. Fractional Compositions of the Eight Most Frequently Collected Fish Species in the CDFW's Summer TNS (1959–2015), and the Seven Most Frequently Collected Fish Species in the FMWT (1967–2015)

The general distribution of Delta Smelt is well known partly due to its limited geographic distribution (Moyle et al. 1992; Bennett 2005; Hobbs et al. 2006, 2007; Feyrer et al. 2007; Nobriga et al. 2008; Kimmerer et al. 2009; Merz et al. 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013). The suitable habitat for Delta Smelt is a geographically limited area (e.g., one example is Sacramento River around Decker Island) and has low-salinity conditions. The additional seasonally suitable habitats utilized for spawning and migration are identified as occasional seasonal use habitats. Distribution extremes do not yield Delta Smelt in most sampling years.

Delta Smelt have been observed as far west as San Francisco Bay, as far north as Knights Landing on the Sacramento River, as far east as Woodbridge on the Mokelumne River and Stockton on the Calaveras River, and as far south as Mossdale on the San Joaquin River (Figure 2.14-5). This distribution represents a range of salinity from essentially 0 ppt to about 20 ppt, which includes brackish water exceeding 2 ppt salinity. However, most Delta Smelt that have been collected in the extensively surveyed San Francisco Estuary have been collected from locations within the defined ranges of the critical habitat rule. In addition, all habitats known to be occupied year-around by Delta Smelt occur within the conditions defined in the critical habitat rule.

Each year, the distribution of Delta Smelt seasonally expands when adults disperse in response to winter flow increases, increases in turbidity, and decreases in water temperature (Figure 2.13-1). The annual range expansion of adult Delta Smelt extends up the Sacramento River to about Garcia Bend in the Pocket neighborhood of Sacramento, up the San Joaquin River from Antioch to areas near Stockton, up the lower Mokelumne River system, and west throughout Suisun Bay and Suisun Marsh. Some Delta Smelt seasonally and transiently occupy Old and Middle River in the south Delta each year, but face a high risk of entrainment when they do (Grimaldo et al. 2009).

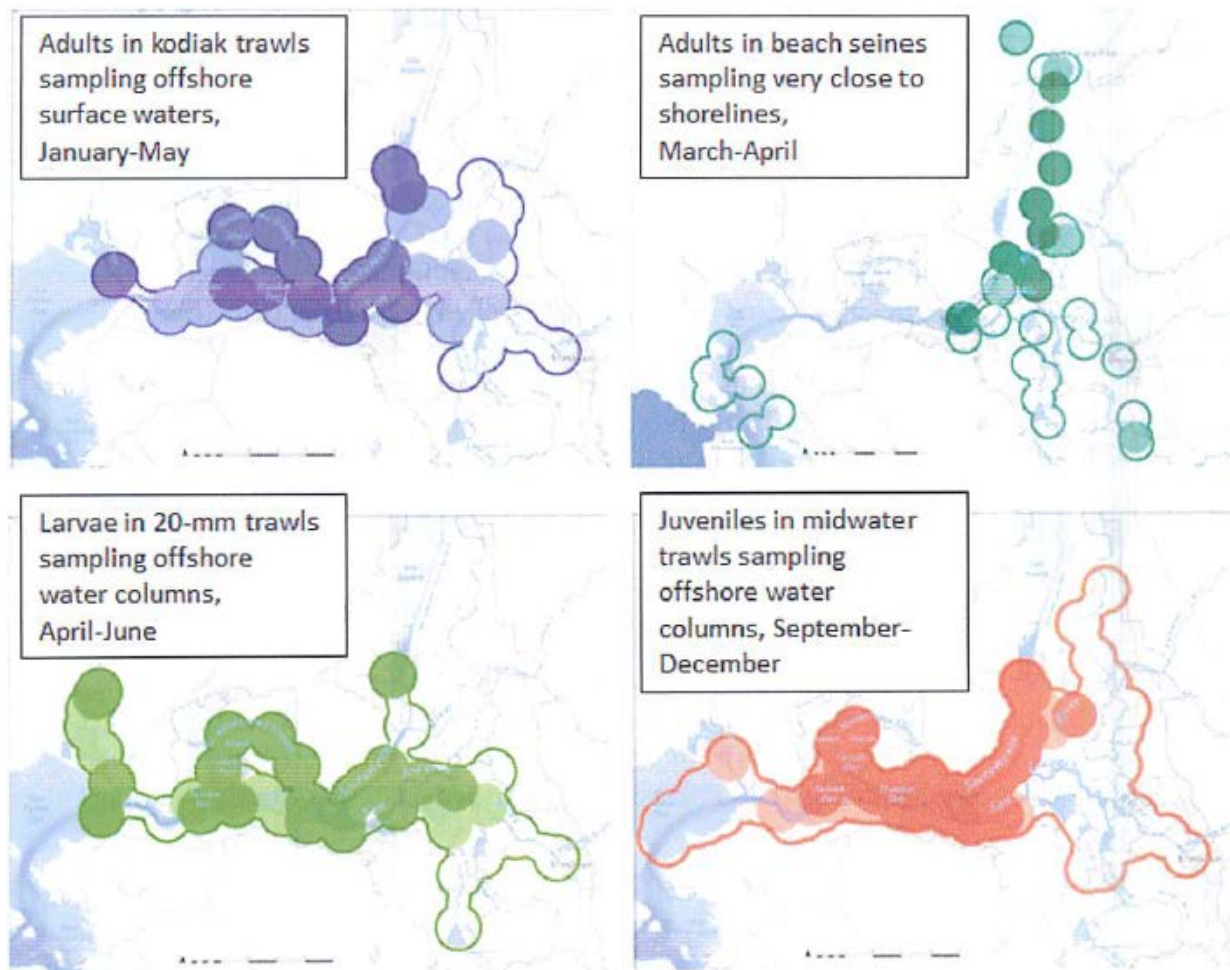


Figure 2.14-5. Maps of Multi-Year Average Distributions of Delta Smelt Collected in Four Monitoring Programs

The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the Delta Smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of Delta Smelt collections occurred (Murphy and Hamilton 2013).

The distribution of Delta Smelt occasionally expands beyond this area (Figure 2.14-5). For instance, during high outflow winters, adult Delta Smelt also disperse west into San Pablo Bay and up into the Napa River (Hobbs et al. 2007). Similarly, Delta Smelt have occasionally been reported from the Sacramento River north of Garcia Bend up to Knights Landing (Merz et al. 2011; Vincik and Julienne 2012).

The relative abundance of Delta Smelt has declined substantially for a small forage fish in an ecosystem the size of the San Francisco Estuary. The recent relative abundance reflects decades of habitat change and marginalization by nonnative species that prey on and outcompete Delta Smelt. The anticipated effects of climate change on the San Francisco Estuary and watershed, such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflows from the Delta, and the potential for frequent extreme drought, indicate challenges to maintaining a sustainable Delta

Smelt population. A rebound in relative abundance during the very wet and cool conditions during 2011 indicated that Delta Smelt retained some population resilience (IEP 2015). However, since 2012, declines to record low population estimates have been broadly associated with the 2012–2015 drought, and wetter conditions in 2017 and 2018 have not produced a rebound similar that seen in 2011.

2.14.4 Limiting Factors, Threats, and Stressors

Limiting factors for Delta Smelt are: SWP and CVP exports due to entrainment of larvae and juveniles and the effects of low flow on the location and function of the estuary mixing zone (now called the low-salinity zone) (Moyle et al. 1992; USFWS 1993; USFWS 2010); drought; in-Delta water diversions; reduction in food supplies by nonindigenous aquatic species, specifically overbite clam and nonnative copepods; toxicity due to agricultural and industrial chemicals; increasing water transparency; and Brazilian waterweed (*Egeria densa*). Predation was considered a low-level threat linked to increasing waterweed abundance and increasing water transparency. Additional threats considered potentially significant by the USFWS in 2010 were entrainment into power plant diversions, contaminants, and reproductive problems that can stem from small population sizes.

The long-term rarity of the Delta Smelt has had a consequence for understanding the reasons for their population decline, which adds challenges for implementing effective resource management strategies. Some pelagic fishes have shown long-term relationships between Delta inflow, Delta outflow, or X2 and abundance or survival (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Kimmerer et al. 2009). A predictive correlation between freshwater flow conditions and relative abundance has not been established (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Kimmerer et al. 2009). Since 2010, several conceptual models (Interagency Ecological Program [IEP] 2015) and empirical models (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a; Hamilton and Murphy 2018) have explored life cycle models for the Delta Smelt in an attempt to describe the reasons for the population decline. Some of these models have recreated the trend observed in abundance indices (Figure 2.14-6), but each model has applied different methodology and variables. Collectively, these modeling efforts generally support water temperature and changes in the estuary's trophic dynamics as "universally supported" factors affecting Delta Smelt. However, they have varying conclusions regarding the effectiveness of alterations in water operations as management strategies to increase the likelihood of population increases for Delta Smelt.

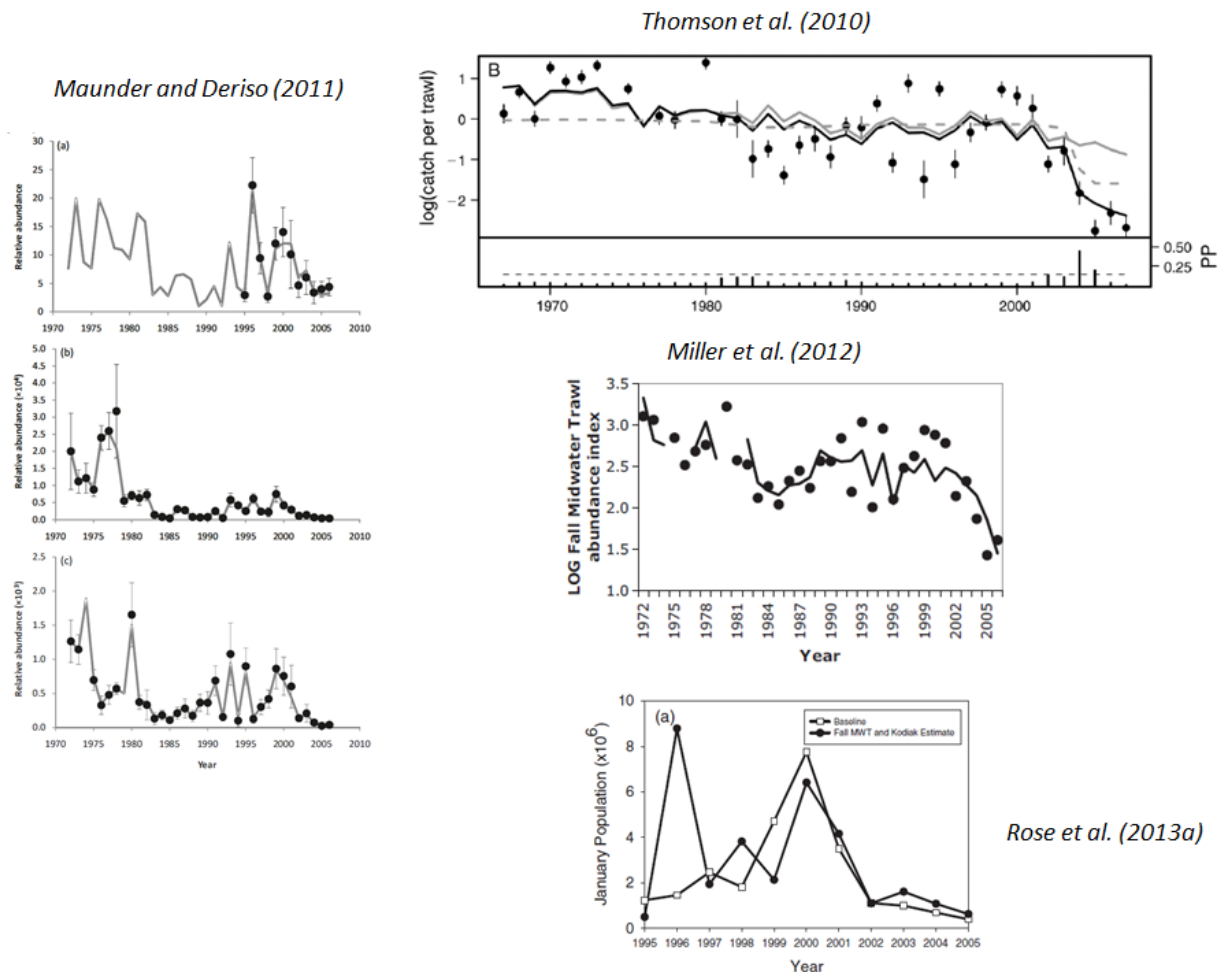


Figure 2.14-6. Examples of Recent Published Model Fits to Time Series of Delta Smelt Relative Abundance Data

The source of each is referenced above or alongside each time series. In each plot, observed catches are depicted as black dots and model predictions of the data as gray or black lines. Model predictions from Rose et al. (2013a) are a black line with open symbols. In Maunder and Deriso (2011), the three panels represent the 20-mm Survey, summer TNS, and FMWT Survey from top to bottom, respectively. The other three studies are fit to estimates of adult Delta Smelt relative abundance (Thomson et al. 2010; Miller et al. 2012) or absolute abundance (Rose et al. 2013a). See each study for further details on methods, results, and the authors’ interpretations of their results.

The ecological function of the low-salinity zone can vary depending on Delta outflow (Jassby et al. 1995; Kimmerer 2002a; Kimmerer 2004). During the past four decades, the low-salinity zone ecosystem has undergone substantial changes in turbidity (Schoellhamer 2011) and foodweb function (Winder and Jassby 2011) that cannot be undone solely by increasing Delta outflow. These habitat changes, which extend into parts of the Delta where water is fresher than 0.5 ppt, are hypothesized to have also decreased the ability of the low-salinity zone and adjacent habitats to support the production of Delta Smelt (Thomson et al. 2010; Rose et al. 2013b; IEP 2015).

At all life stages, numerous small planktonic crustaceans, especially a group called calanoid copepods, make up most of the Delta Smelt diet (Nobriga 2002; Slater and Baxter 2014). Small crustaceans are ubiquitously distributed throughout the estuary, but the prey species present at particular times and locations has changed dramatically over time (Winder and Jassby 2011; Kratina et al. 2014). This has likely affected Delta Smelt feeding success, particularly during central California's warm summers.

Climate projections for the San Francisco Bay–Delta and its watershed indicate that temperature and precipitation changes would reduce snowpack in the Sierra Nevada, changing the timing and availability of natural water supplies (Knowles and Cayan 2002; Dettinger 2005). Temperature increases may result in more precipitation falling as rain and less water stored in spring snowpacks. Increased frequency of rain-on-snow events would increase winter runoff and an associated decrease in runoff for the remainder of the year (Hayhoe et al. 2004). Overall, these and other storm track changes may lead to increased frequency of flood and drought cycles during the 21st century (Dettinger et al. 2015).

Central California's warm summers are already a source of energetic stress for Delta Smelt and warm springs already compress the duration of their spawning season (Rose et al. 2013a, 2013b; Moyle et al. 2016). Central California's climate is anticipated to get warmer (Cayan et al. 2009). Warmer estuary temperatures present a significant conservation challenge for Delta Smelt (Brown et al. 2013, 2016). Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern et al. 2011). Warmer water temperatures could further reduce Delta Smelt spawning opportunities, decrease juvenile growth during the warmest months, and increase mortality via several foodweb pathways including: increased vulnerability to predators, increased vulnerability to toxins, and decreased capacity for Delta Smelt to successfully compete in an estuary that is energetically more optimal for warm-water tolerant fishes.

2.14.5 Water Operations Management

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.

2.14.6 Recovery and Management

The USFWS (2010) recommended the following conservation actions: establish Delta outflows proportionate to proposed action flows to set outflow targets as fractions of runoff in the Central Valley watersheds; minimize net reverse flow in Old and Middle River; and, establish a genetic management plan with the goals of minimizing the loss of genetic diversity and limiting risk of extinction caused by unpredictable catastrophic events. The USFWS (2012b) added climate change to the list of threats to the Delta Smelt.

Continued protection of the Delta Smelt from excessive entrainment, improving the estuary's flow regime, suppressing nonnative species, increasing zooplankton abundance, and improving water quality are among the actions recommended to aid the recovery of Delta Smelt (USFWS 2010).

2.14.7 Monitoring and Research

The Enhanced Delta Smelt Monitoring (EDSM) program began in November 2016 to acquire finer temporal resolution information than existing surveys provided about the spatial distribution and abundance of Delta Smelt. EDSM is a year-round weekly sampling program that samples randomly selected locations using a probabilistic procedure aimed at providing a spatially dispersed sample. This is a significant improvement on existing surveys, which sample in the same locations again and again, and

may find no fish. EDSM sampling is repeated until a fish is caught or an upper limit on the number of tows is reached. EDSM methodology attempts to lower the probability of a “False Zero,” that is, failing to catch fish when fish are present, while aiming to minimize the “take” of a threatened species. EDSM is the only survey that allowed agencies to measure where Delta Smelt are located in 2018, given their increasingly low abundance.

2.15 Delta Smelt Critical Habitat

The USFWS designated critical habitat for the Delta Smelt on December 19, 1994 (USFWS 1994). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; the Napa River; and the existing contiguous waters contained within the legal Delta, as defined in section 12220 of the California Water Code (USFWS 1994).

The primary objective in designating critical habitat was to identify the key components of Delta Smelt habitat that support successful completion of the life cycle, including spawning, larval and juvenile transport, rearing, and adult migration back to spawning sites. Delta Smelt are endemic to the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) and the vast majority only live 1 year. Thus, regardless of annual hydrology, the estuary must provide suitable habitat all year, every year. The primary constituent elements essential to the conservation of the Delta Smelt are physical habitat, water, river flow, and salinity concentrations required to maintain Delta Smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration (USFWS 1994). The USFWS 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 Resources Control Board’s “X2 standard” described in D-1641 and the Board’s current Water Quality Control Plan.

Table 2.15-1 compares the original descriptions of the primary constituent elements with current scientific understanding.

Table 2.15-1. Comparison of Delta Smelt Primary Constituent Elements of Critical Habitat between the 1994 Publication of the Rule and the Present

| Primary Constituent Element | 1994 Critical Habitat Rule | 2018 State of Scientific Understanding |
|------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Spawning Habitat | Shallow fresh or slightly brackish edgewaters. | No change. |
| | Backwater sloughs. | Possible, never confirmed. Most likely spawning sites have sandy substrates and need not occur in sloughs. Backwater sloughs in particular tend to have silty substrates that would suffocate eggs. |
| | Low concentrations of pollutants. | No change. |
| | Submerged tree roots, branches, emergent vegetation (tules). | Not likely. Unpublished observations of spawning by captive Delta Smelt suggest spawning on |

| Primary Constituent Element | 1994 Critical Habitat Rule | 2018 State of Scientific Understanding |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | substrates oriented horizontally and a preference for gravel or sand that is more consistent with observations of other osmerid fishes. (Bennett 2005, p.17). |
| | Suspected spawning locations: Sacramento River "in the Delta," Barker Slough, Lindsey Slough, Cache Slough, Prospect Slough, Georgiana Slough, Beaver Slough, Hog Slough, Sycamore Slough, Suisun Marsh. | All of the locations listed in 1994 may be suitable for spawning, but based on better monitoring from the Spring Kodiak Trawl Survey, most adult fish have since been observed to aggregate around Grizzly Island, Sherman Island, and in the Cache Slough complex, including the subsequently flooded Liberty Island, Sacramento River Deep Water Ship Channel (SRDWSC), and Montezuma Slough. |
| | Adults could spawn December–July. | Adults are virtually never fully ripe and ready to spawn before February and most spawning is completed by May (in warm years) or June (in cool years). However, new research confirms that Delta Smelt are capable of multiple batch spawning (Kurobe et al 2016). |
| Larval and juvenile transport | Larvae require adequate river flows to transport them from spawning habitats in backwater sloughs to rearing habitats in the open waters of the low-salinity zone. | Not likely. Most Delta Smelt that survive to the juvenile life stage do eventually inhabit water that is in the 0.5 to 6 ppt range, due to either downstream movement or decreasing outflow, or both. However, Delta Smelt larvae can feed in the same habitats they were hatched in and juvenile fish can rear in water less than 0.5 ppt salinity. |
| | Larvae require adequate flow to prevent entrainment. | No change. |
| | Larval and juvenile transport needs to be protected from physical disturbances like sand and gravel mining, diking, dredging, riprapping. | No change, but these disturbances seem likely to have more impact on spawning habitat than larval transport. |
| | 2 ppt isohaline (X2) must be west of the Sacramento–San Joaquin River confluence to support sufficient larval and juvenile transport. | X2 is generally west of the confluence during February–June due to State Water Resources Control Board X2 standard. Movement downstream of larval or other life stages is likely to have less of an energy cost with more outflow versus less. |
| | Maturation must not be impaired by pollutant concentrations. | Developmental contaminants are present at benchmark levels in the Delta (Fong et al. 2016; Jabusch et al. 2018). |

| Primary Constituent Element | 1994 Critical Habitat Rule | 2018 State of Scientific Understanding |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Additional flows might be required in the period July–August to protect Delta Smelt that were present in the south and central Delta from being entrained in export pumps. | July–August outflow augmentations may be helpful, but not to mitigate entrainment. Habitat changes in the central and south Delta have rendered it seasonally unsuitable to Delta Smelt during the summer; entrainment is seldom observed past June. |
| Rearing habitat | 2 ppt isohaline (X2) should remain between Carquinez Strait in the west, Three-Mile Slough on the Sacramento River and Big Break on the San Joaquin River in the east. This was determined to be a range for 2 ppt salinity (including its tidal time scale excursion into the Delta). | X2 is generally in this area during February–June due to State Water Resources Control Board X2 standard; however the standard does have a drought off-ramp. Most juvenile Delta Smelt still rear in this area but it is now recognized that a few remain in the Cache Slough complex as well. It has not been verified that the X2 isohaline must be between Carquinez and the confluence for biotic factors regarding Delta Smelt. |
| Adult migration | Adults require unrestricted access to spawning habitat from December–July. | Adults disperse faster than was recognized in 1994; most spawning is finished by the time Spring Kodiak Trawls start in January. |
| | Unrestricted access results from adequate flow, suitable water quality, and protection from physical disturbance. | Biotic factors can also restrict access. |

2.15.1 Primary Constituent Element 1

Physical habitat is defined as the structural components of habitat (USFWS 1994). The ancestral Delta was a large tidal marsh–floodplain habitat totaling approximately 300,000 acres. During the late 1800s and early 1900s, most of the wetlands were diked and reclaimed for agriculture or other human use. The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization. Water conveyance projects and river channelization have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the DCC, storage reservoirs like CCF, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

Between the 1930s to 1960s, the shipping channels were dredged deeper (about 12 meters) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento–San Joaquin River confluence region as the largest places with the greatest depth variation in the typical range of the low-salinity zone. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle et al. 1992; Jassby et al. 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the low-salinity zone in the large Suisun Bay/river confluence region than was once required. The shipping itself has historically provided a source of nonnative organisms, that, along with lower Delta outflow and deep channelization, have contributed to the changing ecology of the upper estuary (Winder and Jassby 2011; Kratina et al. 2014; Andrews et al. 2017).

Although the Delta Smelt is a generally pelagic or open-water fish, depth variation of open-water habitats is an important habitat attribute (Moyle et al. 1992; Hobbs et al. 2006). In the wild, Delta Smelt are most frequently collected in water that is somewhat shallow (4 to 15 feet deep) where turbidity is often elevated and tidal currents exist but are not excessive (Moyle et al. 1992; Bever et al. 2016). In Suisun Bay, the deep shipping channels are poor quality habitat because tidal velocity is very high (Bever et al. 2016), but in the north Delta where tidal velocity is slower, the Sacramento Deepwater Shipping Channel is used to a greater extent. Adult Delta Smelt also use edge habitats as tidal current refuges and corridors to spawning habitats (Bennett and Burau 2015).

2.15.2 Primary Constituent Element 2

Water is defined as water of suitable quality to support various Delta Smelt life stages that allow for survival and reproduction (USFWS 1994). Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for Delta Smelt and are discussed in detail below. Contaminant exposure can degrade this primary constituent element even when the basic habitat components of water quality are otherwise suitable (Hammock et al. 2015).

Turbidity: Delta Smelt require turbidity. Even in captivity, clear water is a source of physiological stress (Lindberg et al. 2013; Hasenbein et al. 2016). The small plankton that Delta Smelt larvae eat are nearly invisible in clear water. The sediment (or algal) particles that make turbid water turbid, provide a dark background that helps Delta Smelt larvae see their translucent prey (Baskerville-Bridges et al. 2004). Older Delta Smelt are less reliant on turbidity to see their prey, but juvenile fish still feed more effectively in water of moderate turbidity (Hasenbein et al. 2016) and probably need turbid water to help disguise themselves from predators (Ferrari et al. 2014). The turbidity of the Delta and Suisun Bay has been declining for a long time due to dams and riprapped levees, both of which cut off sources of sediment from rivers flowing into the estuary (Arthur et al. 1996; Wright and Schoellhamer 2004), and due to the spread of Brazilian waterweed (Hestir et al. 2016) which filters the water, increasing clarity. Water exports from the south Delta may also have contributed to the trend toward clearer water by removing resuspended sediment in the exported water (Arthur et al. 1996). The primary turbid areas that remain in the upper estuary are the semi-shallow embayments in northern Suisun Bay (Bever et al. 2016) and the lower Yolo Bypass region that includes Liberty Island and the upper reach of the Sacramento Deepwater Shipping Channel (Morgan-King and Schoellhamer 2013). Both tidal and river flows, as well as wind speed, affect turbidity in these locations (Bever et al 2018). Many of the estuary's deeper channels tend to have somewhat lower turbidity because water velocity and wind cannot resuspend sediment that sinks into deep water (Ruhl and Schoellhamer 2004).

Water temperature: Water temperature is the primary driver of the timing and duration of the Delta Smelt spawning season (Bennett 2005). Water temperature also affects Delta Smelt's growth rate which in turn can affect their readiness to spawn (Rose et al. 2013a). Water temperature is not strongly affected by variation in Delta outflow; the primary driver of water temperature variation in the Delta Smelt critical habitat is air temperature (Wagner et al. 2011). Very high flows can transiently cool the upper estuary (e.g., flows in the upper 10th percentile, Kimmerer 2004) during the early part of the year, but the system rapidly re-equilibrates once air temperatures begin to warm.

Older laboratory based research suggested an upper water temperature limit for Delta Smelt of about 25°C, or 77°F (Swanson et al. 2000). Newer laboratory research suggests Delta Smelt temperature tolerance decreases as the fish age, but is a little higher than previously reported, up to 28°C or 82°F in the juvenile life stage (Komoroske et al. 2014). It should be kept in mind that these are upper acute water temperature limits, meaning temperatures in this range will kill, on the average, one of every two fish.

In the laboratory and the wild, Delta Smelt appear to have a physiological optimum temperature near 20°C or 68°F (Nobriga et al. 2008; Rose et al. 2013a; Jeffries et al. 2016); most of the upper estuary exceeds this water temperature from June through September (Wagner et al. 2011). Thus, many parts of the estuary are energetically costly and stress Delta Smelt. Generally speaking, spring and summer water temperatures are cooler to the west and warmer to the east due to the differences in overlying air temperatures between the Bay Area and the warmer Central Valley (Kimmerer 2004). In addition, there is a strong water temperature gradient across the Delta with cooler water in the north and warmer water in the south. The higher flows from the Sacramento River probably explain this north-south gradient. Note that water temperatures in the north Delta near Liberty Island and the lower Yolo Bypass are also typically warmer than they are along the Sacramento River (Sommer et al. 2001; Nobriga et al. 2005).

Food: Food and water temperature are strongly interacting components of Delta Smelt health and habitat because the warmer the water, the more food Delta Smelt require (Rose et al. 2013a). If the water gets too warm, then no amount of food is sufficient. The more food Delta Smelt eat (or must try to eat) the more they will be exposed to predators and contaminants. Water exports can limit the flux of phytoplankton production from the Delta into Suisun Bay (Jassby and Cloern 2000), but the effect of water exports on phytoplankton production appears to be lower than grazing by clams (Jassby et al. 2002) and ammonium inhibition of phytoplankton growth from Sacramento's urban wastewater inputs (Dugdale et al. 2007).

Historically, prey production peaked when the low-salinity zone was positioned over the shoals of Suisun Bay during late spring through the summer, but this function has been depleted due to grazing by overbite clams (Kimmerer and Thompson 2014), high ammonium concentrations in critical habitat (Dugdale 2012; Dugdale et al. 2016), and water diversions (Jassby and Cloern 2000). Recent research suggests Delta Smelt occupying Suisun Bay may experience poor nutritional health (Hammock et al. 2015). Delta Smelt occupying the Cache Slough region in the north Delta are in better nutritional health, but have shown evidence of relatively high contaminant impacts. The southern Delta is among the more productive areas remaining in the upper estuary (Nobriga et al. 2005), but Delta Smelt cannot remain in this habitat during the warmer months of the year (Nobriga et al. 2008) and may face a high risk of entrainment when they occupy it during cooler months (Kimmerer 2008; Grimaldo et al. 2009). Extensive blooms of the toxin-producing cyanobacteria *Microcystis* in the central and southern Delta became abundant around 1999 and depending on flow, and temperature, blooms can extend westward into the low-salinity zone where Delta Smelt are rearing (Brooks et al. 2012). In one recent study, Delta Smelt that occupied Suisun Marsh fared better both in terms of nutrition and in experiencing a lower level of contaminant impacts (Hammock et al. 2015).

2.15.3 Primary Constituent Element 3

“River flow” was originally defined as transport flow to facilitate spawning migrations and transport offspring to low-salinity zone rearing habitats (USFWS 1994), currently called tidal surfing (Bennett and Bureau 2015). Both the flood and ebb tide influence the Delta Smelt distribution and dispersal.

The spawning microhabitats of Delta Smelt are not known, but it is likely there is more available suitable spawning habitat when Delta outflow is high during spawning than when it is low because more of the estuary is covered in fresh- and low-salinity water when outflow is high (Jassby et al. 1995). An examination of the adults found that a majority were using fresh to low salinity water. Most spawning occurs between February and May. Delta outflow during February through May is mainly driven by the climatic effect on the amount and form of precipitation in the watershed, the storage and diversion of water upstream of the Delta, and CVP and SWP water operations in the Delta (Jassby et al. 1995;

Kimmerer 2002a). Thus far, the 21st Century has tended to be pretty dry and warm and that could have resulted in some chronic reduction in spawning habitat availability or suitability.

2.15.4 Primary Constituent Element 4

Older laboratory research suggested that Delta Smelt have an upper acute salinity tolerance of about 20 ppt (Swanson et al. 2000) which is about 60 percent of seawater's salt concentration of 32 to 33 ppt. Newer laboratory-based research suggests that some individuals can acclimate to seawater, but that comes at a high energetic cost that is lethal to about one in four individuals (Komoroske et al. 2014, 2016). In the wild, Delta Smelt are nearly always collected at very low salinities, which recent laboratory research has confirmed is nearer to the physiological optimum (Komoroske et al. 2016). Few individuals are collected at salinities higher than 6 ppt (about 20 percent of seawater salt concentration) and very few are collected at salinities higher than 10 ppt (about 30 percent of seawater salt concentration) (Bennett 2005). This well documented association with fresh to low salinity water is a reason for the scientific emphasis on X2 as a Delta Smelt habitat indicator (Dege and Brown 2004; Feyrer et al. 2011). Recent research combining long-term monitoring data with three-dimensional hydrodynamic modeling shows that the spatial overlap of several of the key habitat attributes described above increases as Delta outflow increases (Bever et al. 2016). This means that higher outflow, which lowers the salinity of Suisun Bay and Suisun Marsh, increases the suitability of habitat in the estuary by increasing the overlap of some, but not necessarily all, needed elements.

2.16 Coho Salmon, Southern Oregon/Northern California Coastal ESU

2.16.1 ESA Listing Status

Southern Oregon/Northern California Coast (SONCC) Coho Salmon were listed as threatened under the ESA on May 6, 1997 (62 FR 24588). Subsequent to the Alsea Valley decisions (*Alsea Valley Alliance v. Evans*, 161 F. Supp. 2d 1154 (D. Or. 2001)), which provided guidance on the appropriate composition of an ESU, this listing status was reaffirmed on June 28, 2005 (70 FR 37160). This ESU consists of populations from Cape Blanco, Oregon, south to Punta Gorda, California, including Coho Salmon in the Trinity River. NMFS designated critical habitat for SONCC Coho Salmon on May 5, 1999 (64 FR 24049) as accessible reaches of all rivers (including estuarine areas and tributaries) between the Elk River in Oregon and the Mattole River in California, inclusive).

2.16.2 General Life History and Habitat Requirements

Coho salmon exhibit a 3-year life cycle in the Trinity River and are dependent on freshwater habitat conditions year round because they spend a full year residing in freshwater. Most Coho Salmon enter rivers between August and January with some more northerly populations entering as early as June. Coho salmon river entry timing is influenced by a number of factors including genetics, stage of maturity, river discharge, and access past the river mouth. Spawning is concentrated in riffles or in gravel deposits at the downstream end of pools with suitable water depth, velocity, and substrate size. Spawning in the Trinity River occurs mostly in November and December.

Coho salmon eggs incubate from 35 to more than 100 days depending on water temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching. Coho eggs hatch after an accumulation of 400 to 500 temperature units measured in degrees Celsius (°C) and emerge from the gravel after 700 to 800

temperature units. After emergence, fry move into areas out of the main current. As Coho grow they spread out from the areas where they were spawned.

During the summer, juvenile Coho prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots. Juvenile Coho overwinter in large mainstem pools, beaver ponds, backwater areas, and off-channel pools with cover such as woody debris and undercut banks. Most juvenile Coho Salmon spend a year in freshwater with some northerly populations spending 2 full years in freshwater. Coho in the Trinity River are thought to be exclusively 3-year lifecycle fish (1 year in freshwater). Because juvenile Coho remain in their spawning stream for a full year after emerging from the gravel, they are exposed to the full range of freshwater conditions. Most smolts migrate to the ocean between March and June with most leaving in April and May.

2.16.3 Historical and Current Distribution and Abundance

According to NMFS (2014), all nine Coho Salmon population units in the Klamath-Trinity Basin have declined dramatically in abundance relative to historical levels, including the three populations within the Trinity River Basin. These three populations are including (1) the Upper Trinity (North Fork Trinity River to Ramshorn Creek inclusive), (2) the Lower Trinity (Weitchpec to just below North Fork Trinity River confluence and tributaries excluding South Fork Trinity River), and (3) the South Fork Trinity sub-population (NMFS 2012). Coho Salmon were not likely the dominant species of salmon in the Klamath Trinity River before dam construction. They were, however, widespread in the Trinity Basin ranging as far upstream in the Trinity River as Stuarts Fork above Trinity Dam. Wild Coho in the Trinity River today are not abundant and the majority of the fish returning to the river are of hatchery origin. Returns to the Trinity River are monitored at the Willow Creek Weir, (typically sited within a few miles of the town of Willow Creek) (see figure 2.16-1 below). Run size estimates include Coho Salmon from all or part of the three Trinity River Coho Salmon populations. The proportion of Coho Salmon from each population is unknown, though most are thought to be of the Upper Trinity River Population Unit. Few juveniles or adults are observed in the Lower or South Fork Trinity Population Units. Adult return numbers to the TRH provide rough estimates of the hatchery-origin coho salmon return numbers.

Data from this monitoring program indicates the Trinity River portion of the Southern Oregon/Northern California Coast Coho Salmon ESU is predominately of hatchery origin (Figure 2-16.1). NMFS (2012) views such a high proportion of hatchery fish as a population to be a high level risk factor for continued existence of the populations in the Trinity Basin. NMFS, USBR, and CDFW are working to develop a Hatchery and Genetics Management Plan to mitigate the adverse effects of the hatchery program on production of wild Coho Salmon in the Trinity River (NMFS 2017, USBR and CDFW 2017).

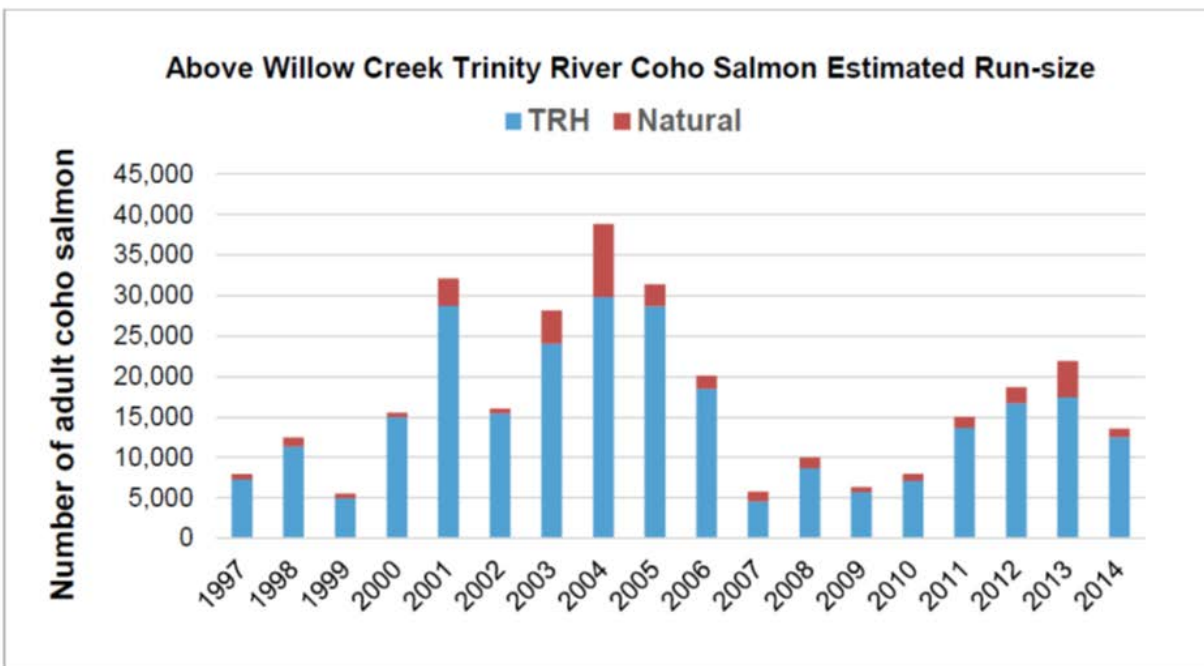


Figure 2.16-1. Estimated run-size of hatchery-origin and natural-origin coho salmon in the Trinity River based on data collected at the Willow Creek weir (Reclamation and CDFW 2017).

2.16.4 Limiting Factors, Threats, Stressors

A number of interrelated factors affect Coho abundance and distribution in the Trinity River. These include water temperature, water flow, habitat suitability, habitat availability, hatcheries, predation, competition, disease, ocean conditions, and harvest. Current CVP operations affect primarily water temperature, water flow, and habitat suitability in the Trinity River. Climate change also affects water temperature, water flow, and habitat suitability in the Trinity River.

Juvenile Coho Salmon in the Trinity River spend up to a full year in freshwater before migrating to the ocean. Their habitat preferences change throughout the year and are highly influenced by water temperature. During the warmer summer months when Coho are most actively feeding and growing, they spend more time closer to main channel habitats. Coho tend to use slower water than Steelhead or Chinook Salmon. Coho juveniles are more oriented to submerged objects such as woody debris while Chinook and Steelhead tend to select habitats in the summer based largely on water movement and velocities, although the species are often intermixed in the same habitat. Juvenile Coho tend to use the same habitats as pikeminnows, a possible reason that Coho are not present in Central Valley watersheds. Juvenile Coho would be highly vulnerable to predation from larger pikeminnows during warm-water periods. Pikeminnow are limited to only a few SONCC Coho streams and they are not present in the Klamath River basin. When the water cools in the fall, juvenile Coho move further into backwater areas or into off-channel areas and beaver ponds if available. There is often no water velocity in the areas inhabited by Coho during the winter. These same off-channel habitats are often dry or unsuitable during summer because temperatures get too high.

Lewiston Dam blocks access to 109 miles of upstream habitat (U.S. Department of the Interior 2000). Trinity River Hatchery produces Coho Salmon with a production goal of 300,000 yearlings to mitigate for the upstream habitat loss. Habitat in the Trinity River has changed since flow regulation with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al 2000). According to the Trinity River Restoration Plan, higher peak flows are needed to restore attributes of a more alluvial river such as alternate bar features and more off-channel habitats. These are projected in the restoration plan to provide better rearing habitat for Coho Salmon than the dense riparian vegetation currently present. Physical habitat manipulations have been implemented providing better juvenile rearing in selected sites along the river.

2.16.5 Water Operations

Reclamation makes releases from Lewiston Dam in accordance with the Trinity ROD, which considers requirements for Coho in the Trinity River. Increases in Trinity River releases in the late summer and fall result in lower storage in Trinity Reservoir at the end of the water year. The decreases in storage accumulate from water year to water year when the reservoir does not refill resulting in lower end-of-summer storages, negative impacts on cold water pool, and warmer stream temperatures for Coho and Fall-Run Chinook Salmon spawning in the Trinity River.

2.16.6 Recovery and Management

Reclamation is currently working on a Hatchery Genetics Management Plan for Trinity River Hatchery Coho.

2.17 Coho Critical Habitat

The critical habitat designation includes all waterways, substrate, and adjacent riparian zones, excluding: (1) areas above specific dams identified in the *Federal Register* notice (including Lewiston Dam); (2) areas above longstanding, natural impassable barriers (i.e., natural waterfalls in existence for at least several hundred years); and (3) Indian tribal lands.

2.18 Eulachon

2.18.1 ESA Listing Status

The southern DPS of Eulachon was listed as threatened under the ESA on March 18, 2010 (75 FR 13012) and the listing was reaffirmed on April 1, 2016. Critical habitat was designated on October 20, 2011 (76 FR 65324). The listing encompassed all spawning populations in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010).

2.18.2 General Life History and Habitat Requirements

Eulachon are an anadromous fish, meaning adults spend most of their life in the ocean but migrate into freshwater to spawn. Although they spend 95 to 98 percent of their lives at sea (Hay and McCarter 2000), current data only provides an incomplete picture concerning their saltwater existence. Their offspring hatch in freshwater but are carried to the estuary/ocean as larvae by the flow of the natal creek or river. The species is endemic to the northeastern Pacific Ocean, ranging from Northern California to the

southeastern Bering Sea in Bristol Bay, Alaska (McAllister 1963; Scott and Crossman 1973; Willson et al. 2006). This distribution coincides closely with the distribution of the coastal temperate rainforest ecosystem on the west coast of North America (with the exception of populations spawning west of the Cook Inlet in Alaska).

Eulachon eggs can vary considerably in size but typically are approximately 1 mm (0.04 in) in diameter and average about 43 mg (0.002 oz) in weight (Hay and McCarter 2000). Eggs are enclosed in a double membrane; after fertilization in the water, the outer membrane breaks and turns inside out, creating a sticky stalk that acts to anchor the eggs to the substrate (Hart and McHugh 1944; Hay and McCarter 2000). Eulachon eggs hatch in 20–40 days with incubation time dependent on water temperature (Howell 2001). Shortly after hatching, the larvae are carried downstream and dispersed by estuarine, tidal, and ocean currents. It is not known how long larval Eulachon remain in the estuary before entering the ocean. Similar to salmon, juvenile Eulachon are thought to imprint on the chemical signature of their natal river basins. However, because juvenile Eulachon spend less time in freshwater environments than do juvenile salmon, researchers hypothesize that this short freshwater residence time may cause returning Eulachon to stray between spawning sites at higher rates than salmon (Hay and McCarter 2000).

Once juvenile Eulachon enter the ocean, they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in 9 waters 20–150 m deep (66–292 ft) (Hay and McCarter 2000) and sometimes as deep as 182 m (597 ft) (Barraclough 1964). There is currently little information available about Eulachon movements in nearshore marine areas and the open ocean. However, Eulachon occur as bycatch in the pink shrimp fishery (Hay et al. 1999; Olsen et al. 2000; NWFSC 2008; Hannah and Jones 2009), which indicates that the distribution of these organisms overlaps in the ocean.

Eulachon typically spend several years in salt water before returning to fresh water to spawn from late winter through early summer. Spawning grounds are typically in the lower reaches of larger rivers fed by snowmelt (Hay and McCarter 2000). Willson et al. (2006) concluded that the age distribution of Eulachon in a spawning run varies considerably, but typically consists of fish that are 2–5 years old. Eulachon eggs commonly adhere to sand (Langer et al. 1977) or pea-sized gravel (Smith and Saalfeld 1955), though eggs have been found on a variety of substrates, including silt, gravel to cobble sized rock, and organic detritus (Smith and Saalfeld 1955; Langer et al. 1977; Lewis et al. 2002). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel (Langer et al. 1977). The sexes must synchronize their activities closely, unlike some other group spawners such as herring, because Eulachon sperm remain viable for only a short time, perhaps only minutes (Hay and McCarter 2000). Eulachon are semelparous, meaning that they spawn once and then die. In many rivers, spawning is limited to the part of the river that is influenced by tides (Lewis et al. 2002), but some exceptions exist. In the Berners Bay system of Alaska, the greatest abundance of Eulachon is observed in tidally-influenced reaches, but some fish ascend well beyond the tidal influence (Willson et al. 2006). Eulachon once ascended more than 160 km (100 mi) in the Columbia River system (Smith and Saalfeld 1955). There is some evidence that water velocity greater than 0.4 meters/second (1.3 ft/second) begins to limit the upstream movements of Eulachon (Lewis et al. 2002).

Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al. 1954; Smith and Saalfeld 1955; Spangler 2002). Spawning generally occurs in January, February, and March in the Columbia River, the Klamath River, and the coastal rivers of Washington and Oregon, and April and May in the Fraser River. Eulachon runs in central and northern British Columbia typically occur in late February and March or late March and early April. Eulachon typically spawn when water levels are lower and prior to spring freshets (Lewis et al. 2002). Rivers that experience Eulachon

spawning generally have the characteristics of spring freshets caused by melting snow packs or glaciers (Hay and McCarter 2000). However, attempts to characterize Eulachon run timing are complicated by marked annual variation in timing. Willson et al. (2006) give several examples of spawning run timing varying by a month or more in rivers in British Columbia and Alaska. Water temperature at the time of spawning varies across the distribution of the species. Although spawning generally occurs at temperatures from 4 to 7°C (39 to 45° F) in the Cowlitz River (Smith and Saalfeld 1955), and at a mean temperature of 3.1°C (37.6° F) in the Kemano and Wahoo Rivers, peak Eulachon runs occur at noticeably colder temperatures (between 0 and 2°C [32 and 36° F]) in the Nass River. The Nass River run is also earlier than the Eulachon run that occurs in the Fraser River, which typically has warmer temperatures than the Nass River (Langer et al. 1977). Water temperatures between 4 and 10°C is preferred for adults entering the Columbia River (WDFW and ODFW, 2001). Sudden increases in temperatures above this range can lead to adult mortality and spawning failure (Blahm and McConnell 1971).

Eulachon larvae and juveniles eat a variety of prey items, including phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, and worm larvae (Barraclough 1967, Barraclough and Fulton 1967, Robinson et al. 1968a, 1968b). Eulachon adults feed on zooplankton, chiefly eating crustaceans such as copepods and euphausiids (Hart 1973; Scott and Crossman 1973; Hay 2002; Yang et al. 2006), unidentified malacostracans (Sturdevant 1999), and cumaceans (Smith and Saalfeld 1955). Adults and juveniles commonly forage at moderate depths (20 to 150 m [66 to 292 ft]) in nearshore marine waters (Hay and McCarter 2000). Eulachon adults do not feed during spawning (McHugh 1939; Hart and McHugh 1944).

2.18.3 Historical and Current Abundance

Eulachon spawn in rivers from southwestern Alaska to Northern California. The southern DPS encompasses spawning populations in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010). Historically, the only large river basins in the contiguous United States with large, consistent spawning runs were the Klamath River in Northern California and the Umpqua River in Oregon. However, Eulachon have been found both frequently and infrequently in other coastal rivers within this range, including the Mad River, Redwood Creek, and Humboldt Bay in California (Monaco et al. 1990; Willson et al. 2006, as cited in Gustafson et al 2010).

There are no reliable historical abundance estimates for Eulachon. Available information (based largely on commercial fishery records) indicates that, starting in 1994, the southern DPS of Eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Since the 2010 listing, improved monitoring of Eulachon in several rivers detected general increases in adult spawning abundance, especially in 2013-2015 (NMFS 2016). However, sharp declines in Eulachon abundance occurred in 2016 and 2017 likely in response to poor conditions in the north east Pacific Ocean (NMFS 2017). The likelihood that these conditions will persist into the near future suggest that declines may again be widespread in upcoming years (NMFS 2017).

2.18.4 Limiting Factors, Threats, and Stressors

Factors that have been identified as major threats to southern DPS Eulachon include climate change impacts on marine and freshwater habitat, bycatch in offshore shrimp and groundfish fisheries, changes in flow quantity due to dams or water diversions, and predation (Gustafson et al. 2010). Because of similar trends in abundance across their range, large-scale oceanic and atmospheric patterns in the northeast Pacific Ocean associated with both natural climate variability and anthropogenic-forced climate change is likely the principal threat to Eulachon (NMFS 2017). The relationship between ocean conditions and population dynamics of Eulachon suggests that marine survival, most likely during the first weeks or

month in the ocean, may have a large influence on overall survival and adult recruitment (NMFS 2016). Consequently, anomalously warm marine and freshwater conditions combined with below average precipitation may have contributed to poor returns of spawning adults in recent years (NMFS 2017). In 2010, an analysis of these threats, together with large declines in abundance, indicated that the southern DPS of Eulachon was at moderate risk of extinction throughout its range (Gustafson et al. 2010, 2012). NMFS's recent threats analysis indicated that the collective risk to the persistence of Eulachon has not changed significantly since the listing determination (NMFS 2016).

2.18.5 Water Operations Management

Reclamation currently does not manage for Eulachon, although they benefit from TRRP ROD flows and other releases in the Trinity River.

2.18.6 Recovery and Management

The Recovery Plan for Southern DPS of Eulachon (NMFS 2017) established recovery goals, objectives, and delisting criteria that NMFS will use in future ESA status reviews. The recovery goals for Eulachon are to (1) increase abundance and productivity of Eulachon, and (2) protect and enhance the genetic, life history, and spatial diversity of Eulachon throughout its geographical range, and reduce existing threats to warrant delisting of the species. Conservation actions that have been implemented in the U.S. and Canada to support recovery efforts include state regulations requiring the use of bycatch reduction devices in ocean shrimp fisheries, commercial and recreational fishery closures and catch prohibitions, seasonal dredging restrictions, dam removal, and Salmon and Steelhead habitat restoration projects (NMFS 2017). In recent years, the states of Oregon and Washington opened a limited-opportunity Eulachon fishery to better understand trends and variability in Eulachon abundance, fill critical information gaps on species biology and distribution, support cultural traditions of Northwest tribes, and provide limited public and commercial opportunities for Eulachon harvest to promote public engagement in Eulachon conservation and recovery (NMFS 2107).

2.18.7 Monitoring and Research

NMFS proposes to advance the conservation of Eulachon by working with stakeholders to continue to implement actions that further reduce the severity of threats to Eulachon, as well as develop a comprehensive research program to improve understanding of Eulachon population abundance and demographics, and understanding of large-scale threats (e.g., climate change) on Eulachon productivity, recruitment, and persistence (NMFS 2017). Specific research and monitoring needs include implementation of annual in-river spawning stock surveys and distribution surveys (e.g., environmental DNA), and identification of data and assessment needs to monitor annual variability and long-term trends in abundance, productivity, and viability of Eulachon across their range.

2.19 Eulachon Critical Habitat

Critical habitat was designated under the ESA for southern DPS Eulachon on October 20, 2011 (76 FR 65324). Critical habitat extends from the Elwha River in Washington to the Mad River in California. In California, designated critical habitat includes the Klamath River, Redwood Creek and Mad River. NMFS identified the following physical or biological features as essential for conservation of the southern DPS of Eulachon:

1. Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation.
2. Freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.
3. Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Critical habitat does not include any Indian lands of the following federally-recognized tribes in the States of California, Oregon, and Washington: Lower Elwha Tribe, Washington; Quinault Tribe, Washington; Yurok Tribe, California; and Resighini Rancheria, California.

2.20 Riparian Brush Rabbit

2.20.1 ESA Listing Status

The USFWS listed riparian brush rabbit (*Sylvilagus bachmani riparius*) as an endangered species under the Endangered Species Act (ESA) on February 23, 2000 (65 FR 8881).

2.20.2 Critical Habitat Designation

No critical habitat rules have been published for the riparian brush rabbit.

2.20.3 General Life-History and Habitat Requirements

Riparian brush rabbits prefer dense, brushy areas of valley riparian forests, marked by extensive thickets of wild rose (*Rosa* spp.), blackberries (*Rubus* spp.), and willows (*Salix* spp.). Riparian brush rabbits prefer to remain hidden under protective shrub cover and seldom venture more than a few feet from cover. A typical response to danger is to retreat back into cover rather than to be pursued in open areas (USFWS 1998).

Riparian brush rabbits feed at the edges of shrub cover rather than in large openings (e.g., along trails, fire breaks, edges of thickets). Their diet consists of herbaceous vegetation such as grasses, sedges, clover, forbs, buds, bark and leaves of woody plants, and vines (USFWS 1998).

The approximate breeding season of riparian brush rabbits is from January to May. In favorable years, females may produce three or four litters. The young are born in a shallow burrow or cavity lined with grasses and fur and covered by a plug of dried vegetation. Although these rabbits have a high reproductive rate, five out of six rabbits typically do not survive to the next breeding season (USFWS 1998).

2.20.4 Historical and Current Distribution and Abundance

One of eight subspecies of brush rabbit in California, the riparian brush rabbit occupies a range that is disjunct from other brush rabbits, near sea level on the northwestern floor of the San Joaquin Valley (USFWS 1998). Populations are known to have historically occurred in riparian forests on the valley floor along the San Joaquin and Stanislaus Rivers and some tributaries of the San Joaquin River (USFWS 1998).

2.20.5 Limiting Factors, Threats, and Stressors

The primary threats to the survival of riparian brush rabbit are the limited extent of its existing habitat, extremely low numbers of individual animals, and few extant populations. The small sizes of its remaining populations, the localization of the behavior of the subspecies, and the highly limited and fragmented nature of remaining habitat restrict natural dispersal and put the species at risk from a variety of environmental factors.

Flooding is a key issue for riparian brush rabbits and thought to be responsible for major population declines. Riparian brush rabbits are closely tied to brushy cover and will generally not cross large, open areas. Thus, they are unable to disperse beyond the dense brush, making them susceptible to mortality during flood events (Williams 1988; USFWS 1998). Climate change likely to increase the severity of flooding, impacting riparian brush rabbit.

Periodic flooding still occurs along all major rivers in the Central Valley (Kindel 1984). With behavioral restrictions on its freedom of movement (low mobility) and the shortage of habitat that is suitably protected from frequent floods downstream of Caswell Memorial State Park, there is little chance that individuals escaping drowning or predation will be able to meet mates or reproduce (USFWS 1998).

Wildfire also pose a major threat. Long-term fire suppression combined with prolonged drought conditions can result in the buildup of high fuel loads from dead leaves, woody debris, and senescent flammable shrubs. The dense, brushy habitat to which the rabbits are restricted is thus highly susceptible to catastrophic wildfire that would cause both high mortality and destruction of habitat.

Like most rabbits, the riparian brush rabbit is subject to a variety of common contagious, and generally fatal, diseases that could be transmitted easily to riparian brush rabbits from neighboring populations of desert cottontails. For these small remnant brush rabbit populations, this kind of epidemic could quickly eliminate the entire population (Williams 1988; USFWS 1998).

A wide variety of aerial and terrestrial predators prey on riparian brush rabbit, including various raptors, coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), long-tailed weasel (*Mustela frenata*), mink (*Neovison vison*), raccoon (*Procyon lotor*), snakes, feral dogs (*Canis lupus familiaris*), and feral cats (*Felis catus*) (Kelly et al. 2011). A robust population of the riparian brush rabbit should be able to withstand predation, but habitat adjacent to residential properties or along public roads or waterways, or subject to human disturbance, can exacerbate predation risk (Kelly et al. 2011). The black rat (*Rattus rattus*) is an exotic invasive species that may be a threat to riparian brush rabbit populations by preying on offspring and competing for resources.

2.20.6 Recovery Considerations

The USFWS finalized the recovery plan for upland species of the San Joaquin Valley in 1998, which includes the riparian brush rabbit. Additionally, the riparian brush rabbit has limited coverage under the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* (SJMSCP 2000).

The following are important components of riparian brush rabbit habitat when considering recovery actions:

- Large patches of dense brush composed of riparian vegetation such as blackberry (*Rubus* spp.), California wild rose (*Rosa californica*), and low-growing willows (*Salix* spp.), or other dense shrub species.

- Ecotonal edges of brushy species to grasses and herbaceous forbs.
- Scaffolding plants (dead or alive) for blackberry and rose to grow tall enough to withstand flood events.
- A tree overstory that is not closed, if present.
- High-ground refugia from flooding.

2.20.7 Monitoring and Research Programs

The San Joaquin River National Wildlife Refuge encompasses approximately 7,000 acres located where the Tuolumne, Stanislaus, and San Joaquin Rivers join, creating a mix of habitats for terrestrial wildlife and plant species. Initially established to protect and manage habitat for the Aleutian Cackling Goose, the refuge is currently managed to provide habitat for migratory birds and endangered wildlife species (USFWS 2012). River Partners have been working on increasing riparian brush rabbit population size; their restoration actions continue today and are expected to be completed in 2025. Over 500,000 native trees and shrubs such as willow, cottonwood, oak, blackberry, and rose have been planted across 2,200 acres of river floodplain within the San Joaquin River National Wildlife Refuge, creating the largest block of contiguous riparian woodland in the San Joaquin Valley. Endangered riparian brush rabbits have been reintroduced to this restored habitat from captive-reared populations. The goal is to have increased the available habitat for the riparian brush rabbit by more than 30 times its 1997 extent. The restored habitat will protect the population from nearing extinction in inevitable future flood events.

In 2015, Reclamation provided additional funds to the River Partners to restore 175 acres of historic floodplain forest that are now degraded back to riparian floodplain habitat at Dos Rios Ranch to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), least Bell's vireo, and western yellow-billed cuckoo in Stanislaus County. After successful pilot studies, two berms were strategically notched and removed from the landscape in 2018, which reconnected the endangered riparian brush rabbit and nine other endangered species to seasonally flooded land (River Partners 2018).

2.21 Riparian Woodrat

2.21.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed riparian woodrat (*Neotoma fuscipes riparia*) as an endangered species under the ESA on February 23, 2000 (65 FR 8881).

2.21.2 Critical Habitat Designation

No critical habitat rules have been published for the riparian woodrat.

2.21.3 General Life-History and Habitat Requirements

Riparian woodrats are most numerous where shrub cover is dense and least abundant in open areas. In riparian areas, highest densities of riparian woodrats and their houses are often encountered in willow thickets with an oak overstory. They are common where there are deciduous valley oaks, but few live oaks. Mostly active at night, the riparian woodrat's diet is diverse and principally herbivorous. Their diet consists of leaves, fruits, terminal shoots of twigs, flowers, nuts, and fungi (USFWS 2000).

Riparian woodrats are well known for their large terrestrial stick houses some of which can last for 20 or more years after being abandoned. At Caswell Memorial State Park, riparian woodrats construct houses of sticks and other litter. Houses are typically placed on the ground or against/straddling a log or exposed roots of a standing tree and are often located in dense brush. Nests also are placed in the crotches and cavities of trees and in hollow logs. Sometimes arboreal nests are constructed, but this behavior seems to be more common in habitat with evergreen trees such as live oak. With their general dependence on terrestrial stick houses, riparian woodrats can be vulnerable to flooding.

Riparian woodrats live in loosely cooperative societies and have a matrilineal (mother-offspring associations; through the maternal line) social structure. Unlike males, adjacent females are usually closely related and, unlike females, males disperse away from their birth den and are highly territorial and aggressive, especially during the breeding season. Consequently, populations are typically female-biased and, because of pronounced polygyny (mating pattern in which a male mates with more than one female in a single breeding season), the effective population size (i.e., successful breeders) is generally much smaller than the actual population size. This breeding system in combination with the small size of the only known extant population suggests that the riparian woodrat could be at an increased risk of extinction because of inbreeding depression.

2.21.4 Historical and Current Distribution and Abundance

Historical records for the riparian woodrat are similarly distributed along the San Joaquin, Stanislaus, and Tuolumne Rivers, and Corral Hollow, in San Joaquin, Stanislaus, and Merced Counties (Hooper 1938; Williams 1986). Thus, prior to the statewide reduction of riparian communities by nearly 90 percent (Katibah 1984), the riparian woodrat probably ranged throughout the extensive riparian forests along major streams flowing onto the floor of the northern San Joaquin Valley.

The range of the riparian woodrat is far more restricted today than it was in 1938 (Williams 1986). The only population that has been verified is the single, known extant population restricted to about 100 ha (250 acres) of riparian forest on the Stanislaus River in Caswell Memorial State Park. Williams (1993) estimated the size of this population at 437 individuals. Analysis of California Department of Water Resources land use maps indicate that there were approximately 50 acres (20 hectares) of “natural vegetation” present along the San Joaquin River near the type locality in 1988, though no woodrats have been seen in that area. Today there is no habitat for woodrats around El Nido, which is located about 5.5 miles (8.9 kilometers) east of the San Joaquin River, the closest possible riparian habitat.

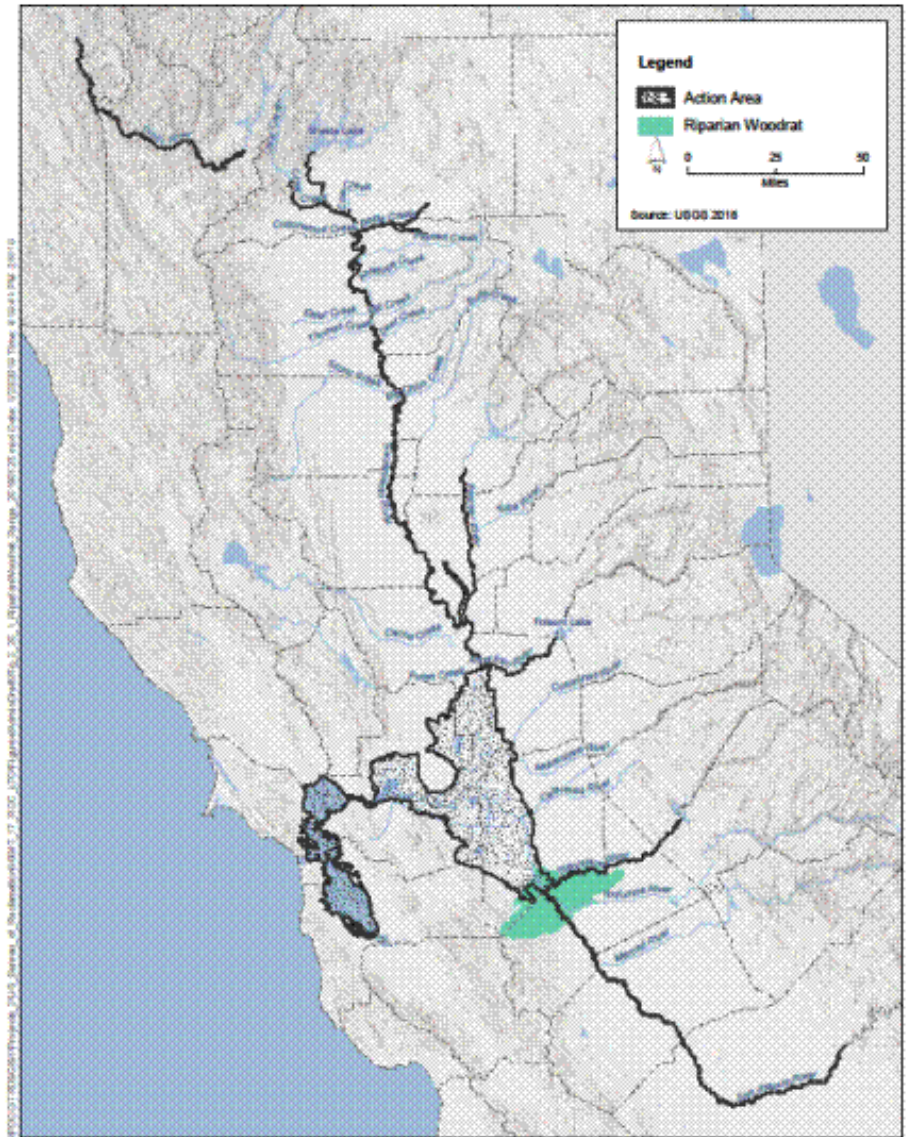


Figure 2.21-1. Riparian Woodrat Range

2.21.5 Limiting Factors, Threats, and Stressors

Loss, fragmentation, and degradation of habitat are the principal reasons for the decline of the riparian woodrat (USFWS 2000).

The most immediate threats to the single, small population of the species include naturally occurring events, such as drought, flooding of Caswell Memorial State Park lands, and wildfires. All of these environmental stressors are likely to increase in severity with climate change as California's snowpack decreases and watersheds move toward more precipitation driven hydrology (i.e., more variable). In addition, riparian woodrats are threatened by disease, predation, competition, clearing of riparian vegetation, use of rodenticide, and loss of genetic variability.

2.21.6 Recovery Considerations

The USFWS finalized the recovery plan for upland species of the San Joaquin Valley in 1998, which includes the riparian woodrat.

No specific conservation measures for the riparian woodrat are in place, but the species does receive some protection through the management plan for the riparian brush rabbit at the Caswell Memorial State Park.

2.21.7 Monitoring and Research Programs

The California Department of Parks and Recreation has supported some general small-mammal studies and woodrat population studies at the Caswell Memorial State Park (Cook 1992; Williams 1993).

In 2000, San Joaquin County developed a multispecies habitat conservation plan that considers habitat for the riparian woodrat. Some of the measures suggested under the plan may benefit or minimize negative impacts on the woodrat. A fire management plan has also been initiated for the Caswell Memorial State Park to protect habitat, but fires from outside sources still pose a threat.

In 2015, Reclamation provided additional funds to the River Partners to restore 175 acres of historic floodplain forest that are now degraded back to riparian floodplain habitat at Dos Rios Ranch to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, least Bell's vireo, and western yellow-billed cuckoo in Stanislaus County. After successful pilot studies, two berms were strategically notched and removed from the landscape in 2018, which reconnected the endangered riparian brush rabbit and nine other endangered species to seasonally flooded land (River Partners 2018).

Section 4(c)(2)(A) of the ESA requires that the USFWS conduct a review of listed species at least once every 5 years. The USFWS announced review of 34 species in California and Nevada on May 21, 2010 which included review of the riparian woodrat (75 FR 28636).

2.22 Salt Marsh Harvest Mouse

2.22.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed salt marsh harvest mouse (*Reithrodontomys raviventris*) as an endangered species under the ESA on October 13, 1970 (35 FR 16047).

2.22.2 Critical Habitat Designation

Critical habitat has not been designated for the salt marsh harvest mouse.

2.22.3 General Life-History and Habitat Requirements

Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed (*Salicornia virginica*). However, harvest mice can use a broader source of food and cover, including salt grass (*Distichlis spicata*) and other vegetation typically found in the salt and brackish marshes of the region. Salt marsh harvest mice are seldom found in cordgrass or alkali bulrush (*Scirpus americanus* and *S. maritimus*). In marshes with an upper zone of peripheral halophytes (salt-tolerant plants), they use this vegetation to escape the higher tides, and may even spend a considerable portion of their lives there. They also move into the adjoining grasslands during the highest winter tides. During the spring and summer months, some individuals will move from pickleweed marsh to bordering grasslands.

Breeding occurs from March through November. The salt marsh harvest mouse does little nest building, and nest structures are generally composed of a loose arrangement of grass. One or two litters may be produced annually with three to four young per litter.

2.22.4 Historical and Current Distribution and Abundance

The salt marsh harvest mouse is endemic to the marshes of the San Francisco Bay. There are two subspecies: the southern subspecies (*R. raviventris*) is found in the South San Francisco Bay (South Bay), the Corte Madera area, and Richmond area in the Central Bay; and the northern subspecies (*R. halicoetes*) is found in the Marin Peninsula, as well as in the tidal and brackish marshes of San Pablo and Suisun Bays (USFWS 2013).

In most of its range, the salt marsh harvest mouse is found in the upper half of tidal salt marshes, where shallow flooding, high tide cover, and escape habitat are available (Shellhammer and Barthman-Thompson 2015; USFWS 2013). They species also occurs in some of the South Bay brackish marshes (Shellhammer et al. 2010).

Differences in population sizes for the two subspecies can likely be attributed to differences in available marsh habitat and ecotones throughout the species' range (Shellhammer and Barthman-Thompson 2015; USFWS 2013). For example, due to loss of marsh habitat, population numbers are low throughout the range of the southern subspecies (Shellhammer et al. 2010). Conversely, population numbers are higher in the brackish marshes of northern and western Suisun Marsh, where there is both a higher quantity and quality of available habitat. A study conducted by Sustaita et al. (2011) found a positive correlation between the density and height of mixed vegetation and salt marsh harvest mouse numbers. Sustaita and colleagues (2011) reported large populations in both pickleweed-dominant (*Salicornia virginica*) areas and areas with mixed halophytes, such as fat hen (*Atriplex triangularis*), alkali heath (*Frankenia salina*), Baltic rush (*Juncus balticus*), Olney's threesquare bulrush (*Schoenoplectus americanus*) and other halophytic species. Additionally, the results showed that areas with mixed vegetation that were not dominated by pickleweed were often as productive as the pickleweed-dominant areas (Sustaita et al. 2011).

CDFW and DWR conducted a 2-year mark-recapture study to investigate demographic performance and habitat use of the northern subspecies of the endangered salt marsh harvest mouse in the Suisun Marsh. The studies examined the effects of different wetland types and microhabitats on three demographic variables: density, reproductive potential, and persistence. The results indicate that microhabitats

dominated by mixed vegetation or pickleweed supported similar salt marsh harvest mouse densities, reproductive potential, and persistence throughout much of the year. The studies showed that densities were higher in diked wetlands, whereas post-winter persistence was higher in tidal wetlands. The results emphasize the importance of mixed vegetation, where at least some vegetation is taller, and suggests that both diked and tidal wetlands support salt marsh harvest mouse populations by promoting different demographic attributes as well as adequate habitat. The southern subspecies, *R. raviventris*, occupies South San Francisco Bay marshes. Marshes in the South Bay generally lack the attributes that contribute to relatively high densities of mice in Suisun. South Bay marshes have lost most of their high marsh and upland ecotones to development, so mice have little escape cover during high tides.

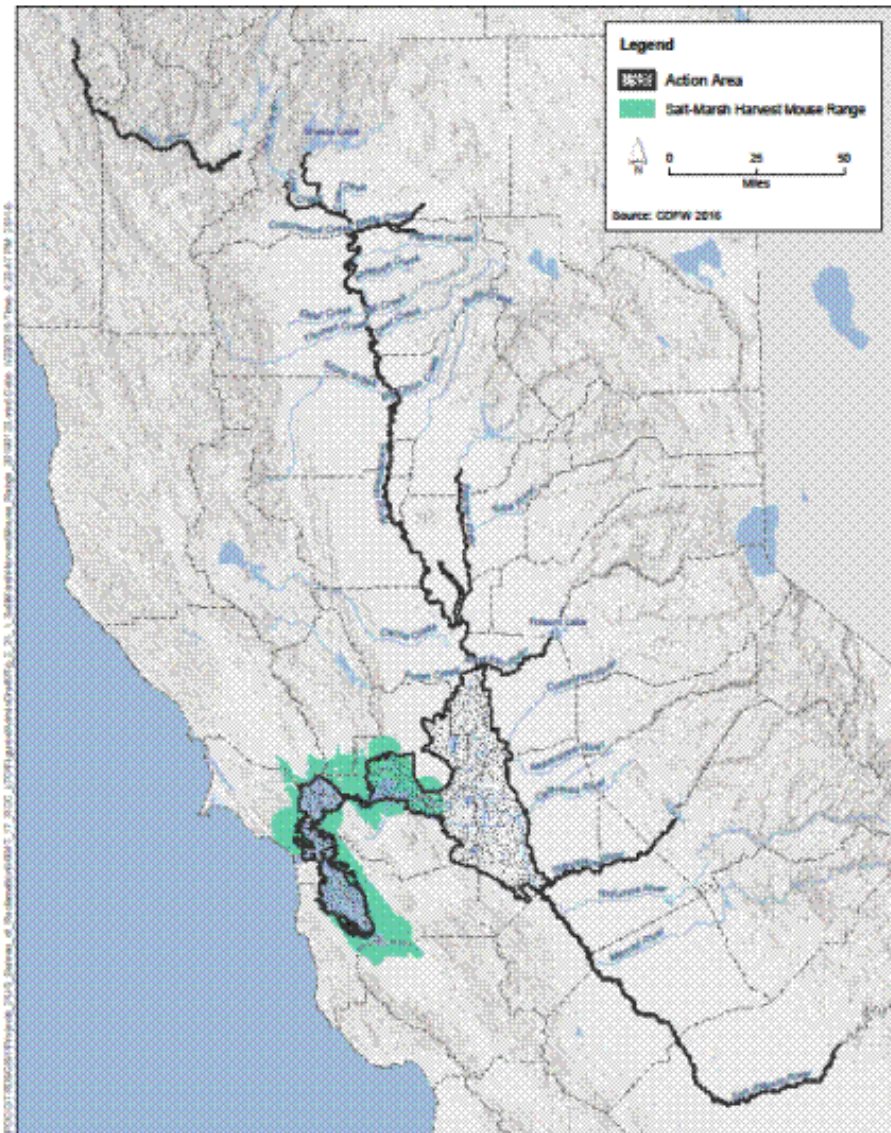


Figure 2.22-1. Salt Marsh Harvest Mouse Range

2.22.5 Limiting Factors, Threats, and Stressors

Salt marsh harvest mouse habitat loss can be ascribed to extensive urban and industrial development, particularly in the South Bay (USFWS 2013). Tidal marshes in the San Francisco Bay have lost the upper half of their mid-marsh zones, most of the high marsh zones, as well as most of the marsh/upland ecotones (Shellhammer and Barthman-Thompson 2015). Loss of the two latter areas means loss of escape cover during high tides. Many of the remaining South Bay marshes are very narrow, have poor vegetative cover, and reduce or prevent the movement of the salt marsh harvest mouse (Shellhammer and Duke 2010). Decreased sediment loads will likely result in narrowing of marshes (Cloern and Jassby 2012). The results are more and smaller populations that experience higher random genetic drift (Shellhammer and Duke 2010).

Climate change, particularly sea level rise due to climate change, will have a significant and negative impact on this species, especially in the South Bay where marshes are already narrow. For most of the mouse's range, marshes are bordered by developed land. Areas of undeveloped upland available as habitat and ecotone still exist, including the Coyote Hills in the South Bay and the Sears Point area in the San Pablo Bay. There are also protected areas along the eastern side of the Marin Peninsula, but unfortunately, they are vulnerable to steeply-rising waters. The Suisun Marsh, which is further inland, is not subjected to the same high tides as the San Francisco Bay. With less intense flooding, development, and infrastructure, Suisun Marsh provides better migration and survival rates (Shellhammer and Barthman-Thompson 2015).

Increased salinity from sea level rise coupled with lower precipitation from climate change could lead to vegetation loss, specifically pickleweed, and changes to vegetation composition (Padgett-Flohr and Isakson 2003; Shellhammer and Barthman-Thompson 2015). Intense flooding and storm events could eliminate cover and refugia, thereby increasing predation (Johnston 1957) and destroying nests (Hadaway and Newman 1971).

2.22.6 Recovery and Management

The *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* covers five endangered species, including the salt marsh harvest mouse. The overall goal of the recovery plan is comprehensive restoration and management of tidal marsh ecosystems. (USFWS 2013)

Population resilience can be increased in tidal salt marshes by acquiring existing, historic, and restorable tidal marsh in order to increase marsh size, connectivity, and expand high marsh and ecotone areas (Shellhammer and Barthman-Thompson 2015; USFWS 2013). One significant and successful endeavor for the southern subspecies is the South Bay Salt Pond Restoration Project, which began in 2003. Projects in San Pablo Bay and Suisun Marsh, where tidal action was restored, have benefited the northern subspecies. Improving marsh connectivity increases genetic exchange and avoids inbreeding depression (Shellhammer and Barthman-Thompson 2015). Increased marsh size, complexity, and the possibility for extension landward are critical to the species' survival.

Benefits to recreating large marshes include the development of raised overflow berms along their intermediate channels, which provide areas for marsh gumplant (*Grindelia robusta* var. *angustifolia*) to grow and offer escape cover from high tides (Shellhammer and Barthman-Thompson 2015). Restored marshes should have sloping upper edges where high marsh and transition zone vegetation can develop, even though the slopes will be narrow. One recurring dilemma with tidal restoration is that some areas to be diked have existing salt marsh harvest mouse populations (USFWS 2013). Because of this, unoccupied or unsuitable habitats have higher priority for tidal marsh restoration.

Salt marsh harvest mouse use of managed wetlands has been documented to be as high, or higher than, tidal wetland use (Sustaita et al. 2011). Downlisting of the salt marsh harvest mouse in the Suisun Bay Recovery Unit is achievable through 1,000 or more acres of muted or tidal marsh in the Western Suisun/Hill Slough Marsh Complex, 1,000 or more acres of muted or tidal marsh in the Suisun Slough/Cutoff Slough Marsh Complex, 1,500 or more acres of diked or tidal marsh in the Grizzly Island Marsh Complex, 1,000 or more acres of muted or tidal marsh in the Nurse Slough/Denverton Slough Marsh Complex, and 500 or more acres of muted or tidal marsh in the Contra Costa County Marsh Complex.

It is recommended that habitat management, restoration, and enhancement efforts include areas containing mixed vegetation, pickleweed in both diked and tidal wetlands, and areas that will accommodate sea level rise.

2.23 California Clapper Rail

2.23.1 ESA Listing Status

The USFWS listed California Ridgway's rail (*Rallus obsoletus obsoletus*), formerly California clapper rail (*Rallus longirostris obsoletus*), as an endangered species under the ESA on October 13, 1970 (35 FR 16047). Recent genetic analyses of rail species resulted in a change in the common name and taxonomy of the large, "clapper-type" rails (*Rallus longirostris*) of the west coast of North America to Ridgway's rail (*Rallus obsoletus*) (Maley and Brumfield 2013; Chesser et al. 2014). However, the change does not change the current listing status of the species. The USFWS will continue to recognize the species as the California clapper rail until the change in common name and taxonomy of the California clapper rail to Ridgway's rail is officially entered into the Federal Register.

2.23.2 Critical Habitat Designation

No critical habitat rules have been published for the species.

2.23.3 General Life-History and Habitat Requirements

The California Ridgway's rail is a year-round resident of tidally influenced salt and brackish marshes in the San Francisco Estuary. Areas used by California Ridgway's rails are dominated by pickleweed, Pacific cordgrass (*Spartina foliosa*), and salt grass in the lower tidal zone and taller pickleweed, gumplant, and wrack (the area where debris is deposited) in the upper tidal zone. They also can occupy habitats with other vegetative components, including bulrush, cattails (*Typha* spp.), and Baltic rush. Shrubby areas adjacent to or within the marsh may be important for predator avoidance during high tides. Nesting also occurs in this habitat.

California Ridgway's rails are most active in early morning and late evening, when they forage in marsh vegetation in and along creeks and mudflat edges. They are highly opportunistic feeders; principal food items include crabs, mussels, spiders, clams, snails, aquatic insects, isopods, pickleweed and Pacific cordgrass vegetation, seeds, and small fish. They often roost at high tide during the day.

The breeding season begins by February. Nesting starts in late March and extends into August. The end of the breeding season is typically defined as the end of August, which corresponds with the time when eggs laid during re-nesting attempts have hatched and young are mobile. Clutch sizes range from 5 to 14 eggs.

Both parents share in incubation and rearing. Nests are placed to avoid flooding by tides, yet in dense enough cover to be hidden from predators, generally on raised ground near tidal sloughs in low marsh habitats. The young are semiprecocial, incapable of moving from the nest for at least 1 hour after hatching and are brooded by the adults for several days. The young follow the adults during foraging and are able to forage independently on small prey soon after hatching.

2.23.4 Historical and Current Distribution and Abundance

The California Ridgway's rail is endemic to tidally influenced salt and brackish marshes of California. Historically, the California Ridgway's rail occurred in tidal marshes along California's coast from Morro Bay, in San Luis Obispo County, to Humboldt Bay, in Humboldt County. Thousands of California Ridgway's rails were eliminated by market hunters from the time of the Gold Rush until the passage of the Weeks-McLean Law in 1913, which was a precursor to the Migratory Bird Treaty Act of 1918 and was designed to stop commercial market hunting and illegal shipment of migratory birds from one state to another. Since that time, diking and filling for conversion to agriculture, urban development, and salt production have reduced the San Francisco Bay tidal marshes by 84 percent or more.

Currently, California Ridgway's rails are known to occur in tidal marshes in the San Francisco Estuary (estuary) (San Francisco, San Pablo, Grizzly, and Suisun Bays) (Olofson Environmental, Inc. 2011; CDFG 2011). California Ridgway's rails are typically found in the intertidal zone and sloughs of salt and brackish marshes dominated by pickleweed, Pacific cordgrass, *Grindelia*, saltgrass, jaumea, and adjacent upland refugia. They may also occupy habitats with other vegetative components, which include, but are not limited to, bulrush, cattails, and Baltic rush. In northern San Francisco Bay, California Ridgway's rails also occur in tidal brackish marshes that vary significantly in vegetation structure and composition, ranging from salt-brackish marsh to fresh-brackish marsh transitions (USFWS 2010a). Use of brackish marshes by California Ridgway's rails is largely restricted to major sloughs and rivers of San Pablo Bay and western Suisun Marsh, and along portions of Coyote Creek in the South Bay (USFWS 2010a). California Ridgway's rails were also found in nearly pure stands of alkali bulrush along Guadalupe Slough in 1990 and 1991 (H. T. Harvey & Associates 1990a, 1990b and 1991). On rare occasions, California Ridgway's rails have been recorded even farther upstream, in brackish/freshwater transition marshes, particularly during the non-breeding season.

The California Ridgway's rail population was first estimated (between 1971-1975) at 4,200 to 6,000 birds, of which 55 percent occurred in the South Bay and 38 percent in the Napa Marshes (Gill 1979). Although the population was estimated at only 1,500 between 1981-1987 (Harvey 1988), the difference between these two estimates is believed to be partially due to survey intensity. Breeding season density data indicate that populations remained stable during the 1970s (Gill 1979; Harvey 1988), but reached an estimated all-time historical low of about 500 birds in 1991, with about 300 California Ridgway's rails in the South Bay (Harding et al. 1998). California Ridgway's rail numbers have rebounded between the 1990s and 2007. However, substantial increases in population may be difficult to achieve due to the current disjunct distribution of their habitat (Albertson and Evens 2000). Bay-wide California Ridgway's rail numbers in the estuary have been declining overall since 2007, and the decline is highly correlated with efforts to eradicate invasive *Spartina* in the estuary. U.S. Geological Survey (USGS) data suggest that Bay-wide California Ridgway's rail call count numbers declined by as much as 50 percent between 2007 and 2011.

Point Blue Conservation Science (formerly PRBO Conservation Science) conducted estuary-wide surveys of the San Francisco Bay for California Ridgway's rail between 2005 and 2010. Results of the 2008 survey indicated only 543 rails, compared to 938 rails detected in 2007 (PRBO Conservation Science

2009a). In both years, the South Bay accounted for the majority of California Ridgway's rails. Between 2005 and 2008, the estimated estuary-wide total population of California Ridgway's rails decreased by about 21 percent (Liu et al. 2009). The South Bay population of California Ridgway's rails decreased by 54 percent between 2007 and 2008 (Liu et al. 2009). Invasive Spartina Project (ISP) California Ridgway's rail survey data collected at 30 sites from 2004 to 2010 also shows an overall decline in California Ridgway's rails. The population increased by 25 percent between 2005 and 2006 and by 25 percent again between 2006 and 2007. Then count numbers decreased by 35 percent between 2007 and 2008, by 32 percent from 2008 to 2009 and by 13 percent from 2009 to 2010.

Data collected by ISP from 2004 to 2010 at 30 sites within the San Leandro Bay, the Hayward region, the San Francisco Peninsula, and the Newark region showed a decline in California Ridgway's rail numbers from 519 in 2007 to 202 in 2010. USGS data suggest that, estuary-wide California Ridgway's rail call count numbers declined by approximately 50 percent between 2007 and 2011. According to the California Ridgway's Rail Population Monitoring Report: 2005–2008, the estuary-wide California Ridgway's rail population showed an overall negative trend (-20.6 percent, $P < 0.0001$) from 2005 to 2008, which can be mostly attributed to the 57 percent decline seen in the South Bay from 2007 to 2008 (PRBO Conservation Science 2009b). This decrease in the population of California Ridgway's rails in 2008 is highly correlated with large scale Spartina eradication during this period which resulted in the loss of cover. No new cover was created or enhanced for California Ridgway's rail to offset this loss.

In 2010, Point Blue Conservation Science detected an increase of California Ridgway's rails in San Pablo Bay and South San Francisco Bay, while ISP detected a decline at other locations. This difference suggests that mature marshes (surveyed by Point Blue Conservation Science) which received a high degree of hybrid Spartina control still provided enough native habitat to support stable California Ridgway's rail population, while young marshes (surveyed by ISP), where hybrid Spartina was a more significant component of marsh vegetation cover, no longer provided habitat for California Ridgway's rails because California Ridgway's rails in these marshes were dependent on the hybrid Spartina for cover. It is unknown if the increased number of California Ridgway's rails detected at some locations is due to high breeding success or is a result of immigration from marshes where Spartina treatment resulted in a loss of high tide refugia habitat. In addition, high tide surveys conducted by East Bay Regional Parks District showed decreases in California Ridgway's rail numbers in San Leandro Bay since 2007. An extreme decline on East Bay Regional Parks District land occurred at Arrowhead Marsh which decreased from 112 California Ridgway's rails in 2007 to 35 in 2010.

2.23.5 Limiting Factors, Threats, and Stressors

California Ridgway's rail populations are limited by their small size, habitat fragmentation, and lack of tidal channel systems and other micro-habitat features. These limitations render much of the remaining tidal marsh acreage unsuitable or of low value for the species. Habitat loss has dramatically slowed since the California Ridgway's rail was listed in 1970, but ongoing disturbance and degradation precludes or reduces occupation of much of the remaining potential habitat by California Ridgway's rails. Remaining habitat has been fragmented by levee systems that reduce and isolate patches of habitat, reduce or eliminate high marsh and refugial habitat, and make habitat accessible to predators and human disturbance. Habitat has been filled, subjected to many contaminants, converted to less suitable vegetation conditions by fresh wastewater discharges, and submerged by land subsidence caused by agricultural practices and groundwater overexploitation. Loss of upper marsh vegetation has greatly reduced available habitat throughout the range of the California Ridgway's rail.

In addition to the problems associated with landscape alteration caused by development, California coastal wetlands are expected to be subject to the effects of global sea level rise and climate change due to global warming. The effects of past subsidence of marsh plain relative to mean tidal level, particularly in the South Bay (Atwater et al. 1979), are likely to be amplified by rising tidal levels.

California Ridgway's rails vary in their sensitivity to human disturbance, both individually and between marshes. California Ridgway's rails have been documented nesting in areas with high levels of disturbance, including areas adjacent to trails, dikes, and roads heavily used by pedestrian and vehicular traffic (J. Didonato pers. comm.; Baye in litt. 2008). In contrast, Albertson (1995) documented a California Ridgway's rail abandoning its territory in the Laumeister Tract shortly after a repair crew worked on a nearby transmission tower. California Ridgway's rail reactions to disturbance may vary with season; however, both breeding and non-breeding seasons are critical times. Public trails that run along a narrow marsh transition zone may be particularly hazardous to California Ridgway's rails that depend on this habitat for refuge during high tides.

Throughout the estuary, the remaining California Ridgway's rail population is impacted by a suite of mammalian and avian predators and is exacerbated by at least 12 native and 3 nonnative predator species known to prey on various life stages of the California Ridgway's rail (Albertson 1995).

Mercury accumulation in eggs is perhaps the most significant contaminant problem affecting California Ridgway's rails in the estuary, with the South Bay containing the highest mercury levels. Mercury is extremely toxic to embryos and has a long biological half-life. Schwarzbach and colleagues (2006) found high mercury levels and low hatching success (due both to predation and, presumably, mercury) in California Ridgway's rail eggs throughout the estuary. California Ridgway's rail habitat is also at risk of contamination due to oil spills (Cosco Busan Oil Spill Trustees 2012).

2.23.6 Recovery and Management

The Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (Recovery Plan; USFWS 2013) is an expansion and revision of the California Clapper Rail and Salt Marsh Harvest Mouse Recovery Plan (USFWS 1984). The Recovery Plan features the California Ridgway's rail (formerly California clapper rail) along with four other endangered species. The Recovery Plan identifies high priority areas for tidal marsh and ecotone restoration including restoring tidal action to many of the salt ponds and other diked baylands along San Francisco Bay. Thousands of acres of former salt ponds and other diked baylands along San Francisco Bay have been restored or are proposed to be restored to tidal action (Service file number 81420-2008-F-0621; USFWS 2008b); however, it may take decades before

many of the heavily subsided areas within the former salt ponds accumulate enough sediment to become suitable tidal marsh habitat for California Ridgway's rails. The USFWS, on June 18, 2018 initiated 5-year status reviews for 50 species in California, Nevada, and the Klamath Basin of Oregon under the Endangered Species Act of 1973, as amended. A 5-year review is based on the best scientific and commercial data available at the time of the review; therefore, the USFWS is requesting submission of any new information on species that has become available since the last review.

2.23.7 Monitoring and Research Programs

The Don Edwards San Francisco Bay National Wildlife Refuge with assistance from the U.S. Department of Agriculture Wildlife Services currently manages mammalian and avian predators within California clapper rail habitat on its refuge lands in the South Bay and on DFW lands; however, the Predator Management Program is underfunded.

Although it has been suggested that habitat quality may be lower in brackish marshes than in salt marshes (Shuford 1993), further studies comparing reproductive success in different marsh types are necessary to determine the value of brackish marshes to California clapper rails.

2.24 Least Bell's Vireo

2.24.1 ESA Listing Status and Critical Habitat Designation

The least Bell's vireo (*Vireo bellii pusillus*) was listed as an endangered species by the USFWS on May 2, 1986 (51 FR 16474).

2.24.2 Critical Habitat Designation

Critical habitat, designated on February 2, 1994 (59 FR 4845 4867), is located in Santa Barbara, Ventura, Los Angeles, Riverside, San Bernardino, and San Diego Counties. No critical habitat for least Bell's vireo is present in the project Action Area or vicinity.

2.24.3 General Life-History and Habitat Requirements

Least Bell's vireo is an obligate riparian species during the breeding season, inhabiting structurally diverse woodlands along watercourses, including cottonwood-willow forests, oak woodlands, and mule fat (*Baccharis salicifolia*) scrub (USFWS 1998). Preferred breeding habitat generally consists of early successional, dense, low, shrubby vegetation in riparian areas, or young second-growth forest or woodland. This vireo is a subtropical migrant, typically arriving at breeding grounds in California from mid-March to early April. It can be highly territorial, and individuals have been known to return to the same breeding site, drainage, territory, and even nest tree each year, but birds may also disperse to new breeding sites (USFWS 1998). Birds may leave their breeding grounds as early as late July but are generally present until late September. Least Bell's vireos winter on the Baja California peninsula, where they occupy a variety of habitats, including mesquite scrub within arroyos, palm groves, and hedgerows bordering agricultural and residential areas (USFWS 1998).

Least Bell's vireos build their nest in dense cover in and along the edges of riparian habitat 3 to 6 feet off the ground, and within a dense, stratified canopy for foraging. Plant species composition and age are not important factors in nest site selection. Although least Bell's vireos nest in riparian habitat, they have also

been observed foraging in adjacent upland habitats (USFWS 1998). Within a few days after pair formation, least Bell's vireos begin building a nest, with both parents constructing the cup-shaped nest composed of leaves, bark, willow catkins, spider webs, and other materials. Both parents incubate the eggs, which usually takes 14 days. Clutch size is typically three to four eggs, but may be as few as two or, rarely, up to five eggs. Fledging occurs approximately 10 to 12 days after the eggs hatch, with the adults continuing to care for the fledglings for 2 weeks. Pairs may attempt as many as five nests in a breeding season, but typically do not start nests after mid-July (USFWS 1998). Least Bell's vireos average between 1.1 and 2.4 young fledged per year (USFWS 1998).

2.24.4 Historical and Current Distribution and Abundance

The least Bell's vireo is a small, insectivorous bird of the southwestern United States. Historically, least Bell's vireo was widespread and abundant, ranging from the interior of Northern California near Red Bluff in Tehama County southward through the Sacramento and San Joaquin Valleys and Sierra Nevada Foothills, and in the Coast Ranges from Santa Clara County south to San Fernando, Baja California, Mexico.

By the early 1980s, least Bell's vireo was extirpated from the Sacramento and San Joaquin Valleys, with the species restricted to two locations in the Salinas River Valley in Monterey and San Benito Counties, one location along the Amargosa River in Inyo County, and numerous small populations in southern California south of the Tehachapi Mountains and in northwestern Baja California, Mexico (USFWS 1998). At the time of listing in 1986, over 99 percent of the least Bell's vireo population was found south of Santa Barbara County (USFWS 2006a). Since 1986, there has been a tenfold increase in the recorded least Bell's vireo population, largely due to efforts to control brown-headed cowbird (*Molothrus ater*) (USFWS 2006a). Breeding pairs have been observed in Monterey, San Benito, Inyo, Santa Barbara, San Bernardino, Ventura, Los Angeles, Orange, Riverside, and San Diego Counties, with the highest concentration of birds in San Diego County along the Santa Margarita River (USFWS 2006a). Pairs have also been observed exhibiting nesting behaviors in 2010 and 2011 in Yolo County within the Action Area (CDFW 2018). Although the breeding records do not yet support that least Bell's vireo has recolonized its historical breeding range in the San Joaquin and Sacramento Valleys (USFWS 2006a), the USFWS is including the small area around the 2010–2011 Yolo County unsuccessful nesting in the current range of the species (USFWS 2018).

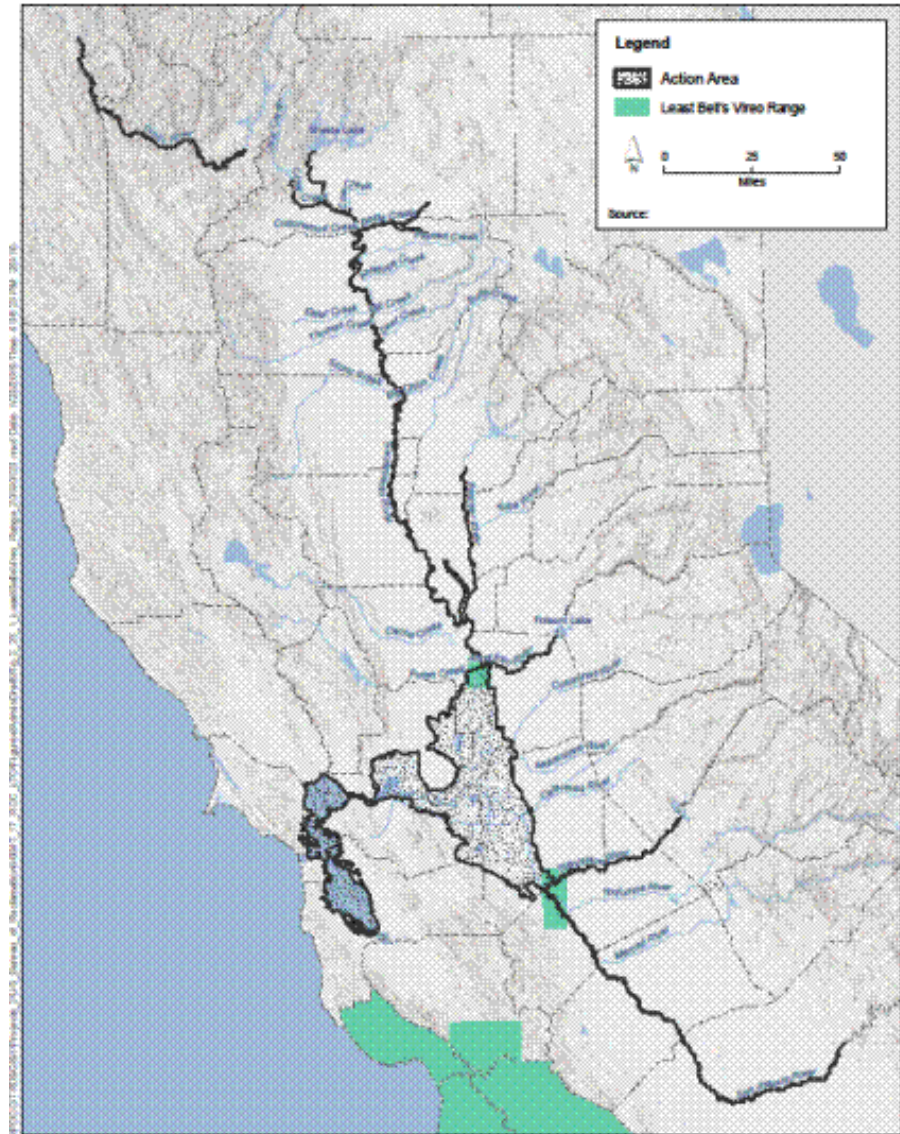


Figure 2.24-1. Least Bell's Vireo Range

2.24.5 Limiting Factors, Threats, and Stressors

The leading causes of least Bell's vireo decline include habitat loss and fragmentation resulting from stream channelization, flood control, water impoundment, water diversion, intensive recreation, agricultural conversion, livestock grazing, and urban development (Riparian Habitat Joint Venture [RHJV] 2004). Alteration of riparian landscapes can narrow or eliminate important population dispersal corridors. In addition, the degradation of riparian habitat resulting from construction of dams, levees, and diversions, clearing associated with farming and development, overgrazing, and invasion by exotic species can lead to disruption of natural hydrological conditions. Some of these factors may be exacerbated by climate change.

Another major threat to least Bell's vireo populations is the expansion of the range of the brown-headed cowbird, which acts as a brood parasite. Agricultural and livestock grazing areas located near riparian zones provide brown-headed cowbirds with ample foraging habitat close to songbird breeding grounds. Cowbird parasitism contributes to lowered productivity in host species through direct destruction of host eggs, competition between cowbirds and host chicks resulting in increased mortality, and nest abandonment in some species, all of which lower overall fecundity within a season (RHJV 2004). In addition, agricultural expansion and urbanization tend to reduce favorable conditions for top predators through habitat fragmentation and increased mortality from roadkill. The elimination of top predators, such as mountain lions (*Puma concolor*) and coyotes (*Canis latrans*), often results in an increased population of mid-level predators, such as raccoons, skunks, and domestic and feral cats, which are well documented nest predators (USFWS 2006bb; RHJV 2004).

2.24.6 Recovery and Management

Since its federal listing in 1986, along with intensive cowbird removal programs and riparian habitat protection, the population of Least Bell's Vireo has increased in the southern portion of its historic range, particularly in San Diego and Ventura counties, and is expanding northward (USFWS 1998). The USFWS prepared a Draft Recovery Plan for the Least Bell's Vireo in 1998. This plan details the importance of habitat conservation for Least Bell's Vireo recovery (USFWS 1998). Habitat features that are essential to Least Bell's Vireo conservation include riparian woodland vegetation that contains both canopy and shrub layers as well as associated upland habitat. Current threats to the remaining Least Bell's Vireo habitat that limit the ability for expansion of this habitat beyond its protected critical habitat core areas include stream channelization, water impoundment and extraction, water diversion, intensive recreation, and urbanization. Riparian areas are increasingly bordered by urban areas, whereas historically they were bordered by native upland plant communities. Vireo territories bordering agricultural and urban areas have been demonstrated to be less successful in producing young than territories bordering native upland plant communities (Kus 2002; USFWS 2006a).

2.25 Western Yellow-Billed Cuckoo

2.25.1 ESA Listing Status

The USFWS listed the western DPS of the yellow-billed cuckoo (*Coccyzus americanus*) as threatened on October 3, 2014 (79 FR 59992).

2.25.2 Critical Habitat Designation

Critical habitat, proposed on August 15, 2014 (79 FR 48547), includes sections of the Action Area along the Sacramento River from south of Red Bluff in Tehama County to Colusa, California. No final critical habitat has been designated for this species.

2.25.3 General Life-History and Habitat Requirements

The western yellow-billed cuckoo is a riparian obligate species, using riparian areas along low gradient rivers and streams and in valleys that provide floodplain conditions. Preferred habitat for this species consists of willow-cottonwood (*Salix-Populus*) riparian forest, but other tree species such as white alder (*Alnus rhombifolia*) and box elder (*Acer negundo*) may be important habitat components in some areas, including occupied sites along the Sacramento River (Laymon 1998). Potential habitat may also include valley marshland with willow riparian corridors, such as that found in the Llano Seco area of Butte County. Nesting habitat requires large expanses of willow-cottonwood forests (RHJV 2004). Along the Sacramento River, orchards of English walnut (*Juglans regia*), prune, and almond trees have also reportedly been used for nesting (Laymon 1980).

In western North America, yellow-billed cuckoos begin arriving from their wintering grounds in South America in mid- to late May (Hughes 1999). Nests usually consist of loose platforms of twigs lined with leaves or finer materials and, in the west, are often placed in willows, cottonwoods, and shrubs (Gaines and Laymon 1984). Clutch size ranges from one to five eggs, but is typically two to three (Hughes 1999). The entire period from egg laying to fledgling is one of the shortest among all bird species, lasting only 17 to 18 days, with incubation extending 9 to 11 days and nestlings fledging at 17 to 19 days of age (Hughes 1999). Young can typically fly at about 3 weeks of age. In years with a good food supply, yellow-billed cuckoos may lay two clutches of eggs. Although yellow-billed cuckoos usually raise their own young, they are facultative brood parasites, meaning they occasionally lay their eggs in nests of other yellow-billed cuckoos or of other bird species (Hughes 1999). They depart breeding grounds by early fall.

Yellow-billed cuckoos feed on katydids, caterpillars, cicadas, and other large insects. They forage in areas that are similar to breeding sites, but these areas may be smaller, narrower, and lack understory vegetation. Riparian vegetation is used by adults and young as a movement corridor between foraging sites and post-breeding dispersal areas. Western yellow-billed cuckoo may be found in a variety of vegetation communities during migration, including coastal scrub, secondary growth woodland, hedgerows, humid lowland forests, and forest edges below 8,125 feet above mean sea level, suggesting that the habitat needs of this species during migration are not as restricted as their habitat needs when nesting (Hughes 1999).

2.25.4 Historical and Current Distribution and Abundance

The yellow-billed cuckoo is a neotropical migrant bird that winters in South America and breeds in North America. The breeding range of the entire species formerly included most of North America, extending from southeastern and western Canada to the Greater Antilles in the Caribbean Sea and northern Mexico. At the time of the proposed listing, western yellow-billed cuckoo was not recognized as a separate subspecies and the USFWS determined that the western population segment, which nests in the portion of the United States west of the Continental Divide, is a DPS under the ESA.

The western DPS range has experienced significant reductions over the past 90 years. The northern limit of this species' breeding range along the west coast of the United States is now the Sacramento Valley. A small, potential breeding population exists in coastal Northern California along the Eel River (USFWS

2014b). In California, the yellow-billed cuckoo breeding range once extended from the Mexican border northward along the southern coast, and through the entire Central Valley (Grinnell and Miller 1944). However, its range is now generally restricted to the Sacramento Valley, the Kern River, and the lower Colorado River, with individuals occasionally reported in other areas (Laymon and Halterman 1987). The Sacramento Valley is believed to be a major population center for this species and the Sacramento River represents an area where yellow-billed cuckoo habitat has potentially increased over the last 30 years (Dettling and Howell 2011). The estimated breeding population in California is currently 40 to 50 pairs (78 FR 61639; October 3, 2013).

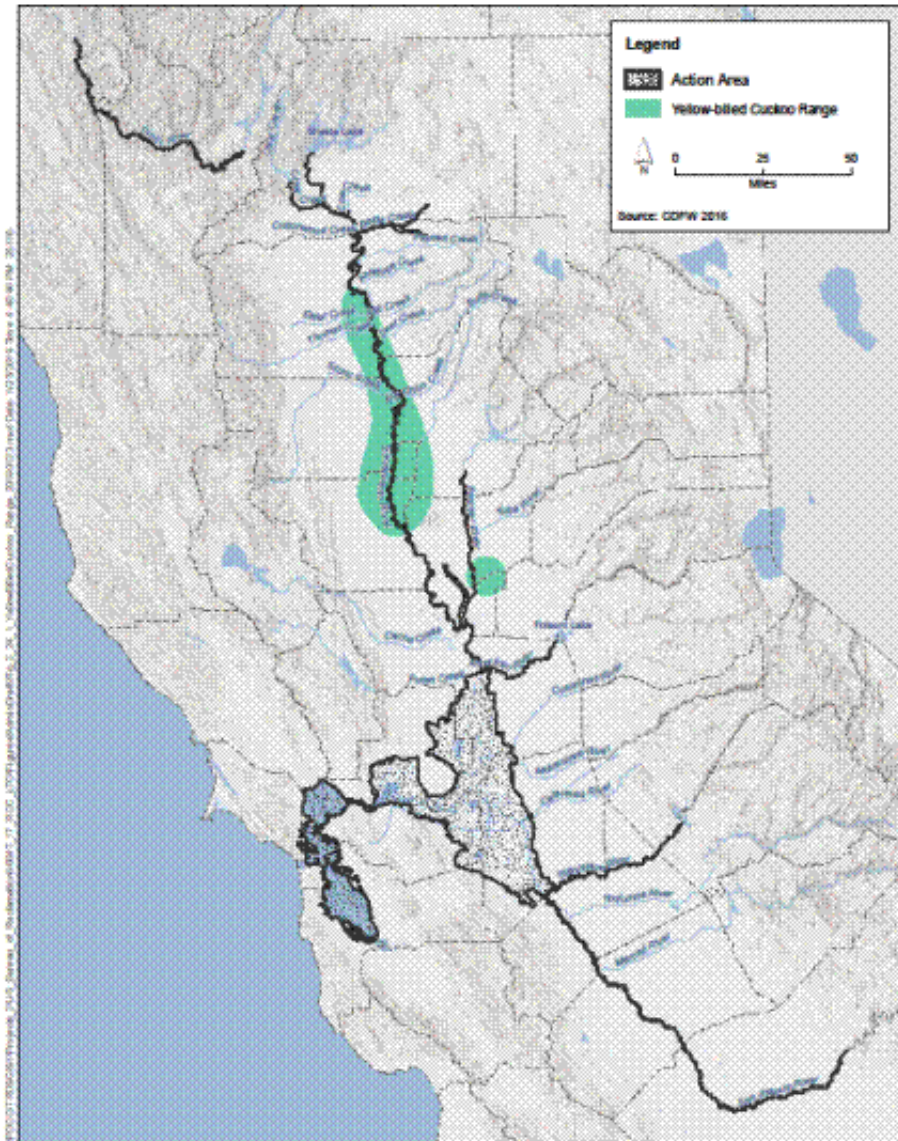


Figure 2.25-1. Western Yellow-Billed Cuckoo Range

2.25.5 Limiting Factors, Threats, and Stressors

Over the past 150 years, land use changes and alterations of river flow regimes have drastically reduced the amount of riparian forest in California and, therefore, the availability of breeding habitat for this neotropical migrant (Laymon and Halterman 1987). Because yellow-billed cuckoo is a riparian obligate, the range of this species in the western United States has become restricted to remaining isolated riparian forest fragments. Similarly, the number of western yellow-billed cuckoos in the western United States has declined substantially. The western population of cuckoos once ranged from northern Mexico to the Canadian border; however, they currently only breed in significant numbers in California, Arizona, New Mexico, and Texas (Gaines and Laymon 1984; Hughes 1999; USFWS 2014b).

Current threats to the yellow-billed cuckoo include habitat loss from flood control projects (including from ongoing maintenance), alterations to hydrology, development of urban and agricultural areas, climate change, and invasive species. The application of pesticides in riparian habitats and adjacent agricultural areas may affect the reproductive success of this species. In addition, a reduction in the availability of suitably sized prey may lead to the abandonment of nesting areas.

2.25.6 Recovery and Management

A recovery plan has not yet been developed for this species, so recovery efforts are based on general conservation needs. For a species like the Western Yellow-billed Cuckoo that has lost much of its former known occupied habitat, recovery would begin with the conservation of much of the remaining occupied and suitable habitat and restoration of suitable habitat that has been disturbed.

2.26 Giant Garter Snake

2.26.1 ESA Listing Status

The USFWS listed the giant garter snake (*Thamnophis gigas*) as a threatened species on October 20, 1993 (58 FR 54053) under the ESA.

2.26.2 Critical Habitat Designation

Critical habitat has not been designated for the giant garter snake.

2.26.3 General Life-History and Habitat Requirements

Endemic to the wetlands of the Sacramento and San Joaquin Valleys of California, giant garter snake historically inhabited tule marshes and seasonal wetlands created by overbank flooding of rivers and streams in the Central Valley. Present populations of giant garter snake inhabit agricultural wetlands and other waterways such as irrigation and drainage canals, sloughs, ponds, small lakes, low-gradient streams, and adjacent uplands. Because of the direct loss of natural perennial wetland habitat, the giant garter snake relies heavily on rice fields in the Sacramento Valley, but also uses managed marsh areas in federal National Wildlife Refuges and state Wildlife Areas.

The giant garter snake is approximately 15 times more active in aquatic habitats (Halstead et al. 2016), but at the same time Halstead et al. (2015) found high frequency use of terrestrial underground habitats to escape hot weather and for brumation. Giant garter snakes have been observed in uplands during the active spring and summer season up to hundreds of meters (hundreds of yards) from water bodies

(USFWS 2017c). The giant garter snake feeds primarily on aquatic prey, including small fish, frogs, and tadpoles.

Habitat requirements consist of adequate water during the active season (typically March through November) to provide food and cover; emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover from predators and foraging habitat during the active season. Essential habitat components consist of 1) freshwater aquatic habitat with protective emergent vegetation cover where snakes can forage; 2) upland habitat near the aquatic habitat that can be used for thermoregulation and summer shelter (i.e., burrows), and 3) upland refugia outside flood waters that can serve as winter hibernacula (U.S. Fish and Wildlife Service 2017).

Ideal giant garter snake aquatic habitat exhibits the following characteristics.

- Water present from March through November.
- Slow moving or static water flow with mud substrate.
- Presence of emergent and bankside vegetation that provides cover from predators and may serve in thermoregulation.
- Absence of a continuous canopy of riparian vegetation.
- Available prey in the form of small amphibians and small fish.
- Thermoregulation (basking) sites with supportive vegetation such as folded tule clumps immediately adjacent to escape cover.
- Absence of large predatory fish.
- Absence of recurrent flooding, or, where flooding is probable, the presence of upland refugia.

Because of the historic loss of natural wetlands, the preferred aquatic habitat for giant garter snake, rice fields and more importantly their associated canals and drainage ditches have become important habitat for giant garter snakes within agricultural areas. While giant garter snakes are known to use rice fields seasonally, the species is strongly associated with the canals that supply water to and drain water from rice fields; these canals provide much more stable habitat than rice fields because they maintain water longer and support marsh-like conditions for most of the giant garter snake active season (Reyes et. al. 2017). The giant garter snake active season extends approximately April through September. While flooded rice fields provide a component of aquatic habitat for giant garter snakes that occupy rice-growing regions, rice fields only provide adequate cover for the species for approximately one-third of their active season (Halstead et. al. 2016). In the Sacramento Valley, cultivated rice generally emerges from flooded fields in late May or early June, but sufficient growth that provides cover for snakes does not occur until approximately late June. Water is then drawn off the fields to allow them to dry in late August or early September.

In addition to providing foraging and refuge habitat, canals and ditches provide connectivity between occupied habitats. Giant garter snakes rely on canals and ditches as movement corridors through agricultural landscapes. These corridors provide important habitat, and are used during daily movement within a home range. Studies of marked snakes indicated that individuals typically move about 0.25 to 0.5 miles per day and individuals have been documented to move up to 5 miles over the course of a few days. (Wylie et al. 2002).

Throughout the winter dormancy period, giant garter snakes inhabit small mammal burrows and other soil or rock crevices above flood elevations, often as far as 656 to 820 feet (200 to 250 meters) from the edge

of summer aquatic habitat. They typically select burrows with sunny exposures along south- and west-facing slopes along canal banks, marshes, or even riprap. The breeding season extends from March into May, with females giving birth to live young from late July through early September (USFWS 2017). Brood size averages 17 to 23 young, but can range from 10 to 46 young. Newborn snakes immediately scatter into dense cover and soon begin feeding on their own. Giant garter snake growth rates are variable, with size typically doubling within a year. Sexual maturity averages 3 years for males and 5 years for females (USFWS 2017).

2.26.4 Historical and Current Distribution and Abundance

Historically, giant garter snake inhabited the Sacramento and San Joaquin Valleys—bounded by the Coast Range to the west and the Sierra Nevada to the east—from the vicinity of Chico in Butte County in the north to Buena Vista Lake in Kern County in the south. Currently, less than 5 percent of the historical 4.5 million acres (1.8 million hectares) of wetlands remain (USFWS 2017). Giant garter snake has been extirpated from the southern one-third of its range in former wetlands associated with the historical Buena Vista, Tulare, and Kern lakebeds. This species now occupies what remains of high-quality fragmented wetlands, including marshes, ponds, small lakes, and low-gradient streams with silt substrates, as well as managed waterways, including irrigation ditches, drainage canals, rice fields, and their adjacent uplands (USFWS 2017).

Occurrence records coincide with the historical distribution of large flood basins, freshwater wetlands, and tributaries of the Central Valley's Sacramento and San Joaquin watersheds. Recent genetic studies indicate that giant garter snake populations should be grouped by watershed basin. The current population groupings that are genetically and geographically distinct are: Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin, Cosumnes-Mokelumne Watershed, Delta Basin, San Joaquin Basin, and Tulare Basin. The Yolo Basin—the Liberty Farms, Burell, and Lanare populations are presumed extirpated (USFWS 2017).

Giant garter snake abundance has decreased throughout its range. The distribution of giant garter snake in the northern part of the range may still reflect its historic distribution; however, distribution in the San Joaquin Valley has been substantially reduced, with only a few recent sightings (USFWS 2017). In the Central Valley, giant garter snake relies heavily on rice fields, but also uses managed marsh areas in National Wildlife Refuges and state Wildlife Areas.

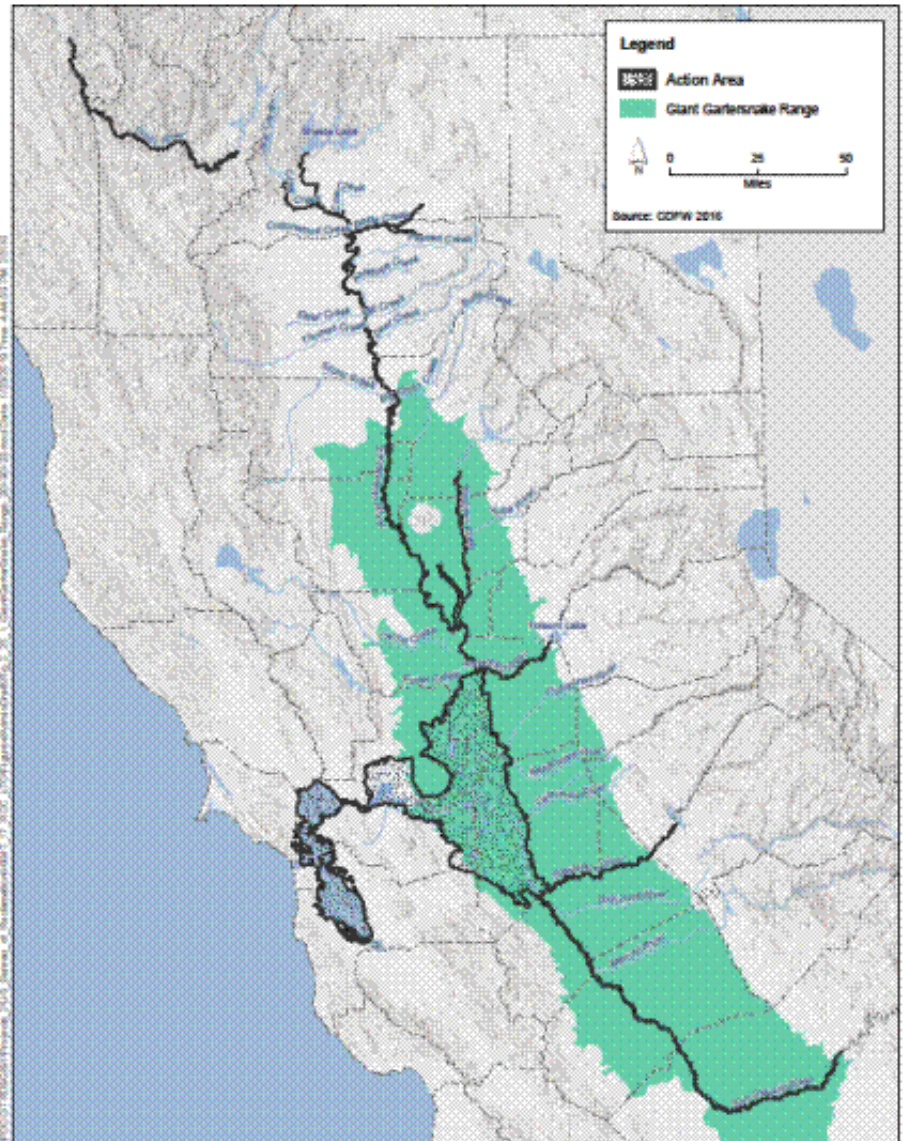


Figure 2.26-1. Giant Garter Snake Range

2.26.5 Limiting Factors, Threats, and Stressors

Habitat loss and fragmentation resulting from urbanization, agricultural conversion, and flood control activities are the main factors that have contributed to the decline of giant garter snake (USFWS 2017). Flood control activities, agricultural practices, and land and water management practices, such as wetland management for waterfowl, nonnative plant management, and water transfers, can alter the availability of summer water, thereby reducing habitat quality for giant garter snake. The loss of wetland ecosystems and suitable habitat has also resulted in giant garter snake using highly modified and degraded habitats among cultivated farm lands, including irrigation ditches, drainage canals, rice fields, and adjacent uplands. Current threats to giant garter snake include habitat loss and fragmentation due to urbanization; changes in the levels and methods of rice production; changes in water availability; levee and canal maintenance, water management, and water deliveries that do not take into account the requirements of the giant garter snake; water transfers (resulting from cropland idling/shifting, reservoir releases, conservation measures, or groundwater substitution); small population sizes; and invasive aquatic species (USFWS 2017).

Flood control and canal maintenance activities can subject snakes to ongoing risks of mortality and injury and can also lead to habitat fragmentation and dispersal barriers. Although giant garter snakes have been observed using rock riprap for thermoregulation, the flood control practice of lining streams and canals with large and extensive quantities of rock can be detrimental to wetland ecosystems and snakes by eliminating a natural thermal mosaic. Flood maintenance activities often include weed management, which destroys surface cover, and rodent eradication, which eliminates the occurrence and abundance of burrows and retreats that are used by giant garter snake for thermoregulation, for cover during shedding, and for over-wintering (USFWS 2012). Additional threats include predation, drought, climate change, roads (resulting in habitat fragmentation and vehicular threats), impaired water quality, selenium contamination, and mosquito abatement (USFWS 2017c).

A “mosaic of cover and water is likely beneficial” to snakes during the active season (Halstead et al. 2016). One study found that a lack of rice production adjacent to occupied canals appears detrimental to giant garter snake survival rates and populations. The study surmises that lower survival rates could be related to lower prey populations, increased predator presence, and a less secure water supply. This study supports the importance of maintaining water in canals adjacent to fallowed rice fields (Reyes et al. 2017). Research results indicate that there is a strong positive association between giant garter snake occupancy, soil classification, elevation, canal density, and the proportion of rice croplands (Hansen et al. 2017).

2.26.6 Recovery and Management

The USFWS finalized its giant garter snake recovery plan in 2017, with the recovery strategy focused on protecting existing, occupied habitat and identifying and protecting areas for habitat restoration, enhancement, or creation, including areas that are needed to provide connectivity between populations (USFWS 2017c). The three habitat components that are important for the giant garter snake include a freshwater aquatic component with protective emergent vegetation cover, nearby uplands that can be used for thermoregulation and summer shelter, and upland winter hibernacula (USFWS 2017c).

Protected waterfowl habitats in wildlife refuges are an important source of habitat for giant garter snake, but do not necessarily provide good habitat when they are flooded in winter and drained in summer. Rice fields and irrigation ditches, which are both flooded in summer, provide good habitat for this species.

2.26.7 Monitoring and Research Programs

In 2009, the California Department of Water Resources (DWR) developed a giant garter snake Baseline Monitoring and Research Strategy to help quantify and evaluate the response of the giant garter snake to rice land idling (USFWS 2015). DWR is working with the USGS Western Ecological Research Center (WERC) on the study of giant garter snake in the Sacramento Valley. The broad objective of this research effort is to provide scientific information to USFWS in support of identifying the effects of rice land idling for the purpose of water transfers on the species. Ultimately, the goal is to design conservation measures that will avoid and minimize effects on giant garter snake from rice land idling for water transfers. Once rice was emergent in the rice fields, giant garter snake used rice fields 39 to 60 percent of the time and canals 40 to 61 percent of the time. These results support that both rice fields and canals are important habitats for the species (Wylie and Casazza 2000a, 2000b).

Restored areas providing summer water were more effective in meeting the habitat needs of giant garter snake in the 2000-2001 study periods; therefore, giant garter snake did not have to venture as far as in previous years to find aquatic habitat during their active period. This was also found to be true for monitoring conducted during 2005. Sampling of the restored areas in Colusa NWR during the summers of 2002 and 2003 continued to document use of the restored wetland area as the habitat quality improves (USFWS 1999; Wylie and Casazza 2000a; Wylie et al. 2002).

The occurrence of rice agriculture, its supporting network of irrigation and drainage canals, and the restoration of marsh habitats currently provide suitable giant garter snake habitat. Research demonstrates, however, giant garter snake have not been able to disperse into all suitable habitats, and are largely restricted to areas near locations at which they were likely historically abundant (Halstead et al. 2016).

Central Valley Project Conservation Program (CVPCP) and Central Valley Project Improvement Act Habitat Restoration Program (HRP)

Developed during the Section 7 consultation process for the CVPIA and renewal of CVP water service contracts, the Central Valley Project Conservation Program (CVPCP) implements actions to protect, restore, and enhance special-status species populations and habitat, especially federally-listed species (USFWS 2015). Since the mid-1990s, the CVPCP and HRP have routinely identified and funded giant garter snake research and habitat improvement as top Priority Actions (USFWS 2015).

2.27 Soft Bird's Beak

2.27.1 ESA Listing

U.S. Fish and Wildlife Service (USFWS) listed soft bird's beak as an endangered species under ESA on November 20, 1997 (62 FR 61925).

2.27.2 Critical Habitat Designation

Critical habitat for soft bird's beak was designated in 2007 (72 FR 18536). The designated critical habitat areas contain physical and biological features (primary constituent elements [PCEs]) that are considered essential to the conservation of the species and that may require special management considerations and protection. The PCEs identified for soft bird's beak are: (1) persistent emergent, intertidal, estuarine wetland at or above the mean high-water line (as extended directly across any intersecting channels); (2)

rarity or absence of plants that naturally die in late spring (winter annuals); and (3) partially open spring canopy cover at ground level, with many small openings to facilitate seedling germination. In total, five critical habitat units covering approximately 2,276 acres (921 hectares) were designated. The critical habitat is located within Contra Costa, Napa, and Solano Counties at Fagan Slough Marsh, Hill Slough Marsh, Point Pinole Shoreline, Rush Ranch/ Grizzly Island Wildlife Area, and Southampton Marsh.

2.27.3 General Life-History and Habitat Requirements

Soft bird's beak is an annual herb of the snapdragon family (Scrophulariaceae). It grows 10 to 16 inches tall, branching sparingly from the middle and above. A floral bract (modified leaf) with two to three pairs of lobes occurs immediately below each inconspicuous white or yellowish-white flower. Flowers appear between May and September. Like other members of *Cordylanthus* and related genera, soft bird's beak is partially parasitic on the roots of other plants. Soft bird's beak is found predominantly in the upper reaches of salt grass/pickleweed marshes of the San Francisco Estuary at or near the limits of tidal action. It is associated with pickleweed (*Salicornia pacifica*), saltgrass (*Distichlis spicata*), fleshy or marsh jaumea (*Jaumea carnosa*), alkali seaheath (*Frankenia salina*) and seaside arrowgrass (*Triglochin maritima*).

2.27.4 Historical and Current Distribution and Abundance

Soft bird's beak grows at the upper margin of tidal brackish high marshes in the San Francisco Estuary, often near the upper marsh–upland boundary (Grewell 2005; Grewell et al. 2007, p. 140). Where the topography is relatively uniform, soft bird's beak is distributed in bands at the upper margin of the brackish high marsh. In Suisun Marsh, these bands are not correlated with elevation, but with soil pore water salinity during the dry season, which is determined by distance to channel and varies from season to season depending on freshwater flows from creeks draining into the marsh (Culbertson 2001). Where the topography is more complex, such as areas with ridges or mounds and on levee banks, soft bird's beak can be found in a variety of patch shapes (Grewell 2005; Grewell et al. 2007, p. 140). Plant distribution is influenced by a number of factors, including the existence of a persistent seed bank, the dispersal and germination dynamics of its floating seed, the extent of bare soil where seedlings can establish, the presence of appropriate long-lived annual or perennial host species, and the absence of dense populations of large, perennial, nonnative plant species (Grewell et al. 2003; Grewell 2005; Grewell et al. 2007, p. 143–144). The presence of a natural tidal inundation pattern is important, and the more muted the tidal influence is, such as tidal creeks with salt water exclusion gates or marshes with extensive levee systems, the less suitable the habitat is for soft bird's beak (Grewell et al. 2003; Grewell 2005; Grewell et al. 2007, p. 140). A number of hypotheses have been suggested to explain the effects of the muted tidal influence, including increased rates of seed predation and herbivory by native insects, high densities of inappropriate host species, such as nonnative annual plants, and invasion and displacement by large nonnative plant species, such as perennial pepperweed (*Lepidium latifolium*) (Grewell 2005).

2.27.5 Limiting Factors, Threats, and Stressors

Threats to the subspecies include the destruction of habitat, erosion, the elimination or muting of tidal regimes, overgrazing and trampling by livestock, rooting by feral pigs, invasion of habitat by nonnative annual plants that are inappropriate hosts, recent invasion of its habitat by perennial pepperweed, alteration of salinity regimes, mosquito abatement, and oil spills (Fiedler et al. 2007; Grewell et al. 2003; Grewell 2005). Trampling and disturbance by cattle, feral pigs, and human foot traffic can directly damage plants and also damage the fragile root connections between soft bird's beak and the host plants (U.S. Fish and Wildlife Service 2009a). Seed predation by moth larvae may be an important factor in population declines at sites in Suisun Marsh (Grewell et al. 2003; Fiedler et al. 2007). Climate change and sea level rise may change tidal regimes faster than species can react, leading to increased pressure on the soft bird's beak.

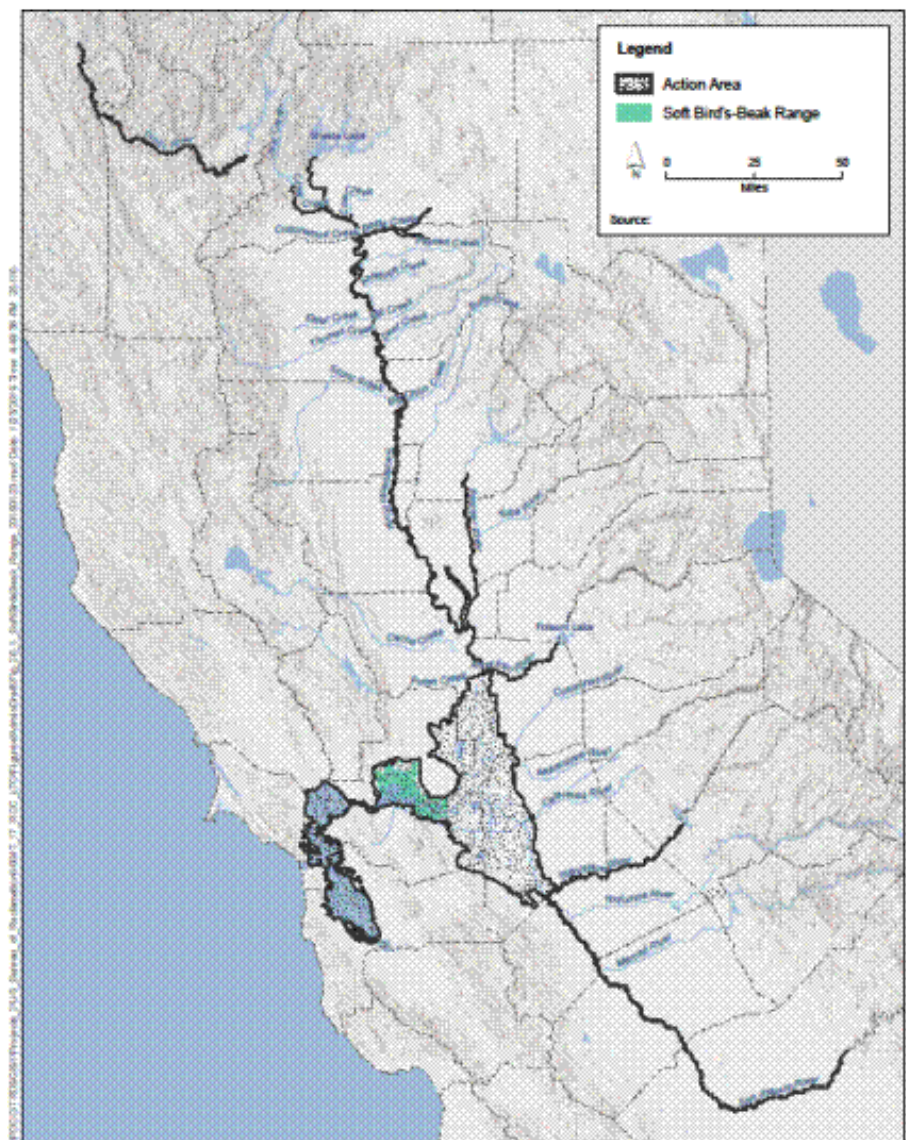


Figure 2.27-1. Soft Bird's Beak Range

2.27.6 Recovery and Management

The status of soft bird's beak and information about its biology, ecology, distribution, and current threats is available in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U. S. Fish and Wildlife Service 2013). The plan features soft bird's beak, along with four other endangered species.

There are two recovery units for this species, the Suisun Recovery Unit and the San Pablo Bay Recovery Unit. Downlisting of soft bird's beak would be achieved if the minimum area inhabited by the species in the Suisun Bay Area Recovery Unit is at least 3,000 acres and at least 1,000 acres in the San Pablo Bay Recovery Unit, over a period of 5 years. A minimum of 5,000 acres of suitable habitat in both recovery units must be permanently established. This must include existing or successfully restored tidal marsh areas with suitable habitat for the species and encompass a minimum of 80 percent of the species. Perennial pepperweed populations must be reduced to less than 10 percent cover in Suisun Marsh for 5 years, natural tidal cycles must be restored at Hill Slough, and the ponded area at Rush Ranch must be returned to periodic tidal flooding. There must be less than 10 percent total cover of other nonnative, invasive perennial or nonnative winter annual grass species.

2.28 Suisun Thistle

2.28.1 ESA Listing Status

USFWS listed Suisun thistle as an endangered species under ESA on November 20, 1997 (62 FR 61925).

2.28.2 Critical Habitat Designation

Critical habitat for Suisun thistle was designated in 2007 (72 FR 18536). The designated critical habitat areas contain physical and biological features (PCEs) that are considered essential to the conservation of the species, and that may require special management considerations and protection. The PCEs identified for Suisun thistle are: (1) persistent emergent, intertidal, estuarine wetland at or above the mean high-water line (as extended directly across any intersecting channels); (2) open channels that periodically contain moving water with ocean-derived salts in excess of 0.5 percent; and (3) gaps in surrounding vegetation to allow for seed germination and growth. In total, three critical habitat units covering approximately 2,052 acres (830 hectares) were designated. The critical habitat is located within Solano County at Hill Slough Marsh, Peytonia Slough Marsh, and Rush Ranch/ Grizzly Island Wildlife Area.

2.28.3 General Life-History and Habitat Requirements

Suisun thistle is a perennial herb in the aster family (Asteraceae). It has slender, erect stems that are 3.0 to 4.5 feet tall and well branched above. Pale, lavender-rose flower heads, 1 inch long, grow singly or in loose groups. Flowers appear between July and September. Suisun thistle grows in the upper reaches of tidal marshes of the San Francisco Estuary, where it is associated with narrowleaf cattail (*Typha angustifolia*), three-square or American bulrush (*Scirpus americanus*), Baltic rush (*Juncus balticus*), and saltgrass.

2.28.4 Historical and Current Distribution and Abundance

This species is known to exist only in Suisun Marsh and typically is found in the middle to high marsh zone along tidal channels and in irregularly flooded estuarine wetlands (Interagency Ecological Program 2001). One population occurs on California Department of Fish and Wildlife's (DFW's) Peytonia Slough Ecological Reserve. The remaining occurrences are associated with the Cutoff Slough tidal marshes and DFW's Joice Island Unit of the Grizzly Island Wildlife Management Area.

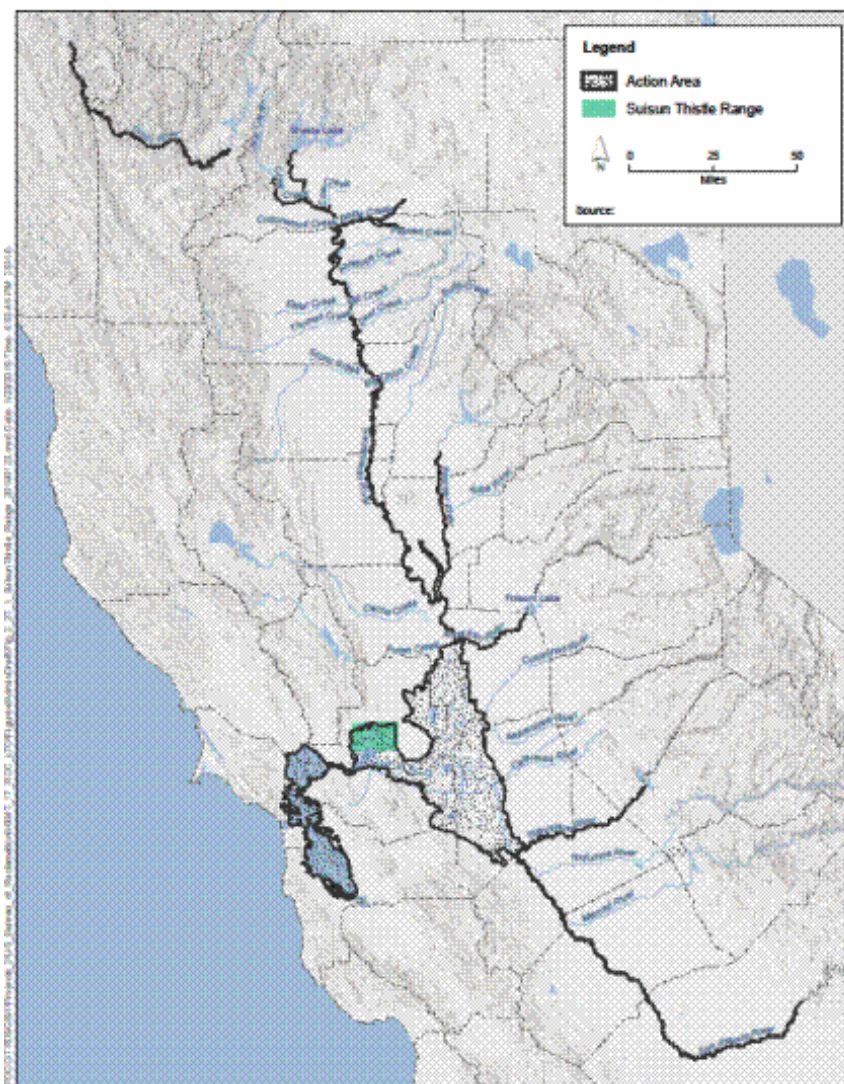


Figure 2.28-1. Suisun Thistle Range

2.28.5 Limiting Factors, Threats, and Stressors

Common threats that may require special management considerations or protections of the PCEs for Suisun thistle in all three critical habitat units include: (1) alterations to channel water salinity and tidal regimes from the operation of the Suisun Marsh Salinity Control Gates that could affect the depth, duration, and frequency of tidal events and the degree of salinity in the channel water column; (2) mosquito abatement activities (dredging, and chemical spray operations), which may damage the plants

directly by trampling and soil disturbance, and indirectly by altering hydrologic processes and by providing relatively dry ground for additional foot and vehicular traffic; (3) rooting, wallowing, trampling, and grazing impacts from livestock and feral pigs that could result in damage or loss to Suisun thistle colonies, or in soil disturbance and compaction, leading to a disruption in natural marsh ecosystem processes; (4) the proliferation of nonnative invasive plants, especially perennial pepperweed, leading to the invasives outcompeting Suisun thistle; and (5) programs for the control or removal of nonnative invasive plants, which, if not conducted carefully, can damage Suisun thistle populations through the injudicious application of herbicides, by direct trampling, or through the accidental transport of invasive plant seeds to new areas. An additional threat that may require special management considerations or protection of the PCEs in Units 1 and 2 includes urban or residential encroachment from Suisun City to the north that could increase stormwater and wastewater runoff into these units. Alterations to channel water salinity and tidal regimes may also occur due to climate change and sea level rise.

2.28.6 Recovery and Management

The status of Suisun thistle and information about its biology, ecology, distribution, and current threats is available in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U. S. Fish and Wildlife Service 2013). The plan features Suisun thistle along with four other endangered species. Supplemental or updated information is provided in USFWS's 2009 5-year review for Suisun thistle (U. S. Fish and Wildlife Service 2009b). In 2009, USFWS recommended no change in the classification of Suisun thistle.

USFWS intends to conserve the geographic areas containing the physical and biological features that are essential to the conservation of the species, through the identification of the appropriate quantity and spatial arrangement of the primary constituent elements sufficient to support the life-history functions of the species. Because not all life-history functions require all the primary constituent elements, not all areas designated as critical habitat will contain all the primary constituent elements.

Downlisting of Suisun thistle will be achieved if the median area inhabited by this species is 2,000 acres, a total of 4,000 acres or more is permanently preserved, perennial pepperweed populations are reduced to less than 10 percent cover in Suisun Marsh, natural tidal cycles are restored at Hill Slough, and the ponded area at Rush Ranch is returned to periodic tidal flooding.

2.29 Valley Elderberry Longhorn Beetle

2.29.1 ESA Listing Status

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) was listed as threatened by the USFWS in 1980 (45 FR 52803). A proposed rule to remove the species from federal listing was initiated in 2012 (77 FR 60237), and then withdrawn in 2014 due to habitat loss continuing to threaten the species (79 FR 55879).

2.29.2 Critical Habitat Designation

Critical habitat, designated at the time of listing in 1980 (45 FR 52803), includes two locations in Sacramento County along the American River where the densest known populations of the beetle occur. These areas are within the Action Area.

2.29.3 General Life-History and Habitat Requirements

The valley elderberry longhorn beetle is a small (0.5 to 0.8 inch) wood borer that depends on red or blue elderberry (*Sambucus* spp.) in every phase of its life cycle and is nearly always found on or close to its host plant along rivers and streams. Females are indistinguishable from the more widespread California elderberry longhorn beetle (*Desmocerus californicus californicus*). The elderberry is a common shrub component of riparian forests and adjacent nonriparian vegetation (valley oak and blue oak woodland, and annual grassland) along river corridors of the Central Valley.

Adult beetles feed on elderberry nectar, flowers, and foliage, and are generally active from March through June (77 FR 60237). As elderberry plants begin flowering in the spring, beetles begin to emerge from tunnels they bored as larvae through the shrub's pith, roaming the shrubs, eating foliage and possibly flowers, until they mate.

Adults live from a few days to a few weeks after emerging, during which time they mate and lay their eggs (Talley et al. 2006). The females lay eggs, singly or in small groups, on the leaves or stems of living elderberry shrubs (Barr 1991). The larvae hatch in a few days and bore into living stems that are at least 1 inch (2.5 cm) in diameter, where they remain within the elderberry stem, feeding on the pith until they complete their development (Talley et al. 2006). Larvae eventually cut an exit hole out of the stem, and then plug the hole up from within using wood shavings. This allows the beetle to eventually exit the stem after it becomes an adult, as adults are not wood borers. Within the stem, the larva becomes a pupa, and finally emerges from its single exit hole as an adult between mid-March and mid-June (77 FR 60237).

Shrub characteristics and other environmental factors appear to have an influence on use by the valley elderberry longhorn beetle, with more exit holes found in shrubs in riparian than in nonriparian habitat types (Talley et al. 2006). Occupancy of elderberry shrubs varies based on elderberry condition, water availability, elderberry density, and the health of the riparian habitat, indicating that healthy riparian systems supporting dense elderberry clumps are the primary habitat of the beetle (Barr 1991; Talley et al. 2006; Talley et al. 2007). However, some studies have demonstrated that valley elderberry longhorn beetles prefer elderberry shrubs with low to moderate levels of damaged stems (USFWS 2014).

2.29.4 Historical and Current Distribution and Abundance

The valley elderberry longhorn beetle is endemic to the Central Valley of California in moist valley oak woodlands along the margins of rivers and streams in the lower Sacramento and San Joaquin Valleys where its obligate larval host plant, elderberry grows. At the time of listing in 1980, the beetle was known from less than 10 locations on the American River, Putah Creek, and Merced River (USFWS 2009). Subsequent surveys have documented a broader distribution of the species and now it is known to occur from southern Shasta County in the north to Fresno County in the south, including the valley floor and lower foothills, and is generally found below 500 feet (152 meters) above mean sea level (USFWS 2017).

Most of the approximately 270 CNDDDB element occurrences are based on observations of exit holes in elderberry stems or branches rather than direct observation of individual beetles; many of these occurrences predate 1997, which was the most recent, comprehensive rangewide survey by observers known to be qualified to detect occupancy of valley elderberry longhorn beetle (CDFW 2018; USFWS 2014). There are approximately 130 known occurrences of valley elderberry longhorn beetle in the San Joaquin and Sacramento Valleys that have been documented since the 1997 comprehensive rangewide survey (CDFW 2018). These occurrences have been found within 18 watersheds at 36 geographic locations (USFWS 2014).

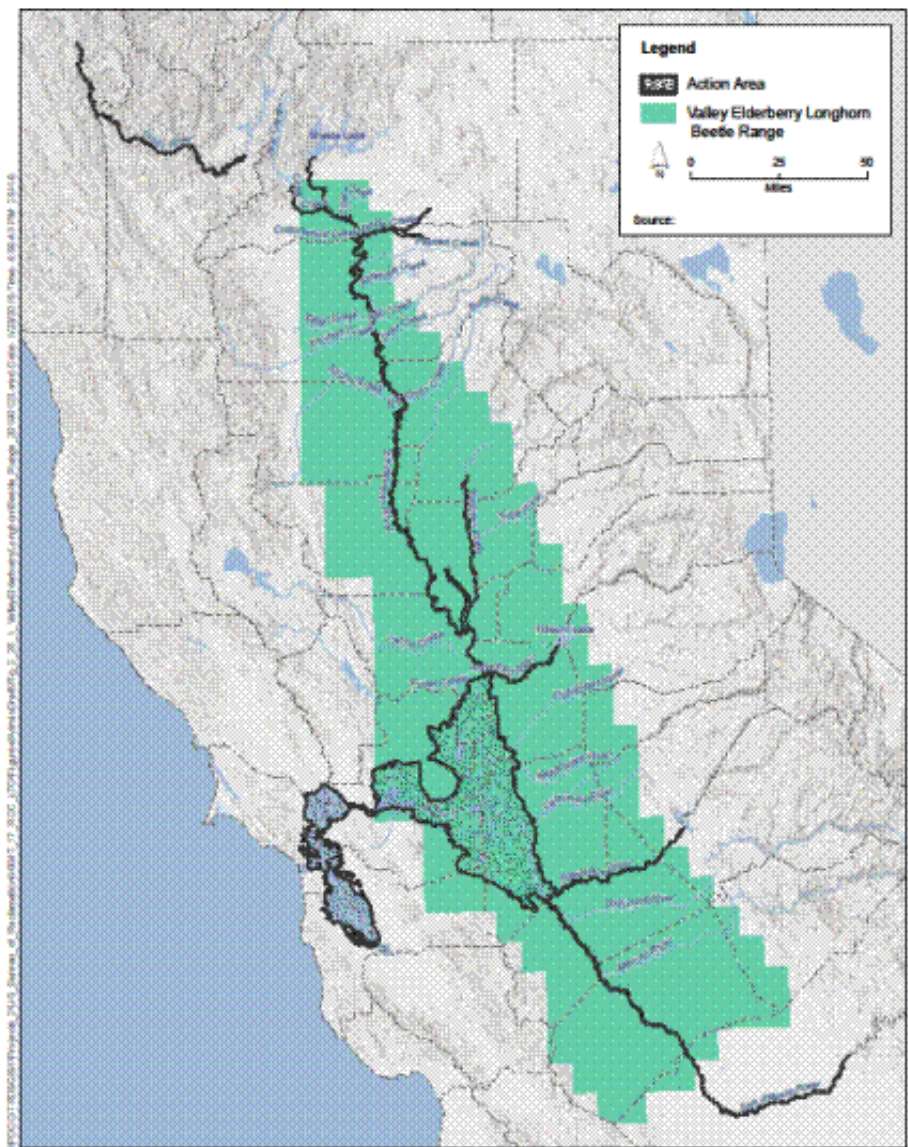


Figure 2.29-1. Valley Elderberry Longhorn Beetle Range

2.29.5 Limiting Factors, Threats, and Stressors

The valley elderberry longhorn beetle, though wide-ranging, is experiencing a long-term decline due to human activities that have resulted in widespread alteration and fragmentation of riparian habitats, and, to a lesser extent, upland habitats that support the beetle.

The primary threats to survival of the beetle include levee construction, stream and river channelization, removal of riparian vegetation, riprapping of shoreline, nonnative animals such as the Argentine ant (*Linepithema humile*), which may eat the early phases of the beetle, and recreational, industrial, and urban

development. Insecticide and herbicide use in agricultural areas and along road right-of-ways may also be factors limiting the beetle's distribution.

Over the past 150 years, agricultural expansion and urbanization in the Central Valley increased. The need for water and flood protection spurred water development and reclamation projects, which reduced the expanse of riparian vegetation, including elderberry plants. Riparian vegetation was also removed for or impacted by the building of artificial levees and dams, river channelization, water diversion, and heavy groundwater pumping, thereby reducing these communities to small, isolated fragments.

Based on valley elderberry longhorn beetle research, this species occurs throughout the Central Valley in metapopulations, or discrete subpopulations that exchange individuals through dispersal or migration (Collinge et al. 2001). The subpopulations may shift spatially and temporally within riparian drainages, resulting in a patchwork of occupied and unoccupied habitat (USFWS 2017e). Valley elderberry longhorn beetles have limited dispersal capabilities, making it difficult to colonize unoccupied habitat areas. Therefore, the preservation of contiguous areas of suitable habitat is important for the longevity of this species. Climate change may change riparian flow regimes, which could remove valley elderberry longhorn beetle habitat and create it elsewhere, without the opportunity for the beetle to disperse to the new habitat.

Small population numbers of valley elderberry longhorn beetle host plants, and even lower numbers of occupied host plants, constitute a threat to the beetle at many locations, which, in turn, may result in small beetle population sizes. Additionally, low mobility, very small local populations, and isolation of habitat patches make beetle populations especially susceptible to extirpation with little chance of recolonization (Talley et al. 2006).

2.29.6 Recovery and Management

When the *Valley Elderberry Longhorn Beetle Recovery Plan* was developed (USFWS 1984), little information regarding the beetle's life history, distribution, and habitat requirements was available to develop specific recovery objectives. The recovery plan did not include recovery criteria, but did include primary interim objectives that have since been at least partially met and include increased surveys, management of additional areas where the beetles have been identified, and some protections afforded to habitat areas (USFWS 2012). The majority of the beetle's habitat along the Lower American River has been protected as part of the American River Parkway that includes both designated critical habitat and essential habitat (USFWS 2012).

Although riparian vegetation in the Central Valley has declined over time, a number of areas have been restored to accommodate the habitat needs and recovery of the valley elderberry longhorn beetle (that is, riparian vegetation that specifically contains elderberry shrubs). In the years since the time of listing, known locations of the beetle have increased through continued survey efforts, with a resultant significantly greater range size than was originally listed (USFWS 2012). In 2012, the USFWS proposed delisting the beetle from its threatened status under the ESA based on this increase, as well as past and ongoing riparian vegetation restoration and the persistence of elderberry shrubs in restored areas. However, the proposal was withdrawn in 2014 (79 FR 55879) because continued data acquisition indicated that threats to the species and its habitat have not been reduced to the point where the species no longer meets the statutory definition of a threatened species.

2.30 Vernal Pool Fairy Shrimp

2.30.1 ESA Listing Status and Critical Habitat Designation

Vernal pool fairy shrimp (*Branchinecta lynchi*) is listed as threatened under the ESA throughout its range (59 FR 48136). In September 2007, the USFWS published a 5-year review recommending that the species remain listed as threatened. On May 25, 2011, USFWS initiated a new 5-year review to determine if the species should be listed as endangered.

The final rule designating critical habitat for vernal pool fairy shrimp was published in the *Federal Register* on February 10, 2006 (71 FR 7118–7316). There is no designated critical habitat for vernal pool fairy shrimp within the action area.

2.30.2 General Life History and Habitat Requirements

Vernal pool fairy shrimp is entirely dependent the temporary waters of natural vernal pool and playa pool ecosystems, as well as the artificial environments of ditches and tire ruts (King et al. 1996; Helm 1998; Eriksen and Belk 1999). The temporary waters fill directly from precipitation and from surface runoff and perched groundwater from their watersheds (Williamson et al. 2005; Rains et al. 2006, 2008; O’Geen et al. 2008). The watershed extent needed to maintain hydrological function of the temporary waters depends on the hydrologic conductivity of the surface soil horizons, the continuity and extent of hardpans and claypans underlying nonclay soils, the existence of a perched aquifer overlying the pans, slope, effects of vegetation on evapotranspiration rates, compaction of surface soils by grazing animals, and other factors (Marty 2005; Pyke and Marty 2005; Williamson et al. 2005; Rains et al. 2006, 2008; O’Geen et al. 2008). Temporary waters that are habitat for the vernal pool fairy shrimp range from low to moderate alkalinity (King et al. 1996; Eriksen and Belk 1999). Vernal pool fairy shrimp commonly co-occur with other fairy shrimp and vernal pool tadpole shrimp (*Lepidurus packardii*) (USFWS 2005).

Vernal pool fairy shrimp cysts can remain dormant in the soil when their habitats are dry. When the pools refill in the same or subsequent seasons, the cysts may hatch. The cyst bank in the soil may comprise cysts from several years of breeding (USFWS 2005, 2007). Beyond inundation of the habitat, the specific cues for hatching are unknown, although temperature and conductivity (solute concentration) are believed to play a large role (Helm 1998; Eriksen and Belk 1999).

In a study using large plastic pools to simulate natural vernal pools, Helm found that vernal pool fairy shrimp can reproduce in as early as 18 days following hatching, with the average being 40 days (Helm 1998). Site-specific conditions, primarily water temperature, have been shown to affect time to reach reproductive maturity (Helm 1998).

2.30.3 Historical and Current Distribution and Abundance

There is little information on the historical range of vernal pool fairy shrimp. The species currently occurs in a wide range of vernal pool habitats in the southern and Central Valley areas of California, and at two sites in Jackson County, Oregon (USFWS 2005). It is currently found at locations across the Central Valley from Shasta County to Tulare and Kings Counties, in the central and southern Coast Ranges from Napa County to Los Angeles County, and inland in western Riverside County, California (USFWS 2005, 2007; CDFW 2019). There are 191 CNDDDB element occurrences for vernal pool fairy shrimp in the action area (CDFW 2019).

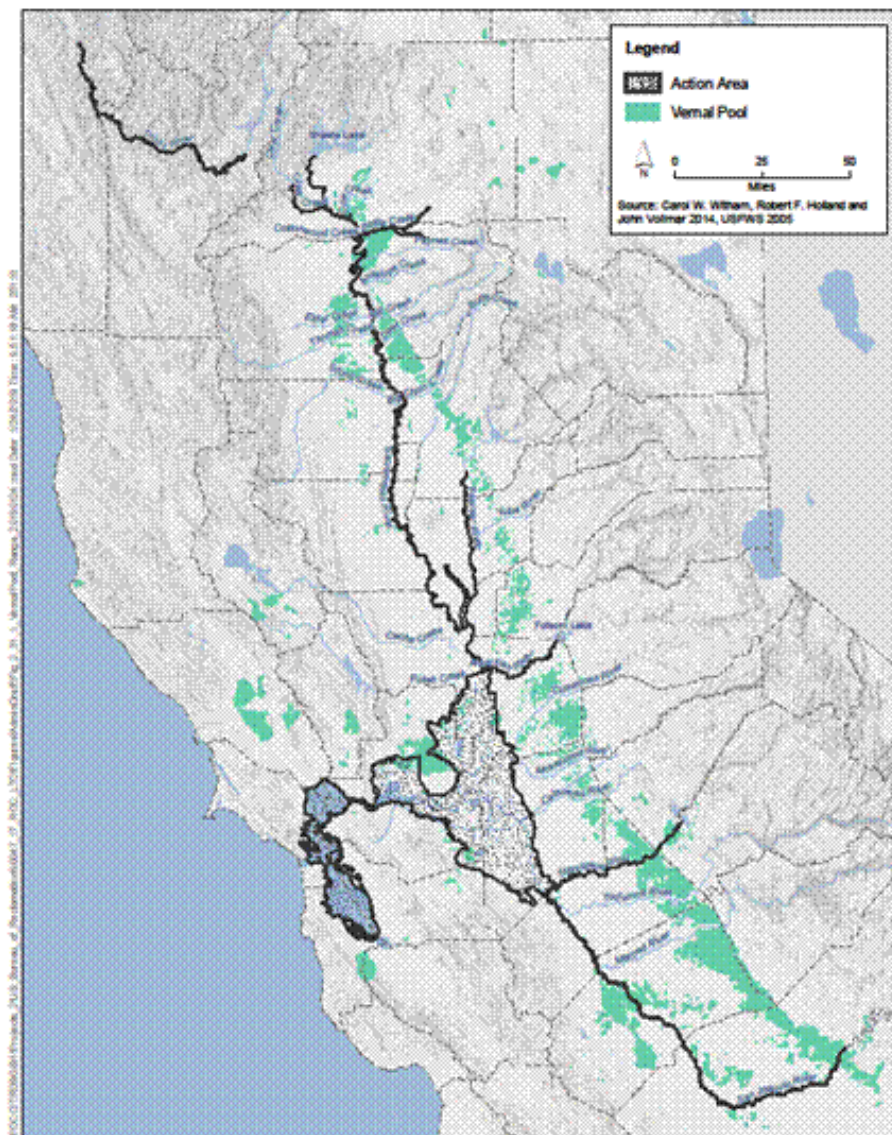


Figure 2.30-1. Vernal Pool Range

2.30.4 Limiting Factors, Threats, and Stressors

Threats to vernal pool habitat and vernal pool branchiopods in general, as well as specific threats to vernal pool fairy shrimp, are described in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (USFWS 2005, 2007). Habitat loss and fragmentation are the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to more developed land uses, while habitat fragmentation results from activities such as road development and other infrastructure projects (USFWS 2005).

Within habitat, grazing practices affect habitat quality. Inappropriate grazing practices include complete elimination of grazing in areas where nonnative grasses dominate the uplands surrounding vernal pools, and inappropriate timing or intensity of grazing. Appropriate grazing regimes help control nonnative weed plants such as Italian ryegrass (*Lolium multiflorum*) and waxy manna grass (*Glyceria declinata*), which, if unchecked, can increase thatch buildup, decrease ponding durations, and decrease the aquatic habitat available to the vernal pool fairy shrimp (USFWS 2007).

Human disturbances and changes in land use practices can alter the hydrology of temporary waters and result in a change in the timing, frequency, or duration of inundation in vernal pools, which can create conditions that render existing vernal pools unsuitable as habitat for vernal pool species (USFWS 2005).

Climate change affects vernal pool hydrology through changes in the amount and timing of precipitation inputs to vernal pools and the rate of loss through evaporation and evapotranspiration. It is unknown at this time if climate change in California is causing localized cooling and drying, or warming with higher precipitation. Either scenario might result in adverse effects on vernal pool invertebrate species. Cooling and drying trends could adversely affect vernal pool fairy shrimp through decreased inundation periods that do not allow the species sufficient time to complete its life cycle. A warming trend could increase inundation periods, but could also increase temperatures above levels needed for the species to hatch or reproduce (USFWS 2007).

Specific threats to vernal pool fairy shrimp habitat include the following (USFWS 2005).

- More than half of the known populations are threatened by development or agricultural conversion. Several populations are found on military bases, and although not an immediate threat, military activities can result in alteration of pool characteristics, including introduction of nonnative plant species (USFWS 2005, 2007).
- In the Livermore Vernal Pool Region, the vernal pool fairy shrimp is located primarily on private land, where it is threatened by development, including expansion of the Byron Airport.
- In the Northeastern Sacramento Valley Vernal Pool Region, most of the known occurrences are located on California Department of Transportation (Caltrans) rights-of-way and are thus threatened by various future road improvement projects in this region, particularly the future expansion of State Route 99. Additional populations are threatened by commercial and residential development projects.
- Some occurrences on private land in the Northwestern Sacramento Vernal Pool Region may be threatened by agricultural conversion or development.
- In the Southern Sacramento Vernal Pool Region, the vernal pool fairy shrimp is threatened by urban development. Both Sacramento and Placer Counties are currently developing habitat conservation plans to address growth in the region.
- In the San Joaquin Valley Region, the vernal pool fairy shrimp is found primarily on private land where it is threatened by direct habitat loss, including urban development and agricultural conversion.
- In the Solano-Colusa Region, the vernal pool fairy shrimp is threatened by development on the private property where it occurs.

2.30.5 Recovery and Management

The Collinsville, Altamont Hills, and Jepson Prairie core recovery areas, which were developed in part for the recovery of the vernal pool fairy shrimp, encompass both designated critical habitat and essential habitat (USFWS 2005). Other recovery areas include the Western Riverside County and Santa Barbara vernal pool regions. For both regions, the recovery and management strategies involve protecting and reestablishing vernal pool habitat (USFWS 2005).

2.31 Vernal Pool Tadpole Shrimp

2.31.1 ESA Listing Status and Critical Habitat Designation

Vernal pool tadpole shrimp (*Lepidurus packardii*) was listed as endangered throughout its range under the ESA on September 19, 1994 (59 FR 48136). In September 2007, USFWS published a 5-year review recommending that the species remain listed as endangered. On May 25, 2011, USFWS initiated a new 5-year review to determine if the species should remain listed as endangered.

Critical habitat for vernal pool tadpole shrimp was designated on February 10, 2006 (71 FR 7118–7316) and does not occur in the action area.

2.31.2 General Life History and Habitat Requirements

Vernal pool tadpole shrimp occur in a variety of seasonal habitats, including vernal pools, ponded clay flats, alkaline pools, ephemeral stock tanks, and roadside ditches. Habitats where vernal pool tadpole shrimp have been observed range in size from small (less than 25 square feet), clear, vegetated vernal pools to large (more than 100 acres) winter lakes (Helm 1998:134–138; Rogers 2001:1002–1005). These habitats must dry out and be inundated again for the vernal pool tadpole shrimp cysts to hatch. This species has not been reported in pools that contain high concentrations of sodium salts, but may occur in pools with high concentrations of calcium salts (Helm 1998:134–138; Rogers 2001:1002–1005).

Vernal pool tadpole shrimp commonly co-occur with other fairy shrimp (U.S. Fish and Wildlife Service 2005).

Vernal pool tadpole shrimp cysts can remain dormant in the soil when their vernal pool habitats are dry. When the pools refill in the same or subsequent seasons, the cysts may hatch. The cyst bank in the soil may comprise cysts from several years of breeding (U.S. Fish and Wildlife Service 2005, 2007). Beyond inundation of the habitat, the specific cues for hatching are unknown, although temperature and conductivity (solute concentration) are believed to play a large role (Helm 1998; Eriksen and Belk 1999).

In a study using large plastic pools to simulate natural vernal pools, Helm found that vernal pool tadpole shrimp can reproduce as early as 41 days following hatching with the average being 54 days (Helm 1998). Site-specific conditions, primarily water temperature, have been shown to affect time to reach reproductive maturity (Helm 1998).

Vernal pool tadpole shrimp have relatively high reproductive rates and may be hermaphroditic. Sex ratios can vary, perhaps in response to changes in water temperature (Ahl 1991). Genetic variation among vernal pool tadpole shrimp corresponds with differences between sites in physical and chemical aspects of the pool habitat (depth, surface area, solutes concentration, elevation, and biogeographic region), and

species richness is positively correlated with both depth and surface area (King et al. 1996). Vernal pool crustaceans generally have low rates of gene flow between separated sites, which is probably a result of the spatial isolation of their habitats and their reliance on passive dispersal mechanisms. Gene flow between pools within the same vernal pool complex is much higher, indicating that vernal pool tadpole shrimp populations are defined by vernal pool complexes rather than by individual vernal pools (USFWS 2005).

2.31.3 Historical and Current Distribution and Abundance

Historically, vernal pool tadpole shrimp probably did not occur outside of the Central Valley and Central Coast regions (USFWS 2005). Currently, vernal pool tadpole shrimp occur in the Central Valley of California and in the San Francisco Bay Area. The species has a patchy distribution across the Central Valley from Shasta County southward to northwestern Tulare County (USFWS 2007). In the Central Coast Vernal Pool Region, the vernal pool tadpole shrimp is found the San Francisco National Wildlife Refuge and on private land in Alameda County near Milpitas (USFWS 2007; CDFW 2019). The largest concentration of vernal pool tadpole shrimp occurrences is found in the Southeastern Sacramento Vernal Pool Region, where the species occurs on a number of public and private lands in Sacramento County (USFWS 2005, 2007). There are 136 occurrences of vernal pool tadpole shrimp in the action area (CDFW 2019).

2.31.4 Limiting Factors, Threats, and Stressors

Threats to vernal pool habitat and vernal pool branchiopods in general, as well as specific threats to vernal pool tadpole shrimp, are identified in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (USFWS 2005). Habitat loss and fragmentation are the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to more developed land uses, while habitat fragmentation results from activities such as road development and other infrastructure projects (USFWS 2005).

Within habitat, grazing practices affect habitat quality. Inappropriate grazing practices include complete elimination of grazing in areas where nonnative grasses dominate the uplands surrounding vernal pools, and inappropriate timing or intensity of grazing. Appropriate grazing regimes help control nonnative weed plants such as Italian ryegrass (*Lolium multiflorum*) and waxy manna grass (*Glyceria declinata*), which if unchecked can increase thatch buildup and decrease ponding durations and decrease the aquatic habitat available to the vernal pool tadpole shrimp (USFWS 2007).

Human disturbances and changes in land use practices can alter the hydrology of temporary waters and result in a change in the timing, frequency, or duration of inundation in vernal pools, which can create conditions that render vernal pools unsuitable as habitat for vernal pool species (USFWS 2005).

Climate change affects vernal pool hydrology through changes in the amount and timing of precipitation inputs to vernal pools and the rate of loss through evaporation and evapotranspiration. It is unknown at this time if climate change in California is causing localized cooling and drying, or warming with higher precipitation. Either scenario might result in adverse effects on vernal pool invertebrate species. Cooling and drying trends could adversely affect vernal pool tadpole shrimp through decreased inundation periods that do not allow the species sufficient time to complete its life cycle. A warming trend could increase inundation periods, but could also increase temperatures above levels needed for the species to hatch or reproduce (USFWS 2007).

Specific threats to vernal pool tadpole shrimp habitat include the following (USFWS 2005).

- Encroachment of nonnative annual grasses on the San Francisco Bay National Wildlife Refuge in the Central Coast Region, and urban development on private land in Alameda County.
- In the Northeastern Sacramento Valley Region, most of the known occurrences of the vernal pool tadpole shrimp are on Caltrans rights-of-way, where they continue to be threatened by road improvement projects related to general urban growth.
- In the Northwestern Sacramento Valley Vernal Pool Region, the vernal pool tadpole shrimp is threatened by development on the few sites on private land where it is known to occur.
- In the Southeastern Sacramento Vernal Pool Region, extant populations of the vernal pool tadpole shrimp are threatened by continued extensive urban development.
- In the San Joaquin Vernal Pool Region, the species is threatened by development on private land.
- In the Solano-Colusa Region, the species is threatened by urbanization on private lands.
- In the Southern Sierra Foothills Vernal Pool Region, the species is threatened by development of the University of California, Merced campus, which will likely contribute to significant growth in the region. Populations on the Stone Corral Ecological Reserve may be threatened by pesticide drift from adjacent farmlands.

2.31.5 Recovery and Management

The Collinsville, Altamont Hills, and Jepson Prairie core recovery areas, which were developed in part for the recovery of the vernal pool tadpole shrimp, encompass both designated critical habitat and essential habitat (USFWS 2005).

2.32 California Tiger Salamander

2.32.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed the Central California DPS of California tiger salamander (which overlaps with the proposed action) as threatened on August 4, 2004 (50 FR 47212–47248). California tiger salamander is also listed as threatened under the California Endangered Species Act (CESA). On August 23, 2005, the USFWS designated approximately 199,109 acres (80,576 hectares) of critical habitat for the Central Valley DPS. The critical habitat is located in 19 California counties (70 FR 49380). No critical habitat overlaps with the action area.

2.32.2 General Life-History and Habitat Requirements

California tiger salamander is found in annual grasslands and open woodland communities in lowland and foothill regions of central California, where aquatic sites are available for breeding (USFWS 2003). The species is typically found at elevations below 1,509 feet (68 FR 13498), although the known elevational range extends up to 3,455 feet (Jennings and Hayes 1994). Ecological characteristics of this area include dry soils, needlegrass grasslands, valley oaks, coast live oaks, and ephemeral flooded claypan vernal pools (USFWS 2003).

Adult California tiger salamanders are terrestrial and spend much of the year (6 to 9 months) in the underground burrows of small mammals, such as California ground squirrels (*Spermophilus beecheyi*) and Botta's pocket gopher (*Thomomys bottae*), in grassland and open woodland habitats (Storer 1925;

Loredo and van Vuren 1996; Petranka 1998). Active rodent burrow systems are considered an important component of California tiger salamander upland habitat (Loredo et al. 1996; USFWS 2013b). Active ground-burrowing rodent populations are probably necessary to sustain California tiger salamander populations because inactive burrow systems begin to deteriorate and collapse over time (Loredo et al. 1996). In a 2-year radiotelemetry project in Monterey County, Trenham (2001) found that salamanders preferentially used open grassland and isolated oaks; salamanders present in continuous woody vegetation were never more than 10 feet from open grassland, potentially because ground squirrels prefer to construct burrows in open habitats (Jameson and Peeters 1988, as cited in Trenham 2001).

Vernal pools and other seasonal rain pools are the primary breeding habitat of California tiger salamanders (Barry and Shaffer 1994; 68 FR 13498). Because the species requires at least 10 weeks of pool inundation to complete metamorphosis of larvae (Anderson 1968; East Contra Costa County Habitat Conservancy 2006), California tiger salamanders are usually only found in the largest vernal pools (Laabs et al. 2001). The species is also known to successfully reproduce in ponds (Barry and Shaffer 1994; 69 FR 47212). In the East Bay Regional Park District in Contra Costa and Alameda Counties, California tiger salamanders breed almost exclusively in seasonal and perennial stock ponds (Bobzien and DiDonato 2007). However, the presence of predatory fish and bullfrogs (*Rana catesbeiana*) can affect the habitat suitability of perennial ponds (Holomuzki 1986; Fitzpatrick and Shaffer 2004). Barry and Shaffer (1994) note that perennial stock ponds can be productive breeding sites as long as they are drained annually, which can prevent predatory species from establishing.

Adult California tiger salamanders move from subterranean refuge sites to breeding pools during relatively warm late winter and spring rains (Jennings and Hayes 1994:12). Breeding generally occurs from December through March (Stebbins 2003:154). Development through metamorphosis requires 3 to 6 months (69 FR 47215). Metamorphosed juveniles leave their ponds in the late spring or early summer and move to terrestrial refuge sites before seasonal ponds dry (Loredo et al. 1996:282).

The distance between occupied upland habitat and breeding sites depends on local topography and vegetation, and the distribution of California ground squirrel or other rodent burrows (WRA Environmental 2005; Cook et al. 2006). While juvenile California tiger salamanders have been observed to disperse up to 1.6 miles from breeding pools to upland areas (Austin and Shaffer 1992) and adults have been observed up to 1.2 miles from breeding ponds, most movements are closer to the breeding pond. Trenham et al. (2001) observed California tiger salamanders moving up to 0.42 mile between breeding ponds in Monterey County. Similarly, Shaffer and Trenham (2005) found that 95 percent of California tiger salamanders resided within 0.4 mile of their breeding pond at Jepson Prairie in Solano County.

Interconnectivity of breeding sites may be an important factor in long-term conservation of this species in order to sustain the species' metapopulation structure, where local extinction and recolonization by migrants of other subpopulations are probably common (69 FR 47212). Thus, providing movement corridors between potential breeding sites and avoiding isolation of these sites may counterbalance the effects of normal ecological processes (e.g., drought) that may result in local extinctions by allowing for movements to new sites and facilitating recolonization (Semlitsch et al. 1996).

2.32.3 Historical and Current Distribution and Abundance

Historically, California tiger salamander occurred throughout the grassland and woodland areas of the Sacramento and San Joaquin River Valleys and surrounding foothills, and in the lower elevations of the central Coast Ranges (Barry and Shaffer 1994). The species is found in a relatively dry landscapes where its range is limited by its aestivation and winter breeding habitat requirements, which are generally

defined as open grassland landscapes with ephemeral pools and with ground squirrel and pocket gopher burrows (Barry and Shaffer 1994).

Within the coastal range, the species currently occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties (CDFW 2013). In the Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties (CDFW 2013).

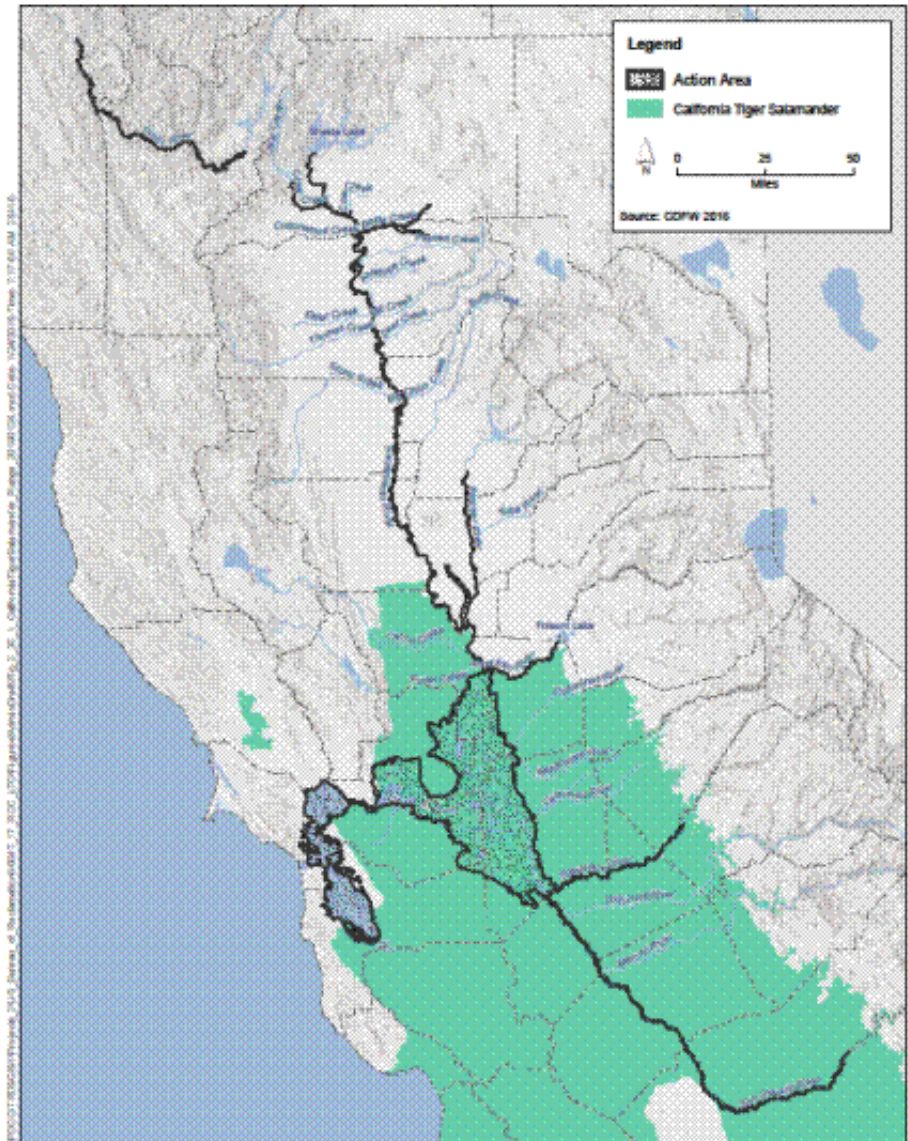


Figure 2.32-1. California Tiger Salamander Range

2.32.4 Limiting Factors, Threats, and Stressors

Conversion of land to residential, commercial, and agricultural activities is considered the most significant threat to California tiger salamanders, resulting in destruction and fragmentation of upland and/or aquatic breeding habitat and killing of individual California tiger salamanders (Twitty 1941; Shaffer et al. 1993; Jennings and Hayes 1994; Fisher and Shaffer 1996; Loredó et al. 1996; Davidson et al. 2002; CDFW 2010). Roads can fragment breeding habitats and dispersal routes in areas where they traverse occupied habitat. Features of road construction, such as solid road dividers, can further impede migration, as can other potential barriers such as berms, pipelines, and fences.

Exotic species, such as bullfrog, mosquitofish (*Gambusia affinis*), sunfish species (e.g., largemouth bass [*Micropterus salmoides*] and bluegill [*Lepomis macrochirus*]), catfish (*Ictalurus* spp.), and fathead minnows (*Pimephales promelas*), that live in perennial ponds such as stock ponds are considered to have negatively affected California tiger salamander populations by preying on larval salamanders (Anderson 1968; Shaffer et al. 1993; Fisher and Shaffer 1996; Lawler et al. 1999; Laabs et al. 2001; Leyse 2005; USFWS 2013b). Hybridization with the barred tiger salamander (*Ambystoma tigrinum mavortium*) is also a threat to this species, although it is unlikely that hybridization or nonnative alleles occur in California tiger salamander populations found in the action area, and hybridization does not appear to be a serious threat in this area (DWR 2013; Riley et al. 2003; Fitzpatrick et al. 2009).

Pesticides, hydrocarbons, and other pollutants are all thought to negatively affect breeding habitat, while rodenticides used in control of burrowing mammals (e.g., chlorphacinone, diphacinone, strychnine, aluminum phosphide, carbon monoxide, and methyl bromide) are considered toxic to adult salamanders (Salmon and Schmidt 1984). California ground squirrel and pocket gopher control operations may have the indirect effect of reducing the availability of upland burrows for use by California tiger salamanders (Loredó-Prendeville et al. 1994).

2.32.5 Recovery and Management

The strategy to recover the Central California tiger salamander focuses on alleviating the threat of habitat loss and fragmentation to increase population resiliency (ensure each population is sufficiently large to withstand stochastic events), redundancy (ensure a sufficient number of populations to provide a margin of safety for the species to withstand catastrophic events), and representation (conserve the breadth of the genetic makeup of the species to conserve its adaptive capabilities) (USFWS 2017). Recovery of this species can be achieved by addressing the conservation of remaining aquatic and upland habitat that provides essential connectivity, reduces fragmentation, and sufficiently buffers against encroaching development and intensive agricultural land uses. Appropriate management of these areas will also reduce mortality by addressing non-habitat related threats, including those from nonnative and hybrid tiger salamanders, other nonnative species, disease, and road mortality (USFWS 2017).

The range of the Central California tiger salamander has been classified into four recovery units: the Central Valley Unit, Southern San Joaquin Valley Unit, Bay Area Unit, and Central Coast Range Unit. The proposed action occurs within the Central Valley Unit, which comprises 12 Management Units across Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, western Amador, western Calaveras, and northwestern Madera Counties. The closest Management Unit to components of the proposed action is the Jepson Prairie Management Unit, located northeast of the Hills Slough Restoration project.

2.33 California Least Tern

2.33.1 ESA Listing Status and Critical Habitat Designation

The USFWS listed the California least tern as endangered on October 13, 1970 (35 FR 8491). California least tern is also listed as endangered under the CESA. On August 23, 2005, the USFWS designated approximately 199,109 acres (80,576 hectares) of critical habitat for the Central Valley DPS. Critical habitat has not been designated for this species.

2.33.2 General Life-History and Habitat Requirements

California least terns nest in loose colonies on barren or sparsely vegetated sandy or gravelly substrates above the high tide line along the coastline and in lagoons and bays of the California coast. Colonies are always near water that provides foraging opportunities. Foraging typically occurs in shallow estuaries or lagoons (Thompson et al. 1997; USFWS 2006d).

California least terns are migratory and are present at nesting areas from mid-April to late September (Anderson and Rigney 1980; Patton 2002). Courtship generally occurs during April and May and usually takes place away from the nesting area on exposed tidal flats or beaches. Nesting begins by mid-May (Massey 1981). Clutch size ranges from one to four eggs but usually consists of two or three eggs, with a single brood raised each year. Incubation is usually 20 to 25 days, and young are fledged by 28 days. The young continue to depend on adults for an additional 2 weeks (Rigney and Granholm 2005). Wintering areas are largely unknown, but are suspected to be along the Pacific Coast of Central and South America (Massey 1977). In the San Francisco Bay Area and Suisun Bay, nesting colonies are typically located in abandoned salt ponds and along estuarine shores, often using artificially or incidentally created habitat (Rigney and Granholm 2005; Marschalek 2008). Foraging occurs in the bay or large river estuaries.

California least terns select nesting colony sites that are free of human or predatory disturbance and are located in proximity to a foraging area. The availability of such sites is a limiting factor for the species. California least terns roost on the ground. Nest sites are shallow depressions without nesting material, typically in barren sandy or gravelly substrate. Prior to egg-laying, adults generally roost away from nest sites, from 0.25 mile at coastal sites to several miles at estuarine sites. This behavior is thought to be a form of predator avoidance (USFWS 2006d).

California least terns are very gregarious and nest, feed, roost, and migrate in colonies. They are highly sensitive to nest disturbance and will readily abandon nest sites if disturbed (Davis 1974, as cited in Rigney and Granholm 2005).

The California least tern feeds in shallow estuaries and lagoons for small fish, including anchovies (*Engraulis* spp.), silversides (*Atherinops* spp.), and shiner surfperch (*Cymatogaster aggregata*) (Rigney and Granholm 2005). It hovers above the water, then plunges but does not completely submerge. It will also forage in the shallow tidal zone of the open ocean and in bays (Rigney and Granholm 2005).

2.33.3 Historical and Current Distribution and Abundance

The historical breeding range of the California least tern extends along the Pacific Coast from approximately Moss Landing to the southern tip of Baja California (Grinnell and Miller 1944). However, since about 1970, colonies have been reported north to San Francisco Bay (USFWS 2006d). The nesting range in California is somewhat discontinuous as a result of the availability of suitable estuarine

shorelines, where California least terns often establish breeding colonies. Marschalek (2006) identified six geographic population clusters along the Pacific Coast in California, including San Diego, Camp Pendleton, Los Angeles/Orange County, Ventura County, San Luis Obispo/Monterey County, and San Francisco Bay. The majority of the California population is concentrated in three counties: San Diego, Orange, and Los Angeles.

Statewide surveys in 2016 estimated 3,989 to 4,661 breeding pairs that established 4,746 nests and produced approximately 1,612 to 2,000 fledglings at 50 breeding sites across California (Frost 2017). Of these, only five breeding sites supporting a total of 570 nests (12 percent of the total) were reported from the San Francisco Bay Area (Frost 2017). Statewide, the growth of the breeding population has been dramatic since state and federal listing of the California least tern, from only several pairs in the late 1960s to a current minimum of 3,989 pairs in 2016 (Frost 2017), 4,202 in 2015 (Frost 2016), and 4,232 in 2014 (Frost 2015).

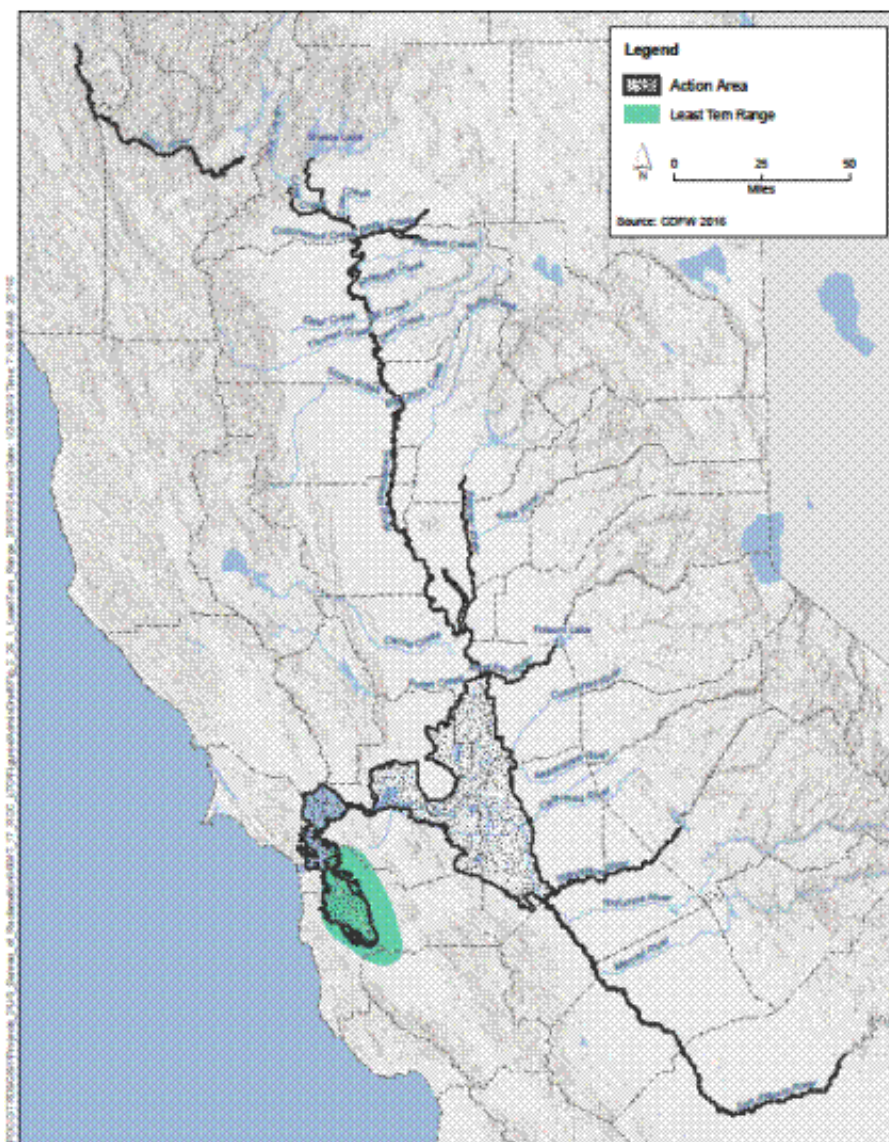


Figure 2.33-1. California Least Tern Range

2.33.4 Limiting Factors, Threats, and Stressors

The loss, degradation, and disturbance of suitable coastal strand and estuarine shoreline habitat is the primary reason for the historical reduction of California least tern populations. Most extant colonies occur on small patches of degraded nesting habitat surrounded on all sides by human activities. The majority of colony sites are in areas that were incidentally created during development projects. Further expansion and recovery of the California least tern population may require the creation or restoration of nesting habitat (USFWS 2006d).

Human disturbance was noted as early as the mid-1920s as a factor in causing colony abandonment and population declines (Rigney and Granholm 2005), and is still considered a major threat to remaining colonies (Garrett and Dunn 1981; Marschalek 2009). There is no suitable natural habitat in California that is free of development, military, or recreation-related human disturbances; thus, opportunities for the species to develop new breeding territories are mostly restricted to artificially or incidentally created habitat. Fencing has been used to prohibit entry into colony sites, but this also restricts the movement of birds. Lack of fencing or damage to existing fencing has led to nesting failures (USFWS 2006d).

Predation is regarded as the most significant threat to existing colonies. Marschalek (2011) reports 47 vertebrate and invertebrate predators or suspected predators of California least tern colonies in 2010. Most depredated tern chicks were taken by gull-billed terns (*Gelochelidon nilotica*, formerly *Sterna nilotica*). Common ravens (*Corvus corax*), coyotes (*Canis latrans*), and American crows (*Corvus brachyrhynchos*) had the highest depredation rate of eggs while peregrine falcons (*Falco peregrinus*) and unknown avian species had the highest depredation rate of fledglings and adults. Marschalek (2011) calculated that 1,007 eggs, 340 chicks, 161 fledglings, and 115 to 129 adults were lost to predation events in 2010.

2.33.5 Recovery and Management

The 1985 recovery plan recommended developing and implementing management plans and programs for “secure” nesting habitat in Alameda, San Mateo, Santa Barbara, Ventura, and Los Angeles, Orange, and San Diego Counties. Management plans created for long-term site ecological security would focus on reducing perturbation, destruction, or pollution of nesting or foraging habitat (USFWS 1985). No plans have been completed for any of these areas.

2.34 California Red-Legged Frog

2.34.1 ESA Listing and Critical Habitat

The USFWS listed the California red-legged frog as threatened in 1996 (61 FR 25813) and published a final rule to revise the designated critical habitat in 2010 (75 FR 12816). The designated critical habitat areas contain physical and biological features (primary constituent elements) that are considered essential to the conservation of the species, and that may require special management considerations and protection. The primary constituent elements identified for the California red-legged frog are:

- 1) Aquatic Breeding Habitat. Standing bodies of fresh water (with salinities less than 7.0 parts per thousand), including: natural and constructed (e.g., stock) ponds, slow-moving streams or pools within

streams, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a minimum of 20 weeks in all but the driest of years.

2) Non-Breeding Aquatic Habitat. Freshwater habitats, as described above, that may or may not hold water long enough for the subspecies to hatch and complete its aquatic life cycle but that do provide for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult California red-legged frogs. Other wetland habitats that would be considered to meet these elements include plunge pools within intermittent creeks, seeps, quiet water refugia during high water flows, and springs of sufficient flow to withstand the summer dry period.

3) Upland Habitat. Upland areas within 200 feet (60 meters) of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat and comprised of various vegetational series such as grasslands, woodlands, and/or wetland/riparian plant species that provides the frog shelter, forage, and predator avoidance. Upland features are also essential in that they are needed to maintain the hydrologic, geographic, topographic, ecological, and edaphic features that support and surround the wetland or riparian habitat. These upland features contribute to the filling and drying of the wetland or riparian habitat and are responsible for maintaining suitable periods of pool inundation for larval frogs and their food sources, and provide breeding, non-breeding, feeding, and sheltering habitat for juvenile and adult frogs (e.g., shelter, shade, moisture, cooler temperatures, a prey base, foraging opportunities, and areas for predator avoidance). Upland habitat can include structural features such as boulders, rocks and organic debris (e.g. downed trees, logs), as well as small mammal burrows and moist leaf litter.

4) Dispersal Habitat. Accessible upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mile (1.2 kilometers) of each other that allows for movement between such sites. Dispersal habitat includes various natural habitats and altered habitats such as agricultural fields, which do not contain barriers to dispersal. (An example of a barrier to dispersal is a heavily traveled road constructed without bridges or culverts.) Dispersal habitat does not include moderate to high density urban or industrial developments with large expanses of asphalt or concrete, nor does it include large reservoirs over 50 acres (20 hectares) in size, or other areas that do not contain those features identified in primary constituent elements 1, 2, or 3 as essential to the conservation of the subspecies.

In total, 34 critical habitat units covering approximately 450,288 acres (182,225 hectares) were designated. The critical habitat is located in Alameda, Butte, Contra Costa, El Dorado, Kern, Los Angeles, Marin, Merced, Monterey, Napa, Nevada, San Benito, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Ventura and Yuba Counties.

2.34.2 General Life History and Habitat Requirements

The California red-legged frog is the largest native frog in the western United States. It is endemic to California and Baja California, Mexico. This species uses a variety of aquatic, riparian, and upland habitats, including ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks, constructed aquatic features, marshes, dune ponds, lagoons, riparian corridors, blackberry thickets, annual grasslands, and oak savannas. The common factor in all habitats used by California red-legged frogs is an association with a permanent water source.

Breeding sites have been documented in a wide variety of aquatic habitats. Larvae, juveniles, and adults have been observed inhabiting streams, creeks, ponds, marshes, sag ponds, deep pools and backwaters within streams and creeks, dune ponds, lagoons, estuaries, and artificial impoundments such as stock ponds. Breeding has been documented in these habitat types irrespective of vegetative cover. They often breed in artificial ponds with little or no emergent vegetation. The importance of riparian vegetation for

this species is not well understood. It is thought that the riparian plant community may provide good foraging habitat and may facilitate dispersal in addition to providing pools and backwater aquatic areas for breeding.

California red-legged frogs disperse upstream and downstream of their breeding habitat to forage and seek shelter. Sheltering habitat for red-legged frogs potentially includes all aquatic, riparian, and upland areas within the range of the species and any landscape features that provide cover, such as existing animal burrows, boulders or rocks, organic debris such as downed trees and logs, and industrial debris. Agricultural features such as drains, watering troughs, spring boxes, abandoned sheds, or hay ricks may also be used. California red-legged frogs breed from November through March with earlier breeding records occurring in southern localities. Individuals occurring in coastal drainages are active year-round, whereas those found in interior sites are normally less active during the cold season. Females attach egg masses to emergent vegetation such as tule stalks, grasses, or willow roots just below the water surface. Larvae hatch 6 to 14 days following fertilization and spend most of their time concealed in submergent vegetation or detritus. Most larvae metamorphose into juvenile frogs 4 to 7 months after hatching, generally between July and September.

The diet of California red-legged frogs is highly variable. Similar to other frog species, larvae most likely consume diatoms, algae, and detritus (USFWS 2002). Invertebrates are the most common food items of adults. Vertebrates, such as Pacific tree frogs (*Hyla regilla*) and California mice (*Peromyscus californicus*), are frequently eaten by larger frogs. Feeding activity likely occurs along the shoreline and on the surface of the water.

2.34.3 Historical and Current Distribution and Abundance

The California red-legged frog has sustained a 70-percent reduction in its geographic range as a result of several factors acting singly or in combination (Jennings et al. 1992). Only a few drainages are currently known to support California red-legged frogs in the Sierra Nevada foothills, compared to more than 60 historical records. In southern California, the California red-legged frog has essentially disappeared from the Los Angeles area south to the Mexican border; the only known population in Los Angeles County is in San Francisquito Canyon on the Angeles National Forest (USFWS 2011).

Based on the best available information at the time of listing, the historic range of the California red-legged frog was described as extending along the coast from the vicinity of Point Reyes National Seashore in Marin County, and inland from the vicinity of Redding in Shasta County, southward to northwestern Baja California, Mexico (61 FR 25814). The listing rule described an intergrade zone between the California red-legged frog and the closely related (and nonlisted) northern red-legged frog (*Rana aurora*; formerly *Rana aurora aurora*) that extended approximately from the Walker Creek watershed in Marin County north to southern Mendocino County. Recent research on the genetics of red-legged frogs indicates that the intergrade zone between the California red-legged frog and the northern red-legged frog likely occurs within a narrower geographic area than previously known, and that the range of the California red-legged frog extends about 60 miles (100 kilometers) farther north (USFWS 2011). The California red-legged frog was probably extirpated from the floor of the Central Valley prior to 1960: the last record of a reproducing population on the valley floor is from the vicinity of Gray Lodge Wildlife Area (Butte County) around 1947, although this record is unverified (USFWS 2002). The species is therefore unlikely to occur in the action area. Reclamation has conducted surveys for California red-legged frog in the action area, and survey results were negative.

2.34.4 Limiting Factors, Threats and Stressors

Factors associated with declining populations of the California red-legged frog include degradation and loss of its habitat through agriculture, urbanization, mining, overgrazing, recreation, timber harvesting, nonnative plants, impoundments, water diversions, degraded water quality, use of pesticides, and introduced predators. The reason for decline and degree of threats vary by geographic location. California red-legged frog populations are threatened by more than one factor in most locations (USFWS 2011).

2.34.5 Recovery and Management

In 2002, USFWS published a recovery plan for the California red-legged frog (USFWS 2002). USFWS initiated a 5-year Status Review of California red-legged frog in June 2018 (USFWS 2018).

2.34.6 Monitoring and Research Programs

Monitoring of the California Red-legged Frog, Rana aurora draytonii, within Properties of the Los Baños Wildlife Area Complex, 2008, by CDFG December 2008

California Department of Fish and Wildlife has been conducting California red-legged frog surveys on the San Luis Reservoir and Upper Cottonwood Creek Wildlife Areas since 2001. Between January and July of 2008, they performed frog surveys on these properties, and additionally at Lower Cottonwood Creek Wildlife Area and Little Panoche Reservoir Wildlife Area at a total of 24 sites. Monitoring consisted primarily of daytime visual surveys and a limited number of night surveys. They were able to confirm frog presence and breeding activity at several sites on Upper Cottonwood Creek Wildlife Area, and observed frog calls during breeding season at Little Panoche Reservoir Wildlife Area. Habitat quality, restoration possibilities, future monitoring, and frog health continue to be key factors in CDFW's monitoring efforts.

One study documented only 20 Sierra Nevada localities and one Cascades Mountains locality where *R. draytonii* occurred between 1916 and 1975, extending from Tehama County southeast about 405 kilometers to Madera County. The elevation range of most of the historical localities was 200 to 900 meters (about 40 kilometers from lower to upper elevation), but three apparently extirpated populations that may have originated from deliberate translocations occurred at 1,500 to 1,536 meters elevation in Yosemite National Park. They surveyed directly or within 5 kilometers of 20 of the 21 historical Sierra Nevada/Cascades *R. draytonii* localities and found that at least one of these historical populations persists today, in large numbers. They also discovered or confirmed six new Sierra Nevada *R. draytonii* populations and individual frogs at three additional new sites, for a total of seven recent populations and three recent single-specimen occurrences extending from Butte County southeast about 275 kilometers to Mariposa County. Historically, *R. draytonii* in the Sierra Nevada probably bred in stream pools, which tend to be small with limited forage and thus may have constrained the historical size and number of Sierra Nevada *R. draytonii* populations. Since the 1850s, constructed ponds sometimes capable of supporting large *R. draytonii* populations have supplemented stream pool breeding habitat. Excluding the southernmost and Yosemite historical localities, the current range of Sierra Nevada *R. draytonii* differs little from the historical range, and further surveys may reveal additional surviving Sierra Nevada *R. draytonii* populations (Barry and Fellers 2013).

Chapter 3 Environmental Baseline

This section analyzes the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat) and the ecosystem, within the action area. The environmental baseline includes the impacts of all federal, state, and 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). It does not include the effects of the action under review in the consultation; that is, the Long Term Coordinated Operations of the Central Valley Project and State Water Project.

As described below, the environmental baseline includes the effects of multiple physical, hydrological, and biological alterations that have negatively affected the species and habitat considered in this consultation. These baseline conditions include the past, present, and ongoing effects of the existence of the CVP structures. It is well established that the existence of dams and other structures, which may already be endangering species survival and recovery, is an existing human activity that is included in the environmental baseline and is not an effect of the action. The decisions of Congress and the state legislature to authorize the construction of those structures fundamentally altered the habitat and survival prospects of the species considered in this document. While those negative effects may continue to occur, they are not effects of the ongoing operation of the CVP and SWP.

Reclamation has discretion in aspects of its operations, such as the exercise of discretion in operational decision making, including deciding how to comply with the existing terms of respective existing water supply and settlement contracts, and legal obligations. However, Reclamation does not have discretion to remove any of the CVP or SWP structures. In contrast to other obligations, Reclamation has a fundamental, nondiscretionary obligation to ensure that its facilities do not present an unreasonable risk to people, property, and the environment. Reclamation Safety of Dams Act, P.L. 95-589, directs Reclamation to “preserve the structural safety of Bureau of Reclamation dams and related facilities...” (P.L. 95-578, as amended).

The environmental baseline projects 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. These are included in the “Past and Present Impacts” section below.

By projecting the prospects for species survival and recovery without the action, the environmental baseline plays a necessary role in defining the effects of the action. That, in turn, allows for a determination of whether the action jeopardizes the continued existence of listed species or adversely modifies their critical habitat.

3.1 Past and Present Impacts

The baseline includes the past and present impacts of all federal, state, and 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 that are contemporaneous with the consultation in process, including the past and present impacts of CVP and SWP operations under 2008 and 2009 biological opinions.

The CVP and SWP operate in an environment vastly different from the conditions under which native aquatic species evolved. Physical, hydrological, and biological alterations present novel conditions that result in stressors on California species and that pre-date the CVP. During the last 200 years, human activities have dramatically altered and reshaped the habitat upon which the species addressed in this consultation depend for survival. Those activities, as well as others, have reduced and continue to reduce significantly the species' likelihood of survival and recovery.

3.1.1 Physical Alteration

Since 1900, approximately 95 percent of historical freshwater wetland habitat in the Central Valley floodplain has been lost, typically through the construction of levees and draining for agriculture or residential uses (Hanak et al. 2011). Human expansion has occurred over vast areas in the Delta and Sacramento and San Joaquin Valleys between the 1850s and the early 1930s, completely transforming their physical structure (Thompson 1957, 1965; Suisun Ecological Workgroup 2001; Whipple et al. 2012; San Francisco Estuary Institute 2010). Levee ditches were built to drain land for agriculture, human habitation, mosquito control, and other human uses, while channels were straightened, widened, and dredged to improve shipping access to the Central Valley and to improve downstream water conveyance for flood management.

3.1.1.1 Dams

Water storage and diversion in California began in 1772, with a 12-foot high dam on the San Diego River. The water needs of mining, agriculture, communities, and electricity generation resulted in dams throughout the Sierra Nevada. In 1890, the California Fish and Game Commission first documented concerns with upstream passage and seasonal barriers for Chinook Salmon. Around the same time, the Folsom Powerhouse created a stone dam across the American River in 1893 (California Parks and Recreation 2018). On the Sacramento River, the Anderson-Cottonwood Irrigation District constructed a dam near Redding in 1916. PG&E developed the Pit River in the 1920s for hydroelectricity (TNC 2007). On the Stanislaus River, the Oakdale and South San Joaquin Irrigation Districts constructed the original Melones Dam in 1926 to provide water for agriculture. On the San Joaquin River, Mendota Dam diverted irrigation water beginning in 1919 (WEF 2018). These early, non-CVP dams and diversions blocked fish passage and reduced downstream flows during the irrigation season. Since the 1850s, declining numbers of California's anadromous salmonids have been attributed, in large part, to dams (Yoshiyama et al. 1998).

On non-CVP and non-SWP streams, local districts have constructed dams and diversion facilities. Examples include Ward Dam on Mill Creek; Deer Creek Irrigation Diversion Dam on Deer Creek; Comanche Dam on the Mokelumne River; Durham Mutual Diversion on Butte Creek; La Grange Diversion Dam on the Tuolumne River; Crocker-Huffman Dam on the Merced River; and New Hogan Dam on the Calaveras River.

The primary negative effect of dams on salmonids is the elimination of access to a portion of spawning habitat, and for some species, the majority of spawning habitat. This effect started before the CVP, as early as 1918. Starting in the 1930s, the "rim dams" were constructed, which blocked higher elevation spawning habitat for salmonids. Construction of major CVP facilities began in 1938 with breaking of ground for Shasta Dam on the Sacramento River near Redding in Northern California. Over the next five decades, the CVP was expanded into a system of 20 dams and reservoirs that together can hold nearly 12

MAF of water. Currently, in California's Central Valley, dams block access to more than 80 percent of historical salmonid spawning areas (Yoshiyama et al. 1998; Lindley et al. 2006).

These CVP, SWP, and other dams prevent fish passage into cold upstream areas with more spawning habitat. Historical Winter-Run Chinook Salmon and Green Sturgeon spawning habitat may have extended up into the three major branches of the Upper Sacramento River above the current location of Shasta Dam; the Upper Sacramento River, the Pit River, and the McCloud River. In a 2014 habitat assessment, Reclamation found suitable and stable temperatures for Chinook Salmon during the warmest weeks of summer in portions of the McCloud and Upper Sacramento Rivers. For Central Valley Steelhead, it has been estimated that access to as much as 95 percent of all spawning habitat in the Central Valley has been lost (California Advisory Committee on Salmon and Steelhead Trout 1988). For several species, dams have resulted in a consolidation of spawning areas into one reach of one river. This increases the vulnerability of the species because a single catastrophic event could eliminate the population. Multiple reaches of spawning habitat in multiple rivers allows for greater resiliency of the population. Preventing access to the coldest water spawning habitat has greatly reduced the resiliency of Chinook Salmon to respond to stressors such as higher temperatures and extended drought.

Dams also trap sediment from upstream, which can lead to downstream streambeds becoming coarser or armored, hindering excavation of redds by spawning salmonids. Also, fine sediment from side channels that is normally flushed out by more frequent and larger flows can accumulate in gravel, reducing spawning success of salmonids.

3.1.1.2 *Disconnected Floodplains and Drained Tidal Wetlands*

Flooding has always been a regular occurrence along the Sacramento River (Thompson 1957, 1960, 1961, 1965) and the San Joaquin River. Floodplains are areas inundated by overbank flow, typically during the winter and spring peak flows. Inundation can last for up to several months. Floodplains can provide conditions that support higher biodiversity and productivity relative to conditions in river channels (Tockner and Stanford 2002; Jeffres et al. 2008). Floodplains also create important habitat for rearing and migrating fish; migratory waterfowl; and amphibians, reptiles, and mammals native to the Central Valley. Historically, Central Valley Chinook Salmon juveniles reared for up to three months on inundated floodplains, growing rapidly prior to ocean entry (Sommer et al. 2001).

Between the 1850s and 1930s over 300,000 acres of tidal marshes in the Delta were diked, drained, and converted to agriculture (Atwater et al. 1979). In addition, fill associated with past development has resulted in the loss of approximately 79 percent of tidal marsh habitat and approximately 90 percent of all tidal wetlands in the San Francisco Bay (California State Coastal Conservancy et al. 2010). Thus, the complex, shallow, and dendritic marshlands were replaced by simplified, deep, and less vegetated channels. This hydrogeomorphic modification fragmented aquatic and terrestrial habitats and decreased the value and quantity of available estuarine habitat (Herbold and Vendlinski 2012; Whipple et al. 2012). In the Central Valley, 95 percent of historical floodplain wetland has disappeared (Katz et al. 2017). The decline in, and disconnection from, floodplain habitat and the food it produces has been linked to native fish population declines (Jassby et al. 2003). The degradation and simplification of aquatic habitat in the Central Valley has also greatly reduced the resiliency of Chinook Salmon to respond to additional stressors (NMFS 2016b). Further, important ongoing development stressors (e.g., urban and agricultural development) continue to affect wetlands in California, and stream-associated salt marsh and wetland habitat have shown declining health and function due to urbanization effects (California Natural Resources Agency 2010).

3.1.1.3 *Levees*

The development of California's agricultural industry and water conveyance system has resulted in the construction of armored, riprap levees on more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). As part of the Sacramento River Flood Control Project, the U.S. Army Corps of Engineers (USACE) constructed levees in the lower Sacramento River Basin. Revetments and bank armoring caused channel narrowing and incision and prevented natural channel migration. Levees have also isolated former floodplains from the river channel, preventing access for rearing for juvenile salmonids.

Many of these levees use riprap to armor the bank. Constructing and armoring levees changes bank configuration and reduces cover (Stillwater Sciences 2006). Constructed levees protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically reduce deposition and retention of sediment and woody debris. This reduces the shoreline variability, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and to escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

In addition, the armoring and revetment of stream banks may narrow rivers, reducing the amount of habitat per unit channel length (Sweeney et al. 2004). As a result of river narrowing and deepening, benthic habitat decreases and the number of macroinvertebrates per unit channel length decreases, affecting salmonid food supply.

3.1.1.4 *Gold and Gravel Mining*

Significant gold and gravel mining in the Sacramento River watershed has further degraded aquatic habitats by decreasing the availability and recruitment of suitable spawning gravels. Hydraulic gold mining began in mid-1800, with an estimated 5,000 miles of mining canals and flumes established by 1859 (Lufkin 1990). Around 1.5 billion cubic yards of debris were sluiced into streams. For over 100 years, around 1.5 billion cubic yards of hydraulic mining debris moved through California's rivers and the Sacramento-San Joaquin Delta (Lufkin 1990). Fine sediments settle in between spawning gravels, reducing hyporheic flow and the movement of required dissolved oxygen to developing salmonid eggs. This contributed to decreased salmonid populations in the 1800s and early 1900s; however, the direct effect no longer occurs, as fine sediments from hydraulic mining are moving past the Golden Gate Bridge (James 2004). Persistent effects from the genetic bottlenecks and physical alterations remain.

3.1.1.5 *Gravel*

Coarse sediment from the upper watershed is prevented from being transported downstream by dams, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the Sacramento River (Wright and Schoellhamer 2004). In addition to the reduction of sediment supply, recruitment of large woody material to the river channel and floodplain has also declined due to a reduction in bank erosion and blockage of wood transport by dams.

3.1.1.6 *Timber Production*

Timber production is a dominant land use within private timber holdings that operate in the mountains of Humboldt, Trinity, and Mendocino Counties. The effects of road building associated with timber harvest, and rural road construction in general, can destabilize hillsides and increase erosional processes that deliver fine sediment to streams and rivers. Poorly designed or constructed stream crossings can often

preclude adult and juvenile fish from migrating upstream past the crossing, and can alter stream channel morphology and hydraulic characteristics within, and upstream and downstream, of the road crossing. High instream sediment loads and poor large woody debris recruitment associated with timber production can affect salmonid habitat for decades after logging has stopped (NMFS 2016).

3.1.1.7 *Marijuana Cultivation*

Changes in land use associated with growing marijuana can result in habitat fragmentation, agricultural water diversions from rivers and streams, and non-point pollutant discharge (i.e., sediment, pesticides, etc.). Illegal marijuana cultivation has grown into a leading threat to Salmon and Steelhead recovery on smaller creeks throughout California, including those that form part of the watersheds of the Trinity and Sacramento Rivers. Illegal growers often dam and dewater creek channels to irrigate their marijuana gardens, and commonly use pesticides, fertilizers and poisons without regard for their impacts on the environment. On January 16, 2019, the the Office of Administrative Law approved California Department of Food and Agriculture's final cannabis cultivation regulations, which include requirements for diversions, fertilizers, and pesticides, and should reduce this effect.

3.1.1.8 *Large Woody Debris*

Prior to the 1970s, some streams were so clogged with logs that biologists believed they were total barriers to fish migration. As a result, in the early 1970s it was common practice for fisheries agencies to remove woody debris (NMFS 1996b). It is now recognized, however, that too much large woody debris was removed from the streams. Large quantities of downed trees are an important component of many streams in order to increase channel complexity, shade the channel, and provide nutrient inputs (NMFS 1996b).

3.1.1.9 *Alterations to Address Effects*

Reclamation, DWR, USFWS, NMFS, and CDFW as well as other agencies have worked to address the effects of these factors on listed species over the past decades as directed by Congress and state legislatures. The following sections describe beneficial physical alterations.

3.1.1.10 *Fish Passage*

Although agencies have reduced fish passage by damming rivers, they have also worked to provide fish passage over their dams. In the late 20th century, agencies including Reclamation and DWR have increasingly worked to increase fish passage above water infrastructure and reduce fish entrainment into diversions. Providing fish passage increases access to spawning habitats, decreasing density-dependent effects and allowing more variability in the population, thereby increasing resiliency.

For example, in August 2012, Reclamation completed the Red Bluff Pumping Plant and Fish Screen to improve fish passage conditions on the Sacramento River. The facility includes a 1,118 foot flat-plate fish screen, intake channel, 2,500-cfs capacity pumping plant, and discharge conduit to divert water from the Sacramento River into the Tehama-Colusa and Corning Canals. In 2011, the dam gates were permanently placed in the open position for free migration of fish while ensuring continued water deliveries by way of the Red Bluff Pumping Plant. Other examples of passage improvements include removal of the McCormack-Seltzer Dam on Clear Creek, passage at the ACID diversion dam, and tributary efforts under the CVPIA on Battle, Butte, Calaveras, Mill, Deer, and Antelope Creeks.

3.1.1.11 *Spawning and Rearing Habitat Augmentation*

Through CVPIA(b)(12), Reclamation has augmented spawning and rearing habitat for listed species in CVP tributaries. Between 1997 and 2008, over 195,000 tons of gravel have been placed in the Sacramento, Stanislaus, and American River tributaries. Since 2016, a number of spawning and rearing side channel restoration sites on the American and Sacramento Rivers have been implemented. In the Lower American River, roughly 24 acres have been devoted to gravel augmentation, while approximately 50 acres have focused on side channel creation. In the Sacramento River, roughly 4 acres have been devoted to ongoing gravel augmentation launching sites, while approximately 20 acres have been devoted to side channel creation. As a result of these actions, Reclamation has improved spawning and rearing habitat for ESA-listed salmonids in these tributaries.

3.1.1.12 *Tidal Marsh Restoration*

To repair some of the 300,000 acres of tidal wetlands that were drained starting in the 1800s, DWR is in the process of implementing 8,000 acres of tidal wetland habitat restoration in the Sacramento—San Joaquin Delta and Suisun Marsh. DWR has completed 159 acres of tidal and subtidal restoration with another 2,020 acres in construction. As some projects are still being planned, Reclamation is programmatically consulting on tidal wetland habitat restoration in this biological assessment.

3.1.1.13 *Suisun Marsh Preservation Agreement*

Reclamation and DWR will address salinity in the Suisun Marsh related to operations through the 2015 Suisun Marsh Preservation Agreement (SMPA) and Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Suisun Marsh Plan), which has separate NEPA and ESA compliance completed in 2014. Public Law 99-546 identifies that Reclamation and DWR will share the implementation cost of the 2015 SMPA. The 2015 SMPA was signed by DWR, CDFW, Suisun Resource Conservation District, and Reclamation. The Suisun Marsh Plan addresses concerns of operations of the CVP and SWP on the ecosystem, much of which is privately owned and home to waterfowl hunting clubs. As part of the Suisun Marsh Plan, Reclamation and DWR propose to work with the SMPA principals to: (1) Restore 5,000 to 7,000 acres of tidal marsh to contribute to the recovery of threatened and endangered species; (2) Protect and enhance 40,000 to 50,000 acres of managed wetlands to benefit waterfowl and other resident and migratory wildlife species; (3) Improve ecological processes and reduce stressors, such as invasive species and contaminants; (4) Maintain waterfowl hunting heritage and expand opportunities for hunting, fishing, bird watching, and other nature-oriented recreational activities; (5) Maintain and improve Marsh levee system integrity; and (6) Protect and, where possible, improve water quality for beneficial uses in the Marsh through operating the Suisun Marsh Salinity Control Gates and Roaring River distribution system.

3.1.1.14 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*

To assist in recovering some of the hundreds of thousands of acres of floodplain that were disconnected from Central Valley streams starting in the 1800s, Reclamation and DWR will modify infrastructure at Fremont Weir to increase access to floodplain habitat in the Yolo Bypass for juvenile salmonids. The project will also increase the ability of adult salmon and sturgeon to migrate from the Yolo Bypass to the Sacramento River.

3.1.2 Hydrologic Alteration

3.1.2.1 Dams

Construction and operation of CVP and SWP dams, as well as other large dams in the California Central Valley, have changed streamflow downstream of the dams. Dams reduce downstream peak spring flows by storing snowmelt and precipitation inflows for industrial and domestic uses and agriculture. A large percentage of the natural historical inflow to Central Valley watersheds and the Delta is now diverted for human uses. Flows are increased in the summer and fall periods due to releases from storage for downstream agricultural, municipal, and industrial water supplies. Dams disrupt natural hydrologic patterns and impair sediment transport, channel morphology, substrate composition, and water quality (including temperature and turbidity) within downstream reaches (Spence et al. 2008). Operations at reservoir-related dams often affect downstream reaches by impairing flow timing and volume. These effects impair salmonid habitat and affect salmonid migration, spawning, and rearing within the affected reaches.

Reduced streamflows have contributed to decreased recruitment of gravel, decreased recruitment of large woody debris, and reduced geomorphic work. Stable year-round flows have resulted in diminished natural channel formation, altered foodweb processes, and slowed regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. Dams have also trapped fine sediment which otherwise could have entered the Delta (Wright and Schoellhamer 2004), thus contributing—along with other factors such as increases in invasive aquatic vegetation (Hestir et al. 2016) and declining wind speed (Bever et al. 2018)—to a long-term reduction in turbidity for Delta Smelt (e.g., Nobriga et al. 2008).

The reduced flow variability has also shifted water temperatures. If warm surface water from the reservoir is released, dams may increase downstream water temperatures, particularly in summer, when flows are lowest. Lower base flows and warm-water releases can reduce the amount of available habitat, increase the metabolic demands of fishes, and disrupt fish migration patterns (Olden and Naiman 2010). Warm water can also facilitate the spread of disease (Okamura et al. 2011; Kocan et al. 2009).

Most large dams, however, release cold water from the bottom of reservoirs. Cold water releases that maintain or increase downstream base flows will usually reduce water temperatures in summer and fall (Huang et al. 2011; Yates et al. 2008), effectively shifting cold-water rearing habitat for juvenile anadromous salmonids from headwaters to below reservoirs (Ward and Stanford 1983). Cold water releases are often crucial for sustaining remnant salmonid populations. For example, endangered Winter-Run Chinook Salmon in the Sacramento River are maintained entirely by cold-water flows from Shasta Dam, which prevents access to their former habitats (Moyle 2002). However, reliance on cold-water releases to protect salmon can be a problem if there is insufficient cold water in the reservoir to keep temperatures cool during late summer or during periods of drought. Cooler temperatures can also delay juvenile migration cues and slow juvenile growth (Moyle and Cech 2004).

3.1.2.2 Diversions

A large number of water diversions were constructed in the Central Valley in the 1900s, for riparian water rights holders, water districts, and CVP and SWP water users. These diversions reduce the flow in California rivers, reducing available spawning area, dewatering redds, and stranding juvenile salmonids.

Water withdrawals, for agricultural and municipal purposes, have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude

to result in reverse flows in the Lower San Joaquin River (Reynolds et al. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival in riverine sections of the Central Valley (Brandes and McLain 2001). Elevated water temperatures in the Sacramento River have limited the survival of young salmon in those waters. Juvenile Fall-Run Chinook Salmon survival in the Sacramento River is also directly related to June streamflow and June and July Delta outflow (Dettman et al. 1987). Diversions can also affect pelagic species, e.g., by influencing the extent of abiotic rearing habitat for juvenile and subadult Delta Smelt (Feyer et al. 2011).

Reclamation delivers water to the Sacramento and San Joaquin Valleys and the San Francisco Bay Area, and DWR delivers water to these areas as well as southern California cities. Effects in both CVP and SWP water delivery service areas have already been addressed in separate, completed ESA consultations. These effects have been previously analyzed and there is no new information that would change that analysis. The results remain valid and are incorporated by reference.

In addition to surface water diversion, groundwater withdrawals also impair stream habitat by lowering groundwater resources. This impairs volume, extent, timing, and temperature of surface flows.

3.1.2.3 *Entrainment*

Entrainment of fish into irrigation canals can be a major source of mortality (Carlson and Rahel 2007). Legislation requiring fish screens in the Western United States began as early as 1893 in Montana (Clothier 1953), and anadromous fish were being entrained by the millions in Oregon in 1928 (McMillan 1928). Fish entering unscreened water diversions undergo injury and mortality (Kimmerer 2008; Baumgartner et al. 2009; Grimaldo et al. 2009), reduced fitness (Bennett 2005; Kimmerer 2008) or habitat degradation (Drinkwater and Frank 1994; Kingsford 2000). Entrainment into water diversions can harm several fish species, including ESA-listed species, such as Delta Smelt (Bennet 2005) and Green Sturgeon (Mussen et al. 2014).

Entrainment at Jones and Banks Pumping Plants, as well as the effects of changed Delta hydrodynamics, is a significant source of mortality for listed species in the Delta. To minimize these effects, Reclamation currently operates in accordance with RPA actions from the 2008 and 2009 biological opinions that minimize and reduce the effects of entrainment, including salvaging fish and operating to OMR reverse flow criteria.

The 1992 passage of CVPIA included construction of new screens, rehabilitation and replacement of existing screens, and relocation of diversions. In 1997, there were at least 3,356 diversions taking water from the Sacramento and San Joaquin Rivers, their tributaries, and the Delta (Herren and Kawasaki 2001). Over 98 percent of these diversions were unscreened or inadequately screened (Herren and Kawasaki 2001). Since the start of CVPIA's Anadromous Fish Screen Program through 2012, Reclamation and USFWS have provided funding for 35 fish screen projects, screening 5,412 cfs of diversions. Only one diversion greater than 100 cfs remains unscreened on the Sacramento River.

3.1.2.4 *Contaminants (Runoff, Waste Treatment, Etc.)*

As described above, historical activities, such as gold mining, have resulted in high concentrations of methylmercury in much of the Central Valley. Many of the more than 500 mercury mines in California have not been remediated and continue to release mercury to the environment (CDFW 2017). Methylmercury is formed from inorganic mercury by microscopic organisms that live in waterbodies and sediments. Inundation of sediments, such as on a floodplain, can increase the methylation of mercury. Methylmercury is a neurotoxin that bioaccumulates and biomagnifies in the aquatic foodweb (Davis et al.

2003). It can also impair the smoltification and subsequent outward migration behavior in juvenile salmon.

Current activities continue to contribute contaminants to Central Valley waterways. For example, from Fong et al 2016: “Monitoring entities and research studies have detected multiple contaminants occurring simultaneously in Delta water samples (Ensminger et al. 2013; Orlando et al. 2013, 2014). Multiple pesticides are continuously detected in the two primary tributaries to the Delta. For example, 27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was 9.”

High levels of toxicity to aquatic invertebrates were found to originate from urban stormwater pyrethroid pesticide loading to San Francisco Estuary tributaries (Weston, 2014, 2015; Brander 2013; Werner 2010; Amweg et al. 2006). Weston and Lydy (2010) detected pyrethroids in all but one of 33 urban runoff samples and observed toxicity over at least a 30 km reach of the American River, and at one site in the San Joaquin River. Pyrethroid pesticides have been identified as a factor possibly contributing to pelagic organism decline because of their increased use in recent years and their high toxicity to aquatic organisms (Fong et al 2016).

The discharge of contaminants into California waters from urban and agricultural sources is likely to continue into the future. The Central Valley is becoming more urbanized, which increases the likelihood of urban discharges entering waterways. Likewise, regional agriculture will continue to discharge agricultural return flows from irrigation practices into surrounding waterways.

3.1.2.5 *Pulse Flows*

As discussed above, operation of dams has reduced flow variability across California. To address this, Reclamation and DWR have implemented pulse flows on a variety of CVP and SWP streams due to the 2000 Trinity River ROD, CVPIA (b)(2), 1960 Memorandum of Agreement (MOA) with CDFG, 1987 CDFG agreement on the Stanislaus, SWRCB water rights orders, and 2009 NMFS Biological Opinion. Spring pulse flows have beneficial effects on salmonids by increasing Chinook Salmon smolt survival (Michel 2015) and subyearling Chinook Salmon smolt survival (Zeug et al. 2014).

3.1.2.6 *Management for Temperature*

Reclamation and DWR have managed for temperature on CVP and SWP tributaries as a result of SWRCB Water Rights Order 90-5 and ESA requirements. These temperature management actions have had generally beneficial effects on species. Reclamation and DWR’s temperature management has resulted in cooler flows during summer and fall periods than would occur without temperature management. Absent these temperature management actions, increased temperatures and therefore increased egg and juvenile salmonid mortality would occur.

3.1.2.7 *Temperature Control Devices*

Reclamation has constructed a TCD at Shasta Dam, a selective withdrawal device at Folsom Dam, and a selective withdrawal device on the Folsom Dam Urban Water Supply Pipeline for greater flexibility in managing the cold water reserves while enabling hydroelectric power generation to occur and to improve salmonid habitat conditions. Many reservoirs have a low-level outlet that accesses the coldest water in the reservoir. However, these outlets often are not routed through the hydroelectric powerplant at the dam. Therefore, a TCD allows several elevations of water to be withdrawn from the reservoir—warm from the

surface or cold from the bottom—and routed through the powerplant. Temperature control devices allow Reclamation to release warmer water from the top of the reservoir in the springtime, when salmonid temperature requirements are warmer, without bypassing power generation. These devices also allow Reclamation to lower the reservoir elevation at which water is taken for river release, in accordance with changing fish temperature requirements throughout the year. As air temperatures and stratification result in a warming surface of the reservoir in the summer and fall, Reclamation uses the warmer surface water until fisheries requirements necessitate withdrawal of colder water from lower in the reservoir.

Without temperature control devices, Reclamation either would not be able to provide as much cold water in any given year for meeting fisheries temperature requirements, or would reduce the hydroelectricity generated from releases from its dams.

3.1.2.8 Water Quality

Although conditions in most streams, rivers, and estuaries throughout the State are much improved from 40 years ago, the rate of improvements have slowed over time (San Francisco Estuary Partnership 2015). Contaminants such as polybrominated diphenyl ethers (PBDEs), and copper have declined over time, however many potentially harmful chemicals and contaminants of emerging concern (pharmaceuticals) have yet to be addressed. Legacy pollutants such as mercury and PCBs limit consumption of most fish, and directly and indirectly affect endangered fish populations, as well as their designated critical habitat.

In particular, urban stormwater runoff is consistently toxic to fish and stream invertebrates (McIntyre et al. 2014, 2015). The array of toxicity is variously attributed to metals from motor vehicle brake pads; petroleum hydrocarbons from vehicle emissions of oil, grease, and exhaust; and residential pesticide use. Urban stormwater toxicity has been linked to pre-spawn mortality of Coho Salmon (*Oncorhynchus kisutch*) (Scholz et al. 2011). The degree of impervious surface (Feist et al. 2011) has also been linked to pre-spawn mortality of Coho Salmon, and both have been directly linked to effects at the population level (Spromber and Scholz 2011). Emphasis on wastewater treatment plant upgrades and new legislative requirements (SWRCB and EPA), development and implementation of total maximum daily load (TMDL) (i.e., pathogens, selenium, pesticides, pyrethroids, methylmercury, heavy metals, salts, nutrients) programs, and adoption of new water quality standards (i.e., Basin Plans), all aid in protecting beneficial uses for aquatic wildlife.

In recent years, NOAA scientists have investigated the direct and indirect effects of pesticides on individual ESA-listed species, the foodwebs on which they depend, and at the population level (Baldwin et al. 2009; Laetz et al. 2009; Macneale et al. 2010; Scholz et al. 2012). NMFS has consulted on seven batched pesticide ESA Section 7 consultations, and concluded that chlorpyrifos, diazinon, malathion, carbaryl, carbofuran, methomyl, bensulide, dimethoate, ethroprop, methidathion, naled, phorate, phosmet, 2,4-D, chlorothalonil, diuron, oryzalin, pendimethalin, and trifluralin jeopardize the continued existence of ESA-listed species and/or adversely modified critical habitat for salmonids across the West Coast Region (NMFS 2008a, 2010, 2011b, 2013).

3.1.3 Biological Alteration

3.1.3.1 Commercial Harvest

Commercial harvest of salmon began in the 1850s (CDFG 1929) and gill net salmon fisheries became well established in the Lower Sacramento and San Joaquin Rivers by 1860. In 1864, the first Pacific Coast salmon cannery was constructed along the Sacramento River. By its peak in 1882, the Sacramento and San Joaquin Rivers had 20 salmon canneries and processed about 11 million pounds of catch

(USFWS 1964; CDFG 1929). In 1910, there were 10 million pounds of commercial salmon catch; that declined to 4.5 million pounds by 1919 when the last inland cannery closed (CDFG 1929). An estimate of historical abundances of Chinook Salmon in the Central Valley is about 1 to 2 million annual spawners (Yoshiyama et al. 1998).

In 1916, ocean harvest at Monterey alone was over 5 million pounds (Yoshiyama et al. 1998). Between 2006 and 2017, the highest total commercial ocean harvest was 3.8 million pounds in 2013, averaging about 1.5 million pounds over that period (CDFW 2016). The ocean commercial harvest at Monterey in 2016 and 2017 was about 150,000 pounds, representing about 25 and 30 percent of the total ocean commercial harvest, respectively (CDFW 2016). NMFS recently revised harvest rules, which had the effect of increasing harvest pressures on Winter-Run Chinook Salmon at low abundances (NMFS 2018).

3.1.3.2 Hatcheries

Five hatcheries currently produce Chinook Salmon in the Central Valley, and four of these also produce Steelhead. Releasing large numbers of hatchery fish can have negative effects on wild populations through competition for space and food, direct predation, and loss of genetic diversity (Moyle 2002). Interbreeding between artificially propagated hatchery and wild individuals can reduce fitness of offspring (Araki et al. 2009). Barnett-Johnson et al. (2008) found that only 10 percent of Central Valley Fall-Run Chinook Salmon harvested in the ocean fishery were of natural origin. On the Mokelumne River, approximately 4 percent of returning adults in the 2004 escapement were found to be of natural origin (Johnson et al. 2012) and the work identified large-scale hatchery production as masking poor natural production and recruitment. These patterns appear throughout the Central Valley, with large proportions of returning adult salmon straying into watersheds without hatcheries (Palmer-Zwahlen and Kormos 2015).

In 1942, CNFH was established to mitigate the loss of spawning areas due to construction of the Shasta and Keswick Dams. Reclamation constructed the LSNFH, a sub-station to CNFH, in 1997 to assist in Winter-Run Chinook Salmon recovery. CDFW operates a number of hatcheries for Salmon and Steelhead, including on the Trinity, Feather, and American Rivers.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between Spring-Run and Fall-Run Chinook Salmon have led to the genetic hybridization of some subpopulations (CDFG 1998). Spring-Run from the Feather River Fish Hatchery have been straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of Fall-Run, an indication that Feather River Fish Hatchery Spring-Run may have Fall-Run life history characteristics.

To start to address these interbreeding and hybridization concerns, modern hatcheries are required to develop a Hatchery Genetic Management Plan under Section 4 of ESA. A Hatchery Genetic Management Plan addresses long-range planning and management of the hatchery fish.

3.1.3.3 Nonnative Predators

Aquatic invasive species (both plants and animals) have been shown to have major negative effects on the receiving communities, where they often outcompete native species, reduce species diversity, change community structure, reduce productivity and disrupt foodweb function by altering energy flow among trophic levels (Cohen and Carlton 1995; Ruiz et al. 2000; Stachowicz and Byrnes 2006). Multiple mechanisms of impact affect salmonids directly, such as predation and infection (disease and parasitism), and indirectly, such as competition, hybridization, and habitat alterations (Mack et al. 2000; Simberloff et

al. 2005). Based on the number of species, individuals and biomass, as well as high and accelerating rate of invasion, the Delta may be the most invaded estuary in the world (Cohen and Carlton 1998).

Striped Bass were introduced in 1880s to provide a commercial fishery. Now a recreational fishery, Striped Bass and other introduced species including Catfish prey upon listed species. A Striped Bass population of 1,000,000 could consume 9 percent of out-migrating Winter-Run Chinook Salmon based on Bayesian population dynamics modeling (Lindley and Mohr 2003). According to the Coalition for a Sustainable Delta's website, invasive species represent 95 percent of the total biomass in the Delta. Striped Bass are identified by the USFWS (2010) as a low potential threat to Delta Smelt.

High rates of predation have been known to occur at diversions and locations where rock revetment has replaced natural river bank vegetation (NMFS 2009, as cited in Reclamation 2015). Young salmonids are more susceptible to predation at these locations because predators congregate in areas that provide refuge (Tucker et al. 2003; Williams 2006). Nonnative centrarchids, such as Largemouth Bass and Spotted Bass, will opportunistically feed on juvenile salmonids.

3.1.3.4 Invasive Aquatic Weeds

The Delta has changed as a result of the proliferation of invasive aquatic vegetation in recent years (Ta 2017). These aquatic plants, largely comprised of invasive species, create highly productive microhabitats (Lucas et al. 2002; Nobriga et al. 2005; Grimaldo et al. 2009), but they degrade habitat quality for native species by increasing water transparency (Nobriga et al. 2008; Hestir et al. 2016) and harboring predatory fishes (Ferrari et al. 2014; Conrad et al 2016), increasing nonnative predator populations. Aquatic weeds have resulted in increased nonnative predator populations, while on their own they would likely be helpful for salmon by providing food and shelter.

3.1.3.5 Foodweb Dynamics and Clams

Diatoms are the group of phytoplankton that tend to be most important to open-water foodwebs in estuaries and coastal marine systems. Diatoms need three things to grow: sunlight, nutrients, and time. The primary historical limit on sunlight was turbidity so diatoms tended to grow best in shallow water. Suisun Bay and marsh were important locations for fish in the low-salinity zone because the Delta was already so channelized and deep (Cloern et al. 1983; Cole and Cloern 1984). Historically, the estuary was considered to have excess nutrients for diatom growth, so that nutrients were not limiting the base of the foodweb (Jassby et al. 2002). The third thing diatoms need to grow is time. Historical limits on this were water residence time and clam grazing rates (Cloern et al. 1983; Lopez et al. 2006).

There are two clam species that affect phyto- and zooplankton biomass. The freshwater *Corbicula fluminea*, which has been in the Delta and its tributaries since the 1940s, and the estuarine overbite clam *Potamocorbula amurensis*, which has been in the Bay and west Delta (but not tributaries) since 1986. Freshwater *Corbicula fluminea* can have foodweb impacts in shallow freshwater habitats with long water residence times (Lucas et al. 2002; Lopez et al. 2006).

Year to year variation in Delta outflow, especially during the spring and summer, led to year to year variation in plankton productivity because in wet years, outflow brought nutrients and organic carbon into the low-salinity zone, and in dry years, the elevated salinity let a marine clam (*Mya arenaria*) colonize Suisun Bay and eat the diatoms down to low levels (Knutson and Orsi 1983; Cloern et al. 1983). This lowered the production of opossum shrimp (*Neomysis*) that was a significant food source for native fish species at the time (Feyrer et al 2003). However, wet year plankton productivity did not extend to increases in Delta Smelt abundance (Stevens and Miller; Jassby et al. 1995). It was also shown through

modeling and data analysis that water exports could affect foodweb productivity in the low-salinity zone by affecting rates of organic carbon/diatom subsidy from the Delta (Jassby and Cloern 2000).

By 1987, the overbite clam (*P. amurensis*) was established and resulted in a permanent source of loss to diatoms and copepod larvae. This resulted in rapid step-declines in the abundance of the most important historical foodweb components like diatoms, *Neomysis*, and *Eurytemora affinis* (Alpine and Cloern, 1992; Kimmerer and Orsi 1996). *Eurytemora affinis* was a major prey for both *Neomysis* and Delta Smelt (Knutson and Orsi).

Another hypothesis for the decline in foodweb components in the Delta is ammonium from wastewater treatment plants. Also around 1987, ammonium levels frequently rose above 4 micro-molar, which is a critical threshold that slows diatom growth (Wilkerson et al. 2006; Gilbert et al. 2011; Rev Fish Sci; Dugdale et al. 2016; Dugdale et al. 2007). Opponents of this hypothesis argue that but for the overbite clam, diatom populations would eventually build up enough biomass each year to use up the ammonium and then rapidly accelerate their growth by feeding on nitrate. The overbite clam recruitment increases in the late spring to early summer, and the clam population eats most of the diatom biomass so that there is no opportunity for sustaining enough diatoms long enough into the summer to consume the ammonium and reach the nitrate (Dugdale et al. 2012; Dugdale et al. 2016). Uncertainty exists in the scientific literature on this point, with Dugdale et al. (2016) stating that estimates of the overbite clam's grazing rates are too high, while Kimmerer and Thompson (2014) defend overbite clam grazing rates and further state that other microscopic organisms also contribute to the grazing rate calculation.

In addition to directly reducing fish food, the overbite clam changed the overall ecosystem of the Delta. By repressing the production of historically dominant diatoms and zooplankton, several invertebrates invaded the Delta, causing changes in plant communities (Kimmerer and Orsi 1996; Bouley and Kimmerer 2006; Winder and Jassby 2011). Drought is also thought to have contributed to the species changes (Winder et al. 2011). The reduction in diatoms reduced and changed the copepod community, which is the majority of the diet of younger Delta Smelt (Slater and Baxter 2014).

After the overbite clam invasion came the copepod invasions of the late 1980s and early 1990s, which actually helped stem (but not recover from) what had been a major decline in their abundance (Winder and Jassby 2011). Prior to the overbite clam, Delta Smelt mostly ate the native copepod *E. affinis* from the time the larvae started feeding into the following fall (Moyle et al. 1992). The overbite clam suppressed *E. affinis*, leading to several nonnative copepods including *Pseudodiaptomus forbesi* taking over *E. affinis*'s niche in the ecosystem. *P. forbesi* then became the new main prey of larval and juvenile Delta Smelt (Nobriga 2002; Hobbs et al. 2006; Slater and Baxter 2014; Hammock et al. 2017).

P. forbesi production originates in the freshwater parts of the Delta (Merz et al. 2016; Kayfetz et al. 2017), including the Cache Slough-Yolo Bypass complex (Kimmerer et al. 2018). *E. affinis* had peak abundance near X2 (Orsi and Mecum 1986). However, now, when either *E. affinis* or *P. forbesi* are in the low-salinity zone, they are consumed by both the overbite clam and a predatory nonnative copepod that appeared in the 1990s (Kayfetz et al. 2017). Therefore, Delta Smelt food in the low-salinity zone has to be constantly replenished or subsidized from the Delta where the overbite clam and the predatory copepod are less abundant. Delta outflow can provide this food subsidy (Kimmerer et al. 2018a and Kimmerer et al. 2018b).

3.2 Status of the Species in the Action Area

California native freshwater fishes have declined as a result of the aforementioned anthropogenic influences and climate change, and have benefited by anthropogenic improvements as also discussed above. These species will likely continue to suffer population declines in the future in the action area due to existing stressors as well as long-term meteorological variability, sea level rise, and extreme weather events. Moyle et al. (2010) found that 83 percent of California's native freshwater fishes are extinct, endangered, or in decline. Fishes requiring cold water (<22°C) are particularly likely to go extinct (Moyle 2013). For this consultation, the action area encompasses most if not all of the range of the species. Therefore, please refer to Chapter 2, Aquatic and Terrestrial Status of the Species and Designated Critical Habitat, for more information on the status of the species in their entire range and the action area, as well as for the status of terrestrial species.

Winter-Run Chinook Salmon: Escapements have declined from the levels that occurred in the 1960s and 1970s, several decades after dam construction. The run size in 1969 was approximately 120,000, whereas run sizes averaged 600 fish from 1990 to 1997 (Moyle 2002). Escapement subsequently increased after Red Bluff Diversion Dam operations were modified and temperature control shutters were installed on Shasta Dam (Reclamation 2008). Winter-Run Chinook Salmon adult escapement data for the Sacramento River Basin from 1974 to 2016 are included in Figure 2.1-2 (CDFW 2018). Preliminary data show a decline since 2012 corresponding to severe drought conditions.

Spring-Run Chinook Salmon: The Central Valley drainage as a whole is estimated to have supported annual runs of Spring-Run Chinook Salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The Central Valley Spring-Run Chinook Salmon ESU has displayed broad fluctuations in adult abundance. Estimates of Spring-Run Chinook Salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather Rivers because CDFW's GrandTab does not distinguish between Fall-Run and Spring-Run Chinook Salmon in-river spawners, and not including the FRFH) have ranged from 1,404 in 1993 to 25,890 in 1982. Adult Spring-Run Chinook Salmon are predominantly found in tributaries to the Upper Sacramento River with the bulk of adults found in Mill, Deer, and Butte Creeks. Clear and Battle Creeks also contain regular runs of Spring-Run Chinook. Butte Creek has produced an average of two-thirds of the total production over the past 10 years (DWR and Reclamation 2017; CDFW 2017a). During recent years, Spring-Run Chinook Salmon escapement estimates (excluding in-river spawners in the Yuba and Feather Rivers) have ranged from 23,696 in 2013 to 8,112 in 2016 throughout the tributaries to the Sacramento River surveyed (CDFW 2017a).

Central Valley Steelhead: In the 1950s, Central Valley Steelhead populations numbered approximately 40,000 fish, while during the mid-1960s, the Steelhead population was estimated at 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). McEwan and Jackson (1996) estimated the annual run size for Central Valley Steelhead to be less than 10,000 fish by the early 1990s. Steelhead returns have been lower than average ($n = 1,480$) on the American River during recent years with a return of 756 adults in 2016, 1,032 in 2017, and 513 in 2018. Furthermore, Steelhead redd counts on the American River have been lower than average ($n = 122$) with 53 redds counted in 2015, 10 in 2017, and 63 counted in 2018. A total of 25 Steelhead have been counted migrating upstream on the Tuolumne River from 2009 to 2018, according to the counting weir operated by FishBio, with a high of 16 counted in 2011. On the Stanislaus River 82 Steelhead have been counted passing the FishBio weir from 2011 through 2017 with an annual low of 10 (2011) and a high of 82 (2017). The Mokelumne River regularly passes Steelhead through the Woodbridge fish ladder.

Central Coast Steelhead: CDFG (1965) estimated a total of 94,000 adult CCC Steelhead spawned in the rivers and streams of this DPS during the mid-1960s, including 50,000 fish in the Russian River—the

largest population within the DPS. Near the end of the 20th Century, the Steelhead population in the Russian River was believed to have declined substantially and local CDFG biologists estimated the wild run population in the Russian River Watershed was between 1,700 and 7,000 fish (McEwan and Jackson 1996). Abundance estimates for smaller coastal streams indicate low but stable levels with individual run size estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos Creeks) of approximately 500 fish or less (62 FR 43937).

Green Sturgeon: Based on surveys of sites where adult North American Green Sturgeon aggregated in the upper Sacramento River from 2010 to 2015, the total number of adults in the Southern DPS population was estimated to be $2,106 \pm 860$ (Mora 2016 as cited in NMFS 2018).

Killer Whale: The historical abundance of Southern Resident Killer Whales was estimated based on genetic data to have ranged from 140 to 200 individuals (Kahn et al. 2002; NMFS 2008). As of September 13, 2018, the Southern Resident Killer Whale population comprised 74 individuals. J pod has 22 members; K pod has 18; and L pod has 34 (Orca Network 2018).

Delta Smelt: Fisheries surveys indicate that Delta Smelt abundance has declined substantially in the San Francisco Estuary since the 1970s and has been relatively low during most years since 2004 (CDFW 2016b). The 2018 Delta Smelt 20-millimeter, TNS, and Fall Midwater Trawl (FMWT) indices were all zero or unable to be calculated, the lowest in history, which began with the FMWT in 1967 (CDFW 2016b).

Coho Salmon: Wild Coho Salmon in the Trinity River today are not abundant and the majority of the fish returning to the river are of hatchery origin. Data from the monitoring program at the Willow Creek Weir indicates the Trinity River portion of the Southern Oregon/Northern California Coast Coho Salmon ESU is predominately of hatchery origin (NMFS 2014; Reclamation and CDFW 2017).

Eulachon: There are no reliable historical abundance estimates for Eulachon. Available information (based largely on commercial fishery records) indicates that, starting in 1994, the southern DPS of Eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Since the 2010 listing, improved monitoring of Eulachon in several rivers detected general increases in adult spawning abundance, especially in 2013 to 2015 (NMFS 2016). However, sharp declines in Eulachon abundance occurred in 2016 and 2017, likely in response to poor conditions in the north east Pacific Ocean (NMFS 2017).

3.3 Without-Action Analysis

Environmental baseline is a concept that both courts and agencies have struggled to address for ongoing actions, but it is important in understanding the status of the species and factors affecting species environment within the action area but without the proposed action. In a consultation on a new action, where the status quo does not include the effects of the action under consultation because the action has not yet taken place, a simple projection of the status quo can often represent the without-action scenario. However, 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.

Reclamation reviewed consultations on other ongoing water project actions to inform this analytical approach. Recently, in the USACE (2014) consultation with NMFS on the ongoing operation of the Daguerre Point and Englebright Dams, the agencies recognized that “effects attributable to the existence of a dam over which the agency has no discretion,” as well as “to non-discretionary operations and maintenance should be included in the environmental baseline rather than attributable to the proposed action” (NMFS 2014). The biological opinion utilized a predominantly qualitative analysis to represent the environmental baseline, explaining how the existence of the dams as a baseline condition had multiple effects on the action area.

With this and other examples and the foregoing principles in mind, in the without-action scenario, Reclamation and DWR would not operate to meet the CVP and SWP’s water rights permit obligations, or any environmental or contractual obligations. The without-action scenario is consistent with Reclamation’s mandatory obligation to preserve the integrity of the facilities (per the Reclamation Safety of Dams Act P.L. 95-589). Described in more detail below, this condition essentially entails each of the CVP facilities simply passing inflows with no pumping or flow routing operations.

Reclamation considered multiple types of structural configurations and gate positions to identify a configuration to protect the long-term integrity of the structures in a without-action scenario, regardless of hydrology. One option considered was to set conditions at continuous low flow releases. However, while setting river release valves at a low flow release condition would result in storing water and maintaining a regular high storage, it would eventually result in overtopping of the dams under high inflow conditions, thereby threatening the structural integrity of the dams.

Review of the hydrologic and operational record identified a historical example where Reclamation and the SWP operated most major facilities with gates essentially fully open to pass inflow for the purpose of preserving the integrity of structures pursuant to the National Dam Safety Program. Reclamation and DWR selected a day within the historical period of record with high inflow, February 19, 1986, that resulted in releases that were intended to preserve the integrity of the structures. February 19, 1986, was during a flood event during which Reclamation and DWR were dealing with massive inflows at all major reservoirs, and were operating most dams for the purpose of passing flows. Flows below Shasta Dam and Folsom Dam were 76,900 cfs and 134,000 cfs, respectively, and the configuration was that the projects passed through all the runoff, constrained only by the structural reservoir and gate capacities, for the purpose of protecting the structural integrity of the facilities. Gates and barriers that could be damaged under high flow events, such as the DCC, were closed on this date.

The purpose of this historical example is to provide an empirical precedent for how Reclamation and DWR would model passing flows in a situation where the infrastructure is operating “without action,” for the purpose of preserving the existence of the structures. This is not a separate alternative, but a historical snapshot that provides the basis for isolating the causal effects of operations and, thus, determining whether the effects of operations would jeopardize the species. Consistent with this historical example, the existence of the dams as a component of the without-action scenario is represented by setting the outlet works on storage facilities to release inflows in a way that ensures the structural integrity of the facilities in any hydrologic condition over the period of the proposed action. Generally, the analysis assumes the gate positions as they were on February 19, 1986; however some configurations may differ

from the exact conditions on that day. For example, this scenario assumes Jones and Banks Pumping Plants exist but are turned off, which preserves the integrity of the pumps.

To establish the species' conditions absent operations, Reclamation modeled the hydrograph without the agencies' discretionary reshaping of flows. This approach represents the absence of the action under consultation using both quantitative tools and the qualitative analytical method from the Daguerre Point consultation. Based on the information available, this approach provides the most reasonable representation of the without-action component of the environmental baseline in this consultation.

While all demands continue to exist, the without-action scenario assumes that the CVP and SWP will not be operated to meet demands. However, water right holders having rights that pre-date the CVP and SWP would reasonably be expected continue to divert available supplies. Sacramento River Settlement Contractor, Exchange Contractor, Feather River Settlement contractor, holding contracts, and other senior water rights holder demands are based on senior water rights claimed by the contractors, and this without-action scenario assumes they would continue to divert water off of the rivers under those rights, to the extent water is available and they use their own facilities. This is what these senior water rights holders did previously in the absence of operation of the CVP and SWP. Water district operations and diversions for non-CVP or non-SWP water rights are thus assumed to continue in the environmental baseline.

In addition to the aforementioned senior water rights holders, refuges having pre-CVP rights would be expected to continue to divert available supplies. Sutter National Wildlife Refuge, Los Banos Wildlife Area, San Luis Unit of the San Luis National Wildlife Refuge, and East Bear Creek Unit of the San Luis National Wildlife Refuge all have riparian water rights and non-CVP diversions. Several other refuges have water rights as landowners within non-CVP and non-SWP water districts.

No regulations or RPAs tied to operation of the CVP or SWP would occur. Operations of non-CVP and non-SWP facilities would still occur as they are occurring today.

The specific hydrology of the 1986 date is not relevant; the operational model (CalSim) was run using the standard hydrologic period of record (1922–2003) and projected climate, with facilities configured (i.e., spillways, valves, etc.) mostly as they were on February 19, 1986, to represent preservation of the existing structures.

The detailed assumptions regarding hydrology, demands, facilities, and other criteria in the without-action scenario are explained below.

3.3.1 Trinity

Under the without-action scenario, Trinity and Lewiston Dam gates would be open to the extent necessary to protect Trinity and Lewiston Dams without exports to the Sacramento River watershed. Trinity Reservoir storage is assumed at current capacity (2,400 TAF). No transbasin diversion would occur through the Carr Power Plant to Whiskeytown Lake or through Spring Creek Tunnel to Keswick Reservoir.

Because the CVP and SWP would not operate under the without-action scenario, the Trinity River Restoration Program would not be implemented.

Whiskeytown Dam would pass flows with the river release valves set fully open, approximately 1,200 cfs. Additional flows would pass through the Glory Hole spillway. No flows would be diverted from Whiskeytown Reservoir through Spring Creek Tunnel.

3.3.2 Sacramento

Lake Shasta is assumed at current capacity (4,552 TAF). Under this scenario, it is assumed that Shasta Dam spillway gates would be fully open and river release valves would be set at the static level to pass approximately 80,000 cfs, or the amount necessary to preserve the integrity of the dam under this baseline, consistent with Reclamation's operation on February 19, 1986. The Shasta TCD would not operate under this scenario. All gates are assumed to be open.

Keswick Dam spillway gates are assumed to be open and valves would be set to pass a flow of approximately 80,000 cfs, which is the amount necessary to preserve the integrity of the dam under this scenario.

Because the CVP would not operate to meet project demands under this scenario, there would be no diversions for CVP water service contracts off of the Sacramento River. Sacramento River Settlement Contractors would still divert water off of the Sacramento River under their water rights and using their facilities.

Flood control weirs along the Sacramento River are assumed to be left in place; however, facilities to increase the frequency of floodplain inundation in the bypasses would not be operated.

Freeport Regional Water Project (FRWP) is assumed to be in place; however, CVP diversions through FRWP for delivery would not take place under this without-action scenario. Deliveries based on other water rights would occur under this scenario.

Water transfers that do not rely on CVP and SWP facilities (e.g., NOD) could still occur.

3.3.3 Feather River

Lake Oroville has a capacity of 3,553 TAF. Under this scenario, spillway gates are assumed to be open and valves set to pass a flow of approximately 180,000 cfs, or the amount necessary to preserve the integrity of the Oroville Dam.

Oroville has a FERC license which is non-CVP and non-SWP; however, as the SWP would not be operating in the without-action scenario, Oroville release valves would be set at fixed condition similar to the other reservoirs.

Table A allocations would not occur, nor would Article 21 deliveries. Feather River Service Area settlement contractors would be expected to divert off of the Feather River when there is water available in the Feather River because they have non-CVP and non-SWP water rights.

The CVP and SWP would not be operated for CALFED Agreements under this scenario, including the Lower Yuba River Accord transfers. Operations of non-CVP facilities (i.e., Yuba) would still occur as they are occurring today.

3.3.4 American River

Folsom Reservoir has a capacity of 977 TAF. Under this scenario spillway gates are assumed to be open and valves set to pass a flow of up to 134,000 cfs, or the amount necessary to preserve the integrity of the Folsom Dam. The temperature shutters would be set in the raised position, allowing water to be released from the lowest portions of the reservoir. Reclamation would not operate the M&I Intake. Water agencies

along the American River downstream of the dam would be expected to continue to divert under their own water rights as long as adequate flow is in the river.

Because the CVP and SWP do not operate in the without-action scenario, the American River Flow Management Standard would not apply.

Folsom South Canal would not deliver CVP water, and the Folsom South Canal gate would be closed to protect the structural integrity of the canal. However, water rights holders would be able to divert water from Folsom Reservoir and the American River through their own facilities.

Nimbus Dam spillway gates are open and set to pass all incoming flow.

3.3.5 Delta

The Jones and Banks Pumping Plants are turned off under the without-action scenario. Because in this scenario Reclamation and DWR are operating for protection of the facilities, pumps would be turned off to avoid breakage and destruction of the facility due to lack of maintenance and power. Moreover, because Reclamation's hydropower facilities would not be generating hydroelectricity, Reclamation would not have the power to run Jones Pumping Plant. CCF gates are assumed to be closed. Without filling of CCF, DWR would not run Banks Pumping Plant. No south of Delta pumping would take place. Delta outflow would be the result of the hydrology minus the other non-CVP/SWP facilities throughout the Sacramento and San Joaquin Basins. No south of Delta exports would occur for CVP, SWP, or non-project use. This includes no pumping for health and safety purposes or the facilitation of transfers.

Reclamation and DWR would not pump water into San Luis Reservoir. O'Neill Forebay gates would be left open, and associated pumping plants would be off.

Similar to other non-CVP water rights holders, under this scenario, CCWD is assumed not to divert CVP water, but would divert water based on their water rights through their own facilities.

No Delta barriers would be installed or operated because they are part of SWP operations. The south Delta agricultural barriers would not be in place, nor would the Head of Old River Barrier. However, the current Delta channel configuration would remain intact. In-Delta water users would continue to divert water for use and discharge drainage water.

The DCC would be left closed to prevent scouring around the facility and thus to preserve structural integrity to represent the system without operation of the CVP.

Suisun Marsh Salinity Control Gates would be left open year-round and other Suisun Marsh facilities would not be operated.

Water right permits assigned to Reclamation and DWR would not be applicable because the CVP and SWP would not be diverting water in California. Therefore, all D-1641 requirements including X2 standards, Delta water quality standards, real-time DCC operation, and San Joaquin flow standards are assumed not to be implemented under the without-action scenario. Without project water diversions, exports, or requirements, it is likewise assumed that there would be no implementation of the Coordinated Operations Agreement under this scenario.

3.3.6 Stanislaus River

New Melones Reservoir has a capacity of 2,400 TAF. Under this scenario, the lower level river outlets would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open to pass a flow of up to an assumed 8,000 cfs. Inflow exceeding this capacity would be stored in the reservoir until the releases capacity could physically evacuate the water. The spillway would prevent overtopping of the dam and accordingly protect the structural integrity of the dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height.

3.3.7 San Joaquin River

Millerton Lake has a capacity of 520 TAF. Under the without-action scenario, the river release valves are assumed to be set to pass a flow of up to 15,000 cfs and the spillway gates are assumed to be open to pass the amount necessary to preserve the integrity of the Friant Dam.

Friant-Kern and Madera Canal gates and valves would be closed to protect the structures. Riparian water right holders below Friant Dam would be expected to divert from the San Joaquin River when water is available in the San Joaquin River. San Joaquin River Exchange Contractors would likewise be expected to divert off of the San Joaquin River when water is available. Friant Dam releases for the SJRRP would not be implemented in the without-action scenario.

3.3.8 Non-Operational Actions

The without-action scenario assumes that Reclamation is not operating the CVP for water supply, fish and wildlife, or any other authorized purpose, including CVPIA. Activities intended to protect, restore, and mitigate the effects of CVP and SWP operations would not occur, including but not limited to:

- CVPIA. These actions are in part reimbursable by beneficiaries of project operations. Without the action, Reclamation would have no revenue from project beneficiaries to offset costs. None of CVPIA would occur, including but not limited to:
 - (b)(1) - Reasonable measures to double anadromous fish in the Central Valley and address other identified adverse environmental impacts
 - (b)(12) - Clear Creek Restoration Program
 - (b)(13) - Spawning and Rearing Habitat on CVP Streams
 - (b)(21) - Anadromous Fish Screen Program
- Conservation Hatcheries
 - Livingston Stone National Fish Hatchery
 - U.C. Davis Fish Culture Center
- Monitoring Programs under IEP and CVPIA
 - (b)(1) - Federal Science
 - (b)(16) - Comprehensive Assessment and Monitoring Program
 - Bay Studies - Reclamation would not exercise its water rights
 - Delta Juvenile Fish Monitoring Program (DJFMP)
 - Environmental Monitoring Program (EMP)

- Delta Status and Trend Monitoring Trawls (SKT, STN, FMWT)
- Watershed-Specific Restoration Programs
 - San Joaquin River Restoration Program
 - Trinity River Restoration Program

Reclamation has ongoing activities that would continue, including fish hatchery programs at Coleman and Nimbus, because these facilities were intended as mitigation for the construction of CVP dams. Because CVP dams exist in the without-action scenario, activities tied to the existence of the dam would also occur. The Battle Creek Restoration Program is a nonreimbursable activity that Congress has directed Reclamation to perform that is not tied to operation of the CVP and SWP, which would continue under the without-action scenario.

Chapter 4 Proposed Action

Reclamation and DWR propose to continue the coordinated long-term operation of the CVP and SWP to maximize water supply delivery and optimize power generation consistent with applicable laws, contractual obligations, and agreements; and to increase operational flexibility by focusing on non-operational measures to avoid significant adverse effects. 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. The “Current Operation” shows the applicable criteria for operation of the CVP and SWP today. Although not part of the effects of operating the project into the future, the Current Operation provides a reference for the changes under the proposed action to assist in understanding the proposed action. Table 4-1 below identifies specific changes from current operations that are part of this proposed action. The proposed action includes habitat restoration that would not occur under the without action scenario and provides specific commitments for habitat restoration.

Table 4-1. Comparison of Select Components Across Without Action, Current Operation, and Proposed Action

| Without Action | Current Operation | Proposed Action |
|-------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sacramento | | |
| No temperature management | NMFS RPA I.2.1-I.2.4: Shasta Temperature Management, WRO 90-5 downstream temperature targets | Temperature management based on use of Shasta cold water pool for Winter-Run survival, including WRO 90-5. |
| No spring pulses | No spring pulses | Spring pulses if projected May 1 storage > 4 MAF |
| No fall base flows | 3,250 cfs minimum flow | Measures to reduce Fall-Run redd dewatering and rebuild cold water pool, e.g., when end-of-September storage is: ≤ 2.2 MAF, flow is 3,250 cfs; ≤ 2.8 MAF, flow is 4,000 cfs; ≤ 3.2 MAF, flow is 4,500 cfs; > 3.2 MAF, flow is 5,000 cfs. |
| No Winter-Run Conservation Hatchery | Livingston-Stone National Fish Hatchery | Increased use of Livingston-Stone National Fish Hatchery during droughts |

| Without Action | Current Operation | Proposed Action |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trinity | | |
| No flow control | Trinity ROD Flows + Lower Klamath Augmentation Flows | Trinity ROD Flows + Lower Klamath Augmentation Flows |
| No fish flows in Grass Valley Creek | No fish flows in Grass Valley Creek | Pulse flows between March 1 and April 15 to mobilize gravel, and October and November releases for Coho spawning, to the extent feasible |
| Clear Creek | | |
| No base flows | Base flow of 50–100 cfs based on 1960 CDFG MOA | Base flow of 150 cfs in all except critical years |
| No channel maintenance flows | Channel maintenance flows when flood operations occur | 10 TAF for channel maintenance, unless flood control operations provide similar releases, using the river release outlets, in all but dry and critical years |
| No pulse flows | Two pulse flows in Clear Creek in May and June of at least 600 cfs for at least 3 days for each pulse per year | 10 TAF for pulse flows, using the river release, in all but critical years |
| No temperature management | Daily water temperature of: (1) 60° F at the Igo gage from June 1 through September 15; and (2) 56°F at the Igo gage from September 15 to October 31. | Daily water temperature in below normal and wetter years of: (1) 60°F at the Igo gage from June 1 through September 15; and (2) 56°F at the Igo gage from September 15 to October 31; operate as close as possible to these targets in dry and critical years. |
| Feather | | |
| No minimum flow | FERC License flows | FERC License flows |
| American River | | |
| No minimum flows | 2006 Flow Management Standard | 2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year and annual hydrology, and “planning minimum” |
| No temperature management | Daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31. 56°F temperature target November 1 through December 31. | May 15 through October 31 daily average water temperature of 65°F (or target temperature determined by temperature model) or lower at Watt Avenue Bridge. When the target temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at |

| Without Action | Current Operation | Proposed Action |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. November 1 through December 31 daily average water temperature of 56°F target if cold water pool allows. A temperature higher than 56°F may be targeted based on temperature modeling results. |
| Delta | | |
| No exports | D-1641 requirements; and OMR requirements based on USFWS RPA Actions 1-3 and NMFS RPA Action IV.2.3 | D-1641 requirements; and Risk-based OMR management incorporating real-time monitoring and models where possible |
| DCC closed | DCC operations based on NMFS RPA that requires consultation to avoid exceeding water quality standards | DCC operations that avoid exceeding water quality standards |
| No Delta Outflow requirement | D-1641 requirements; and maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81 km in the fall following above normal years | D-1641 requirements; and Suisun Marsh Salinity Control Gate Operation for 60 days between June and September of above normal and below normal year types |
| No management of reverse flows | Old and Middle River Reverse Flows based on calendar date and workgroups | Old and Middle River Reverse flows based on species distribution, modeling, and risk analysis with provisions for capturing storm flows |
| No Head of Old River Barrier (HORB) | HORB installed between September 15 and November 30 of most years when flows at Vernalis is <5,000 cfs; occasionally also between April 15 and May 30 if Delta Smelt entrainment is not a concern | No HORB installed (WaterFix proposed action continues) |
| No Delta Smelt conservation hatchery | U.C. Davis Fish Culture Center Refugial Population | Delta Fish Species Conservation Hatchery and the introduction of cultured fish into the wild |
| No COA | 1986 COA with 2018 Addendum | 1986 COA with 2018 Addendum |
| Stanislaus | | |
| No base flows | Appendix 2-E flows from NMFS RPA III.1.3 | Stepped release plan |

| Without Action | Current Operation | Proposed Action |
|----------------|---------------------------------------------|---------------------------------------------|
| San Joaquin | | |
| No base flows | San Joaquin River Restoration Program flows | San Joaquin River Restoration Program flows |

4.1 Decreasing Operational Discretion

In the 1920s, farmers and municipalities relied upon intermittent surface flows and groundwater for water supply. Over time, as land in California was reclaimed and demand for water increased, over-pumping caused groundwater-level declines in the Sacramento and San Joaquin Valleys and associated aquifer-system compaction and land subsidence. The concept of a statewide water development project was first raised in 1919 by Lieutenant Robert B. Marshall of the U.S. Geological Survey, in large part to meet the demands of California’s economy and prevent ongoing impacts resulting from water shortages, including land subsidence. He proposed transporting water from the Sacramento River system to the San Joaquin Valley then moving some of it over the Tehachapi Mountains into Southern California. His proposal led to the first plan for a state-operated water project.

In 1931, State Engineer Edward Hyatt introduced a report identifying the facilities required and the economic means to accomplish the north-to-south water transfer. Called the “State Water Plan,” the report took 9 years and \$1 million to prepare. To implement the plan, the Legislature passed the Central Valley Act of 1933, which authorized the project. A \$170 million bond act was subsequently approved by the voters of the State of California in a special election on December 19, 1933. In the midst of the Great Depression, revenue bonds were unmarketable, so the State was unable to secure funding to begin construction of the CVP. The State then sought the assistance of the federal government. Following the issuance of a feasibility report, President Franklin Roosevelt’s administration agreed to take over the CVP as a public works project.

In the Rivers and Harbors Act of 1935, Congress originally authorized the CVP and provided initial funding. The Rivers and Harbors Act of 1937 reauthorized the CVP for the purposes of “improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for construction under the provisions of the Federal Reclamation Laws of such distribution systems as the Secretary of the Interior (Secretary) deems necessary in connection with lands for which said stored waters are to be delivered, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses, and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed.” Congress gave Reclamation broad authority to operate the dams and reservoirs of the CVP “first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and, third, for power.” Reclamation had substantial flexibility in determining how to balance the three original project purposes.

Reclamation and DWR’s operation of the CVP and SWP changed significantly in 1978 with the issuance of the WQCP under the SWRCB Water Right Decision 1485 (D-1485). D-1485 imposed on the water rights for the CVP and SWP new terms and conditions that required Reclamation and DWR to meet certain standards for water quality protection for agricultural, M&I, and fish and wildlife purposes; incorporated a variety of Delta flow actions; and set salinity standards in the Delta while allowing the

diversion of flows into the Delta during the winter/spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the CVP and SWP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure operations of the CVP and SWP were coordinated, the COA was negotiated and approved by Congress in 1986, establishing terms and conditions by which Reclamation and DWR would coordinate operations of the CVP and SWP, respectively. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions.

In 1992, the CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement as having an equal priority with power generation. The CVPIA included a number of other provisions that represented additional Congressional direction for operation of the CVP, and overlaid a more complex statutory framework. These overlapping and sometimes competing requirements create challenges in how to address and balance the myriad of obligations Reclamation has in operating the CVP, and how to coordinate with the SWP.

In 1995, the SWRCB issued an update to the WQCP for the Bay-Delta. In 1999 (revised in 2000) the SWRCB issued D-1641 to implement those elements of the 1995 WQCP that were to be implemented through water rights. The 1995 WQCP and D-1641 included a new export to total Delta inflow (E/I) ratio of 35 percent from February through June. The 35 percent E/I from February to June was a significant change from D-1485. The 1995 WQCP and D-1641 also imposed Spring X2, pumping limitations based on San Joaquin River flow, which in combination with the E/I ratio, reduced the availability of “unstored” flow for the CVP and SWP. February to June became an unreliable season for conveying water across the Delta. The effect of D-1641 was a shift in the export season, in part, to the summer, and the CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter.

In addition, D-1641 imposed a flow requirement for the San Joaquin Basin at Vernalis which included both base flows and a large spring pulse flow. However, it did not address how the requirement would be shared between the three major San Joaquin tributaries. In lieu of the SWRCB assigning responsibility, a number of interested parties entered into the San Joaquin River Agreement, which included flow commitments from all three tributaries, funding commitments, transfers, and voluntary demand reductions. The agreement was initially set to expire in 2009 but was extended to 2012, when it expired and was not replaced.

In 2000, Reclamation signed the Trinity ROD. This defined a minimum flow regime of 369,000 acre-feet in critical dry years ranging to 816,000 acre-feet in wet years in the Trinity River. The ROD decreased the amount of water Reclamation could bring from the Trinity River over to the Sacramento River, reducing water supplies for Delta outflow and salinity and reducing the Shasta Reservoir cold water pool flexibility. This was intended to benefit Trinity River listed fish species, but it complicated Reclamation’s ability to meet requirements imposed for the protection of Sacramento River listed fish.

4.2 Operational Tradeoffs

Operation of the CVP and SWP involves a balancing of various laws, regulations, contracts, and agreements. The overlapping and often conflicting requirements necessitate tradeoffs among watersheds, among fish species, among authorized purposes, and among water users. The tradeoffs occur within a

season, between seasons, and across water years. Summarized below are examples of these conflicts and resulting tradeoffs that inform this proposed action.

To help protect against drought, Reclamation traditionally operated the CVP to achieve higher end-of-water-year storage that provided for increased carryover into the next year. Over time, the CVP has come under increasing pressure to provide water for environmental purposes which has resulted in decreased water supply reliability (see Figure 4-1 below). To meet state permit conditions, contractual demands, and environmental obligations, more demand has been placed on storage, resulting in lower end-of-water-year storage than was typical in the past. Significant tradeoffs in operational decision making now arise due to overlapping and conflicting regulations that make it difficult to meet congressionally authorized CVP purposes, including those for fish and wildlife.

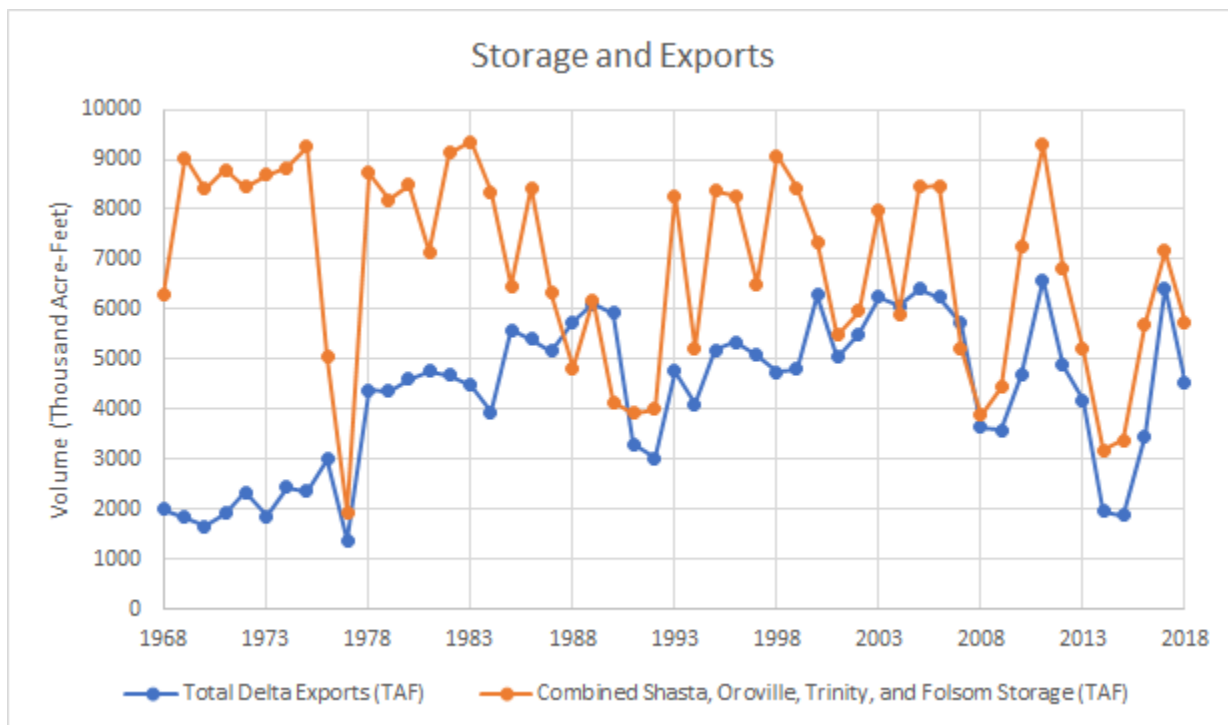


Figure 4-1. Delta Exports and Reservoir End-of-September Storage, 1968–2018

If releases are reduced during some timeframes to maintain higher storage levels in reservoirs, that has a corresponding effect of reducing inflows to the Delta, which then reduces Delta outflows. The benefit of increased reservoir storage has to be weighed against the potential negative downstream impacts on fisheries. In addition, maintaining a higher carryover storage increases the risk of having to make flood control releases early in the season to draw down to the required maximum flood conservation space. Making flood control releases in October and November to draw down to the required maximum storage conflicts with needs to reduce flows rapidly during the fall to encourage development of the cold water pool for the following year.

At Shasta Reservoir, Reclamation seeks to build cold water pool for providing suitable temperatures for Winter-Run Chinook Salmon spawning and incubation in the summer. Releases earlier in the year may reduce this cold water pool. To avoid Winter-Run Chinook Salmon and Fall-Run Chinook Salmon redd dewatering, releases higher than what is needed for instream requirements or Delta requirements may occur. Releases may also occur to facilitate spring pulses for juvenile outmigration, or increased releases

to meet Delta outflow or salinity requirements per D-1641. Water temperature management strategies that deplete cold water pool early in the year come at the expense of later season temperatures.

The Trinity ROD and lower Klamath fall augmentation flows limit Reclamation's transbasin diversions and impact Reclamation's temperature operations and CVP deliveries on the Sacramento River. Increases in Trinity River releases in the late summer and fall result in lower storage in Trinity Reservoir at the end of the water year. The decreases in storage accumulate from water year to water year when the reservoir does not refill. Hydrologic conditions that do not refill the reservoir result in lower end-of-summer storages, negative impacts on cold water pool, and potentially warmer stream temperatures for Fall-Run Chinook Salmon spawning in the Trinity River.

Reclamation and DWR coordinate regarding downstream requirements (Delta outflow, Delta salinity, etc). The amount of water from each reservoir depends upon reservoir storage, channel capacity, fishery concerns, projected inflows, and projected end-of-September storage. With its several upstream reservoirs, Reclamation balances releases so that no one reservoir bears the full burden of meeting its share of the downstream requirements.

On the American River, temperature targets during the summer are intended to benefit Steelhead. Meeting this requirement typically uses nearly the full volume of cold water pool. As a result, there is typically a limited cold water pool remaining in the fall to provide suitable spawning and incubation temperatures for Fall-Run Chinook Salmon. There is rarely enough cold water to provide optimal conditions for both species. Water transfers through Folsom from upstream senior water right holders that occur after Folsom Reservoir has stratified (typically early June) also may have small negative impacts on the cold water pool.

Demands for higher outflow directly conflict with fishery agency requests to maintain substantial cold water pool storage in the reservoirs through the summer for temperature operations in the summer and fall. There are also tradeoffs between species; for example, spring pulse flows on the Sacramento River to benefit Spring-Run Chinook Salmon could negatively impact temperature operations for Winter-Run Chinook Salmon.

San Luis Reservoir is an off-stream storage facility primarily fed by water pumped from the Delta. This supply is used annually to meet south of Delta contractor demands. In the past (prior to major seasonal restrictions of Delta pumping), Delta exports were utilized heavily during the rainy season to capture excess flows in the Delta and store that additional water supply in San Luis Reservoir. The developed water supply (i.e., stored water) was then used during the summer months to provide water to the south of Delta contractors. Now, however, because of significant export restrictions during the precipitation season imposed by the 1995/2006 WQCP and the 2008/2009 biological opinions, the bulk of the joint CVP/SWP Delta export capability is timed during the summer months, resulting in a higher percentage of south of Delta deliveries relying on upstream storage. Ideally, San Luis Reservoir would be as full as possible by April 1 of each water year, then operated to meet south of Delta needs throughout the summer. San Luis Reservoir low point generally occurs the end of August of each water year. If San Luis low point is too low, there can be algae problems for users of water through the San Felipe Project, particularly Santa Clara Valley Water District. Those users have expressed a need to have a plan to prevent San Luis Reservoir from becoming so low that water supplies are negatively impacted by algal growth.

With respect to hydropower generation, the use of direct river release outlets to access colder water below the power penstock intakes for fishery purposes causes the releases to bypasses hydropower production. This impacts the preferential power customers and represents a loss of revenue to Reclamation. In addition, increased requirements and regulations over the years have impacted the ability to deliver CVP

water, resulting in lower allocations. The lower allocations result in lower revenues for the restoration fund and increase power customer costs to make up the difference.

4.3 Coordinated Operation Agreement

Reclamation and DWR propose to operate their respective facilities in accordance with the COA. The COA defines the project facilities and their water supplies, sets forth procedures for coordinating operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. It further identifies how unstored flow will be shared, sets up a framework for exchange of water and services between the projects, and provides for periodic review of the agreement.

Through the COA, Reclamation and DWR share the obligation for meeting in-basin uses. In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the provisions of Exhibit A of the COA [SWRCB Delta standards]. Each project is obligated to ensure water is available for these uses. The respective degree of obligation is dependent on several factors, as described below.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation's Central Valley Operations Office (CVO) and DWR's SWP Operations Control Office jointly decide when balanced or excess water conditions exist. During balanced water conditions, the projects share the responsibility in meeting in-basin uses.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under Article 6(g) of the COA, Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical, legal, and contractual limits.

Implementation of the COA principles has continuously evolved since 1986 as changes have occurred to CVP and SWP facilities, to operating criteria, and to the overall physical and regulatory environment. For example, updated water quality and flow standards adopted by the SWRCB, CVPIA, and ESA responsibilities have affected both CVP and SWP operations. The 1986 COA incorporated D-1485 provisions regarding Delta salinity, outflow, and export restrictions. It also envisioned and provided a methodology to incorporate future regulatory changes, like Delta salinity requirements, but did not explicitly envision (or explicitly address) sharing of export restrictions. Both D-1641 and the 2008 and 2009 biological opinions included various export restrictions that were not explicitly addressed in the 1986 COA; however, the available export capacity as a result of these export restrictions was shared between the projects in the absence of a formal update.

In 2018, Reclamation and DWR modified four key elements of the COA to address changes since COA 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. COA 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, the United States and State 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 60/40.

4.4 CVP Water Contracts

Based on the provisions of federal reclamation law, the CVP delivers water pursuant to water service and water repayment contracts, as well as settlement, exchange, and refuge contracts. Reclamation also delivers water pursuant to temporary, not to exceed 1 year, "Section 215 Contracts," when there are surplus flood flows. Pursuant to the Warren Act, Reclamation provides for the conveyance of non-CVP (which includes SWP water) when there is excess capacity available in CVP facilities. This consultation covers the operation of the CVP and SWP to deliver water under the terms of all existing contracts up to full contract amounts, which includes the impacts of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation. Reclamation is not proposing to execute any new contracts or amend any existing contracts as part of this consultation.

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 CVPIA, and to water service contractors.

Many senior water right holders executed contracts with Reclamation, such as the Sacramento River Settlement Contractors and San Joaquin River Exchange Contractors. The terms of those contracts differ significantly from water service contracts. The pattern of diversion of water under a water service contract depends on the use of the water, with irrigation water typically diverted and used during the irrigation season (March through October), and M&I water diverted and used year-round. All water service contracts contain a shortage provision allowing Reclamation to reduce the amount of water made available for a variety of reasons, such as droughts. Table 4-2 summarizes the number of CVP water service and repayment contracts and the amount of water under contract.

Table 4-2. CVP Water Service and Repayment Contracts

| CVP Division | Number of Contracts | Contract Quantity¹ (Acre-Feet) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------|
| Tehama-Colusa Canal, Corning Canal, Redding Area, and Trinity River Division | 36 | 468,890 |
| American River ² | 9 | 313,765 |
| New Melones/Eastside Contracts | 2 | 155,000 |
| South of Delta | 44 | 2,112,898 |
| Friant Division | 27 | 2,249,475 |
| Contra Costa Water District | 1 | 195,000 |
| ¹ Contract quantities do not reflect actual deliveries due to system conditions. | | |
| ² Includes foreseeable long-term water service contract actions currently under review through separate consultation processes (i.e., pending contract pursuant to Fazio legislation for the El Dorado County Water Agency and contract renewals for the City of Roseville, Sacramento Municipal Utility District, Sacramento County Water Agency, and Placer County Water Agency). | | |

This consultation covers Reclamation’s operational actions to meet the terms of its existing CVP water supply contracts (i.e., water service contracts, and settlement, exchange, and refuge contract).

CVP Water service and repayment contracts include shortage provisions as follows: Article 12, Constraints on the Availability of Water, provides for a Condition of Shortage, which is defined in Article 1(c) as “...a condition respecting the Project during any Year such that the Contracting Officer is unable to deliver sufficient water to meet the Contract Total.” Article 12(c) provides “In any Year in which there may occur a shortage for any of the reasons specified in subdivision 12(b) above, the Contracting Officer shall apportion Project Water among the Contractor and others entitled, under existing contracts and future contracts (to the extent such future contracts are permitted under subsections (a) and (b) of Section 3404 of the CVPIA) and renewals thereof, to receive Irrigation Water consistent with the contractual obligations of the United States.” Article 12(d) states, “Project Water furnished under this Contract will be allocated in accordance with the then-existing Project M&I Water Shortage Policy. Such policy shall be amended, modified, or superseded only through a public notice and comment procedure.”

The largest contracts belong to the Sacramento River Settlement Contractors (approximately 2.1 MAF) and the San Joaquin River Exchange contractors (approximately 840 TAF). In very dry years, Reclamation and DWR are often limited to operating the CVP and SWP solely to meet these, and other senior water right requirements, along with refuge water supply requirements and minimum instream and Delta flows, M&I deliveries pursuant to the CVP M&I Shortage Policy, and SWP exports for health and safety. In recent drought years, limited water supplies, dry hydrology, and regulatory restrictions made it difficult for Reclamation to make water available to satisfy contracts already reduced by 25 percent in those years. Reclamation delivers Level 2 refuge water primarily from the CVP and acquires Incremental Level 4 water from voluntary measures which include water conservation, conjunctive use, purchase, lease, donations, or similar activities, or a combination of such activities which do not require involuntary

reallocations of project yield. This proposed action covers the operation to deliver up to full contract amounts, including full Level 4 refuge contract amounts. Table 4-3 summarizes senior CVP water rights holders and the amount of water under contract.

Table 4-3. CVP Settlement Agreements

| Contractor | Number of Contracts | Contract Quantity (Acre-Feet) |
|--------------------------------------------------------------------------------------|----------------------------|----------------------------------------------------|
| Sacramento River Settlement (SRS) | 132 | 2,112,194 (1,775,313 Base + 336,881 Project) |
| San Joaquin River Exchange | 4 | 840,000 |
| Oakdale/S. San Joaquin ID Agreement and Stipulation | 1 | ≤ 600,000 |
| American River Contracts | 13 | 578,441 |
| Friant Division Riparian Holding Contracts | n/a | 5 cfs past each diversion |
| South of Delta Settlement Contractors | 9 | 35,623 |
| North of Delta Refuges—Level 2 CVP | 2 | 179,000 |
| South of Delta Refuges—Level 2 CVP | 3 | 376,515 |
| Note: Contract quantities do not reflect actual deliveries due to system conditions. | | |

The contracts referenced above usually include articles such as Article 5, Constraints on the Availability of Water, which states that “in a Critical Year, the Contractor's Base Supply and Project Water agreed to be diverted during the period April through October of the Year in which the principal portion of the Critical Year occurs and, each monthly quantity of said period shall be reduced by 25 percent.”

4.5 SWP Water Contracts

The SWP has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system. These contracts are with both M&I water users and agricultural water users. The contracts specify the charges that will be made to the water agency for both: (1) Conservation of Water, and (2) Conveyance of Water. The foundational allocation of water to each contractor is based on their respective “Table A” entitlement, which is the maximum amount of water delivered to them by the SWP, on an annual basis. Typically, annual water deliveries to individual agencies are less than their maximum Table A amount, due to a wide variety of reasons.

DWR proposes to operate the SWP in accordance with contracts with senior water right holders in the Feather River Service Area (approximately 983 TAF). Further, under State Water Contracts, DWR

allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with over 3 MAF for San Joaquin Valley and Southern California water users.

Article 21 of the long-term SWP water supply contracts provides an interruptible water supply made available only when certain conditions exist: (1) the SWP share of San Luis Reservoir is physically full, or projected to be physically full; (2) other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess condition; (4) current Table A demand is being fully met; and (5) Banks has export capacity beyond that which is needed to meet current Table A and other SWP operational demands.

4.5.1 SWP Settlement Agreements

DWR has water rights settlement agreements to provide water supplies with entities north of Oroville, along the Feather River, Bear River, and in the Delta. These agreements provide users with water supplies that they were entitled to prior to the construction of the SWP's Oroville Complex. Collectively, these agreements provide over 1 MAF of water each year. DWR also has agreements with several (more than 60) riparian diverters along the Feather, Yuba, and Bear Rivers to provide water for diversion. Table 4-4 summarizes the volumes under the water rights settlement agreements.

Table 4-4. SWP Settlement Agreements

| Location | Entity | Amount (Acre-Feet) |
|-------------------|--------------------------------|--------------------|
| North of Oroville | Andrew Valberde | 135 |
| North of Oroville | Jane Ramelli | 800 |
| North of Oroville | Last Chance Creek WD | 12,000 |
| Feather River | Garden Highway Mutual Water | 18,000 |
| Feather River | Joint Water Districts Board | 620,000 |
| Feather River | South Feather Water & Power | 17,555 |
| Feather River | Oswald WD | 3,000 |
| Feather River | Plumas Mutual Water | 14,000 |
| Feather River | Thermalito Irrigation District | 8,200 |
| Feather River | Tudor Mutual Water | 5,000 |
| Feather River | Western Canal/PG&E | 295,000 |
| Bear River | South Sutter/Camp Far West | 4,400 |
| Delta | Byron-Bethany ID | 50,000 |

| Location | Entity | Amount (Acre-Feet) |
|-----------------|---------------------------------------------|---------------------------|
| Delta | East Contra Costa ID | 50,000 |
| Delta | Solano Co./Fairfield, Vacaville and Benicia | 31,620 |

4.5.2 SWP Contracting Agencies

The SWP has signed contracts with 29 parties to provide water supplies developed by the SWP. Table 4-5 shows the maximum contracted annual water supply per DWR's most recent water supply reliability report.

Table 4-5. SWP Water Service Contracts

| Contracting Agency | Maximum Supply (Acre-Feet) |
|-----------------------------------------------------------|-----------------------------------|
| Butte County | 27,500 |
| Plumas County | 2,700 |
| Yuba City | 9,600 |
| Napa County Flood Control and Water Conservation District | 29,025 |
| Solano County | 47,756 |
| Alameda County—Zone 7 | 80,619 |
| Alameda County Water District | 42,000 |
| Santa Clara Valley Water District | 100,000 |
| Oak Flat Water District | 5,700 |
| Kings County | 9,305 |
| Dudley Ridge Water District | 45,350 |
| Empire West Side Irrigation District | 3,000 |
| Kern County Water Agency | 982,730 |
| Tulare Lake Water Storage District | 87,471 |
| San Luis Obispo County | 25,000 |
| Santa Barbara County | 45,486 |

| Contracting Agency | Maximum Supply (Acre-Feet) |
|----------------------------------------------------|-----------------------------------|
| Antelope Valley-East Kern Water Agency | 144,844 |
| Santa Clarita Valley Water Agency | 95,200 |
| Coachella Valley Water District | 138,350 |
| Crestline-Lake Arrowhead Water Agency | 5,800 |
| Desert Water Agency | 55,750 |
| Littlerock Creek Irrigation District | 2,300 |
| Metropolitan Water District of Southern California | 1,911,500 |
| Mojave Water Agency | 85,800 |
| Palmdale Water District | 21,300 |
| San Bernardino Valley Municipal Water District | 102,600 |
| San Gabriel Valley Municipal Water District | 28,800 |
| San Geronio Pass Water Agency | 17,300 |
| Ventura County Watershed Protection District | 20,000 |

4.6 D-1641

Reclamation and DWR propose to operate in accordance with obligations under D-1641, which provides protection for fish and wildlife, M&I water quality, agricultural water quality, and Suisun Marsh salinity. D-1641 granted Reclamation and DWR the ability to use or exchange each project's diversion capacity capabilities to maximize the beneficial uses of the CVP and SWP. The SWRCB conditioned the use of Joint Point of Diversion capabilities based on staged implementation and conditional requirements for each stage of implementation.

4.7 Allocation and Forecasts

Reclamation proposes to allocate CVP water on an annual basis in accordance with contracts. Reclamation bases north of Delta allocations primarily on available water supply within the north of Delta system along with expected controlling regulations throughout the year. For south of Delta allocations, Reclamation relies on upstream water supply, previously stored water south of the Delta (in San Luis Reservoir) and conveyance capability through the Delta. Flows on the San Joaquin River often limit conveyance, as these flows are a driver of the flow direction within the Delta and through their influence on Old and Middle net reverse flow, can affect entrainment levels at the State and federal pumps.

The water allocation process for the CVP begins in the fall when Reclamation makes preliminary assessments of the next year's water supply possibilities, given current storage conditions combined with a range of hydrologic conditions. Reclamation may refine these preliminary assessments as the water year progresses. Beginning February 1, Reclamation prepares forecasts of water year runoff using precipitation to date, snow water content accumulation, and runoff to date. All of the CVP's Sacramento River Settlement water rights contracts and San Joaquin River Exchange contracts require that contractors be informed no later than February 15 of any possible deficiency in their supplies. Reclamation targets February 20 as the date for the first announcement of all CVP contractors' forecasted water allocations for the upcoming contract year. Reclamation updates forecasts of runoff and operations plans at least monthly between February and May.

Reclamation performs operations forecasting on a 12-month ahead cycle each month to determine how the available water resources can best be used to meet project objectives and requirements. Reclamation bases forecasts on the 12-month projected runoff volumes that would occur naturally and considers potential upstream operations where relevant. For October and November, projected runoff is based entirely on historical hydrology as no snowpack data are available yet. In December and January, inflow forecasts may include snow pillow information and precipitation as well as historical hydrology. For the February through May period, the runoff volume estimates are based on the observed inflow to date and current snowpack measurements made at the end of each preceding month, projections through September, and historical hydrology for the next water year. These forecasts represent the uncertainty inherent in making runoff predictions. This uncertainty may include sources such as unknown future weather conditions, the various prediction methodologies, and the spatial coverage of the data network in a given basin.

In most years, the combination of carryover storage and runoff into CVP reservoirs and the Central Valley is not enough to provide sufficient water to meet all CVP contractors' contractual demands. Multiple legislative, contractual, and settlement obligations have created an increased tension in Reclamation's ability to make contractual deliveries of water to water users and to meet other legal obligations. As provided in Section 9 of the Reclamation Projects Act of 1939, Section 215 of the Reclamation Reform Act of 1982, and Section 3404(b) of CVPIA, Reclamation is authorized to enter into temporary contracts, not to exceed 1 year, for delivery of surplus flood flows.

4.7.1 SWP Allocation and Forecasting

At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist in the future several months, and hence, the water supplies that will be allocated by the SWP to its water contractors. In recognition of this, DWR utilizes a forecasting-water supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to-date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies that can be delivered to SWP contractors as the water year progresses.

There are many factors considered in the forecast-supply process. Some of these factors are the following:

- Water storage in Lake Oroville (both updated and end-of-water-year (September 30))
- Water storage in San Luis Reservoir (both updated and end-of-calendar-year)
- Flood operations constraints at Lake Oroville
- Snowpack surveys (updated monthly from February through May)
- Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)

- Feather River settlement agreement obligations
- Feather River fishery flows and temperature obligations
- Anticipated depletions in the Sacramento and Delta basins
- Anticipated Delta standards and conditions
- Anticipated CVP operations for joint responsibilities
- Contractor supply requests and delivery patterns

Staff from both the Operations Control Office (OCO) and the State Water Projects Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. OCO primarily focuses on runoff/operations models to determine allocations. SWPAO requests updated information from the contractors on supply requests and delivery patterns to determine allocations. Both OCO and SWPAO staff meet at least once a month with the DWR Director to make final decisions on staff's proposed allocations.

The Initial Allocation for SWP Deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid over-allocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured/known information and conservative forecasts of future hydrology. Monthly briefings are held with the DWR Director to determine formal approvals of delivery commitments announced by DWR.

Another water supply consideration is the contractual ability of SWP contractors to "carry over" allocated (but undelivered) Table A from 1 year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor's current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by SWP contractors can result in higher storage levels in San Luis Reservoir. As project pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, then becomes project water available for reallocation to all contractors in a given year.

Article 21 (surplus to Table A) water which is delivered early in the calendar year may be reclassified as Table A later in the year depending on final allocations, hydrology, and contractor requests. Reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules.

4.7.2 Daily Operations

After the allocations and forecasting process, Reclamation and DWR coordinate their operations on a daily basis. Some factors which Reclamation and DWR consider when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, schedules for the joint use facilities, pumping/wheeling arrangements, and any facility limitations. Both projects must meet the flood obligations of individual reservoirs. CVP operations must also consider navigational flows at Wilkins Slough (see Upper Sacramento River for additional details).

During balanced water conditions, Reclamation and DWR maintain a daily water accounting of CVP and SWP obligations. This accounting allows for flexible operations and avoids the need to change reservoir releases made several days in advance (due to travel time from the Delta). Therefore, adjustments can be made "after the fact," using actual observed data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses. This iterative process of observation and adjustment

results in a continuous truing up of the running COA account. The project that is “owed” water (i.e., the project that provided more or exported less than its COA-defined share) may request the other project adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The COA provides the mechanism for determining each project’s responsibility for meeting in-basin use, but real-time conditions dictate real-time actions. Conditions in the Delta can change rapidly. For example, weather conditions combined with tidal action can quickly affect Delta salinity conditions and, therefore, the Delta outflow required to maintain joint salinity standards under D-1641.

Increasing or decreasing project exports can achieve changes to Delta outflow immediately. Imbalances in meeting each project’s initial shared obligations are captured by the COA accounting and balanced out later.

When more reaction time is available, reservoir release changes are used adjust to changing in-basin conditions. If Reclamation decides the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. DWR’s Lake Oroville water releases require about 3 days to reach the Delta, while water released from Reclamation’s Shasta Reservoir requires 5 days to travel from Keswick Reservoir to the Delta. As water from another reservoir arrives in the Delta, Reclamation can adjust Folsom Reservoir releases downward. Alternatively, if sufficient time exists for water to reach the Delta, Reclamation may choose to make initial releases from Shasta Reservoir. Each occurrence is evaluated on an individual basis, and appropriate action is taken based on multiple factors. Again, the COA accounting captures imbalances in meeting each project’s initial shared obligation.

One of the principal considerations when determining which reservoir to make releases from is the reservoir refill potential, i.e., the probability that a reservoir will, over the course of a year’s inflow and releases, return to a desirable carryover storage. The refill potential is approximated by the average annual runoff divided by the total reservoir storage. Reservoirs that are large compared to the average runoff of their watershed, such as New Melones, have a small refill potential (0.5). Reservoirs that are small compared to the average runoff of their watershed, such as Folsom, have a large refill potential (2.5). Folsom Reservoir generally has the best refill potential of the CVP reservoirs. Refill potential also is a consideration when evaluating how much water to move from Trinity Reservoir (0.5) to the Sacramento River side. Shasta Reservoir currently has an average annual runoff of approximately 8,476 TAF, with 4,500 TAF of storage, meaning an approximate refill potential of 2, so releases from Shasta Reservoir are more likely to be replaced with new inflow and bring storage back up than releases from Trinity Reservoir.

The duration of balanced water conditions varies from year to year. Balanced conditions never occur in some very wet years, while very dry years may have long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one balanced water condition through the excess water condition and into the next balanced water condition. When the project that is owed water enters into flood control operations, which could be Shasta Reservoir for the CVP or Lake Oroville for the SWP, the accounting is zeroed out for that project.

Reclamation and DWR staff meet daily to discuss and coordinate CVP and SWP system operations. A number of items are discussed at this daily meeting, including:

- Current reservoir conditions

- Pumping status and current outages (for both the CVP and the SWP and how they are affecting project operations)
- Upcoming planned outages (CVP and SWP) and what that means for future operations
- Current reservoir releases and what changes may be planned
- Current regulatory requirements and compliance status
- Delta conditions to determine if CVP and SWP pumping make use of all available water

Reclamation and DWR also coordinate with Hydrosystem Controllers and Area Offices to ensure that, if necessary, personnel are available to make the desired changes. Once Reclamation and DWR each decide on a plan for that day and complete all coordination, each issue change orders to effectuate the decisions, if necessary.

Reclamation and DWR are co-located in the Joint Operations Center. Additionally, the California Data Exchange Center, California-Nevada River Forecast Center and the DWR Flood Management Group are also co-located in the Joint Operations Center. This enables efficient and timely communication, particularly during flood events.

4.8 New Science

Reclamation reinitiated consultation on the coordinated long-term operation of the CVP and SWP, in part because of new information. A substantial amount of new information and science has occurred since the 2008 and 2009 biological opinions. The following selected studies particularly inform the proposed action described in this biological assessment, but do not form a comprehensive list:

- Martin, 2017: A phenomenological assessment of temperature-related Chinook Salmon egg mortality modeling, calibrated to fry survival to Red Bluff, Martin et al. concluded the ideal incubation temperature for eggs in the river was 12C or 53.6°F. Below 53.6°F, there is no mortality due to temperature according to Martin. Biophysical models of oxygen transfer across the egg membrane corroborated the difference between temperature-dependent egg mortality predicted in the laboratory versus fry survival to Red Bluff. The 2017 LOBO review (Gore 2018), stated that the Martin approach represents a powerful predictive model for salmon vulnerability to temperature exposure but that the predictions of the oxygen diffusion model should be tested under field conditions because of the model's apparent sensitivity to extremely small changes in flow velocity, and it may be problematic to apply a density dependent model that lacks any mechanistic basis or site-specific information. Additionally, new laboratory studies from UC Davis (Del Rio et al. In Press) affirm earlier findings (USFWS 1999) that embryo survival is not appreciably impaired at daily mean water temperatures at or near 56°F.
- Anderson 2018: Anderson reviewed Martin 2017 and found that for Chinook Salmon egg incubation shifting the focus of management from meeting a compliance temperature of 53.6°F on the Sacramento River all season long to releasing cold water for just the life stage specific requirements of eggs yields efficiencies for when cold water from Shasta Reservoir is needed and when water from Shasta Reservoir can be saved.
- Grimaldo 2017: Models of Delta Smelt and salmonids at both CVP and SWP showed salvage of adult Delta Smelt increased at OMR more negative than -5,000 cfs, when all other variables were held at their averages. While OMR flow was an important predictor of CVP salvage, more

important than even CVP exports, the OMR threshold of -5,000 cfs was most notable in SWP salvage.

- Perry 2018: Statistical modeling revealed that survival was positively related to inflow only in reaches that transitioned from bidirectional tidal flows to unidirectional flow with increasing inflows. Bidirectional to unidirectional transitions occurred in Sutter, Steamboat, and Georgiana Sloughs, and in the Sacramento River from the DCC to Rio Vista, and in the Mokelumne Rivers between the DCC and the San Joaquin River.
- SST 2017: Neither Coded Wire Tag (CWT) nor acoustic tag (AT) data for juvenile Fall-Run Chinook Salmon show a strong and consistent relationship between survival of fish from the San Joaquin River and exports at Jones and Banks Pumping Plants. The evidence of relationship between exports and through-Delta survival is inconclusive, however, the authors stated that their basis of knowledge is low. “It is unknown whether equivocal findings regarding the existence and nature of a relationship between exports and through-Delta survival is due to the lack of a relationship, the concurrent and confounding influence of other variables, or the effect of low overall survival in recent years.”
- Six-Year Acoustic Telemetry Study: The Six-Year Steelhead Acoustic Telemetry Study monitored yearling Steelhead migrating through the San Joaquin River and Old River during 2011 to 2016. Estimated survival was no different between the two routes in 2011, 2012, and 2014, but was greater for Steelhead that migrated through the San Joaquin River route in 2015 (average for all release groups was 0.30 [range, 0.19–0.46]), and 2016 (average was 0.45 for all release groups [range, 0.23–0.61]) (statistically significant for 2015 and 2016 survival estimates at $\alpha = 0.05$; Reclamation 2018a,b,c; Buchanan 2018a,b,c).
- Buchanan 2018. Buchanan et al. summarized results of the Fall-Run Chinook acoustic tag studies in the San Joaquin River from 2010 through 2015. The results were survival of Fall-Run Chinook Salmon has been low since 2002, ranging between 0 and 0.05. Even in the high flow year of 2011, survival was only 0.02, suggesting increased flows alone are not sufficient to resolve low survival. Over half of the Fall-Run Chinook Salmon that made it through the San Joaquin part of the Delta to Chipps Island were salvaged at the CVP and transported to Chipps.
- Hammock 2017 and Kimmerer and Rose 2018: These studies have used field research and modeling respectively to improve the scientific understanding of food limitation in Delta Smelt. Hammock et al. (2015, 2017) showed that feeding success is variable in space and time. Kimmerer and Rose (2018) used an individual-based life cycle model to show that if it were possible to achieve, a return to pre-overbite clam historical prey densities might increase the Delta Smelt’s population growth rate by 14 percent to 81 percent.
- MAST / FLASH Reports: “According to the FLASH conceptual model, conditions are supposed to be favorable for Delta Smelt when fall X2 is approximately 74 km or less, unfavorable when X2 is approximately 85 km or greater, and intermediate in between (Reclamation 2011, 2012). The data generally supported the idea that lower X2 and greater area of the LSZ would support more subadult Delta Smelt. The greatest LSZ area and lowest X2 occurred in September and October 2011 and were associated with a high FMWT index which was followed by the highest SKT index on record, although survival from subadults to adults was actually lower in 2011 than in 2010 and 2006. There was little separation between the other years on the basis of X2, LSZ area, or FMWT index. The position and area of the LSZ is a key factor determining the quantity and quality of low salinity rearing habitat available to Delta Smelt and other estuarine species...” Any perceived benefit to the Delta Smelt population of having X2 in the ‘favorable area’ throughout most of 2017 due to high outflows remains unclear, with the Delta Smelt Fall Midwater Trawl index showing a decrease from that in 2016 and remaining near all-time lows.

- Bush 2012: Using isotopic analysis of otoliths from over a thousand Delta Smelt, Bush (2012) found the species exhibits partial migration through three different life history phenotypes, which include a freshwater resident fish, a brackish water resident fish, and a migratory phenotype, hatching in fresh water then occurring in brackish water during the juvenile and sub-adult stage. The relative abundance of each life history phenotype varied inter-annually with the latter most abundant, but not always dominant, in all years studied. The yearly contributions from each phenotype were found to vary with freshwater flows and temperature.
- CAMT Delta Smelt Entrainment Studies: New research shows that when Delta Smelt salvage is analyzed independently for SWP and CVP fish facility data, OMR flow has smaller explanatory influence on salvage than some other variables (Grimaldo et al. 2017). Population abundance, as indexed by the CDFW FMWT program, and turbidity have high explanatory power for adult Delta Smelt salvage at the SWP and CVP, particularly during the era of OMR management per the 2008 USFWS Biological Opinion. The basis for OMR flow management partially stems for earlier work showing that adult Delta Smelt salvage (Grimaldo et al. 2009) and proportional losses (Kimmerer 2008) increased as net OMR flow increased southward towards the Projects. New statistical techniques suggests a number of factors to minimize salvage or entrainment risk. However, given the correlation of OMR and SWP and CVP models, salvage and entrainment risk could be achieved through management of either indexes of the hydrodynamic influence from Project exports. It is worth noting that the ultimate objective for managing Delta Smelt entrainment should not focus on observed salvage. Rather, the management objective should be to target entrainment losses, in a traditional fisheries sense, to sustainable levels that do not compromise population growth rates (Maunder and Deriso 2011; Rose et al. 2013). New research performed under CAMT, can help scientists and resource managers identify circumstances when those large entrainment losses are likely to occur, which can ultimately be used to develop population risk assessment models (Grimaldo et al. 2017; Gross et al. 2018; Korman et al. 2018; Smith et al. 2018). The question about whether the Delta Smelt population can rebound from record-low abundances, even with improved entrainment management during the winter, remains outstanding given the importance of other factors at play (i.e., poor food supply, growth, water temperatures; see Maunder and Deriso 2011; Rose et al. 2013).

4.9 Proposed Action by Basin

Table 4-6 shows each of the components of the proposed action for this consultation, including both operational changes and non-flow habitat and facility improvements. The table shows whether each action is covered at a site-specific or a programmatic level in this biological assessment and whether the action is part of the Core Water Operations of the CVP and SWP, subject to periodic review after implementation, or whether it is an action to be coordinated prior to implementation (i.e., adaptively managed). The actions identified as a conservation measure represent firm commitments believed necessary to address adverse effects of the ongoing operation of the CVP and SWP and are indicated by an asterisk in the table below. Conservation measures may include habitat restoration, facility improvements, or intervention measures—hands on measures to affect fish directly, rather than affecting their habitat. Completed consultations with existing biological opinions that address the effects of long-term operations, and do not trigger reinitiation under this consultation are identified by “NCO” (Not Consulted On).

Table 4-6. Components of the Proposed Action

| Title | Site Specific or Programmatic? | Core Operation or Adaptive Management? |
|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------|----------------------------------------|
| CVP/SWP Wide | | |
| Divert and store water consistent with obligations under water rights and decisions by the State Water Resources Control Board | Site-specific | Core |
| Shasta Critical Determinations and Allocations to Water Service and Water Repayment Contractors | Site-specific | Core |
| 2018 Revised Coordinated Operations Agreement | NCO | NCO |
| Upper Sacramento | | |
| Seasonal Operations | Site-specific | Core |
| Spring Pulse Flows | Site-specific | AM |
| Shasta Cold Water Pool Management | Site-specific | Core |
| Fall and Winter Refill and Redd Maintenance | Site-specific | Core |
| Operation of a Shasta Dam Raise | Site-specific | Core |
| Rice Decomposition Smoothing* | Site-specific | Core |
| Spring Management of Spawning Locations* | Site-specific | AM |
| Cold Water Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough, Shasta TCD Improvements)* | Programmatic | AM |
| Spawning and Rearing Habitat Restoration* | Programmatic | AM |
| Small Screen Program* | Programmatic | AM |
| Winter-Run Conservation Hatchery Production* | Programmatic | AM |
| Adult Rescue* | Programmatic | AM |
| Juvenile Trap and Haul* | Programmatic | AM |

| Title | Site Specific or Programmatic? | Core Operation or Adaptive Management? |
|-------------------------------------------------------------------|---------------------------------------|-----------------------------------------------|
| Trinity | | |
| Seasonal Operations | Site-specific | Core |
| Trinity River Record of Decision | NCO | NCO |
| Long-Term Plan to Protect Adult Salmon in the Lower Klamath River | NCO | NCO |
| Grass Valley Creek Flows from Buckhorn Dam | Site-specific | Core |
| Whiskeytown Reservoir Operations | Site-specific | Core |
| Clear Creek Flows | Site-specific | Core |
| Spring Creek Debris Dam | Site-specific | Core |
| Clear Creek Restoration Program* | NCO | NCO |
| Feather River | | |
| FERC Project #2100-134 | NCO | NCO |
| American River | | |
| Seasonal Operations | Site-specific | Core |
| 2017 Flow Management Standard Releases and “Planning Minimum” | Site-specific | Core |
| Spawning and Rearing Habitat Restoration* | Programmatic | AM |
| Drought Temperature Facility Improvements* | Programmatic | AM |
| Stanislaus | | |
| Seasonal Operations | Site-specific | Core |
| Stanislaus Stepped Release Plan | Site-specific | Core |
| Alteration of Stanislaus DO Requirement | Site-specific | Core |
| Spawning and Rearing Habitat Restoration* | Programmatic | AM |
| Temperature Management Study* | Programmatic | AM |

| Title | Site Specific or Programmatic? | Core Operation or Adaptive Management? |
|------------------------------------------------------|--------------------------------|----------------------------------------|
| San Joaquin | | |
| San Joaquin River Restoration Program | NCO | NCO |
| Lower SJR Habitat* | Programmatic | AM |
| Bay-Delta | | |
| Seasonal Operations | Site-specific | Core |
| Minimum Export Rate | Site-specific | Core |
| Delta Cross Channel Operations | Site-specific | Core |
| Agricultural Barriers | Site-specific | Core |
| Contra Costa Water District Rock Slough Operations | Site-specific | Core |
| North Bay Aqueduct | Site-specific | Core |
| Water Transfers | Site-specific | Core |
| Clifton Court Aquatic Weed Removal | Site-specific | Core |
| Suisun Marsh Preservation Agreement | NCO | NCO |
| OMR Management | Site-specific | Core |
| Tracy Fish Collection Facility* | Site-specific | Core |
| Skinner Fish Facility* | Site-specific | Core |
| Operations | | |
| Suisun Marsh Salinity Control Gates Operation* | Site-specific | Core |
| Fall Delta Smelt Habitat* | Site-specific | AM |
| Clifton Court Predator Management* | Site-specific | Core |
| San Joaquin Basin Steelhead Telemetry Study* | Site-specific | AM |
| Sacramento Deepwater Ship Channel Food Study* | Programmatic | AM |
| North Delta Food Subsidies/Colusa Basin Drain Study* | Programmatic | AM |

| Title | Site Specific or Programmatic? | Core Operation or Adaptive Management? |
|-----------------------------------------------------------------------|--------------------------------|----------------------------------------|
| Suisun Marsh Roaring River Distribution System Food Subsidies Study* | Programmatic | AM |
| Habitat Restoration | | |
| Tidal Habitat Restoration (Complete 8,000 acres from 2008 BiOp)* | Programmatic | AM |
| Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* | NCO | NCO |
| Predator Hot Spot Removal* | Programmatic | AM |
| Facility Improvements | | |
| Delta Cross Channel Gate Improvements* | Programmatic | AM |
| Tracy Fish Facility Improvements* | Programmatic | AM |
| Skinner Fish Facility Improvements* | Programmatic | AM |
| Small Screen Program* | Programmatic | AM |
| Fish Intervention | | |
| Reintroduction efforts from Fish Conservation and Culture Laboratory* | Site-specific | AM |
| Delta Fish Species Conservation Hatchery* | Programmatic | AM |
| *Denotes a Conservation Measure | | |

The proposed action for each basin is described in more detail below. These sections give some background for context along with a description of the proposed seasonal operations and proposed action.

4.9.1 Upper Sacramento River (Shasta and Sacramento Divisions)

Reclamation operates the CVP Shasta Division for flood control, navigation, agricultural water supplies, M&I water supplies, fish and wildlife, hydroelectric power generation, Delta water quality, and water quality in the upper Sacramento River. Water rights, contracts, and agreements specific to the Upper Sacramento include SWRCB Decisions 990, 90-5, 91-1, and 1641, Settlement Contracts, Exchange Contract, and Water Service Contracts. Facilities include the Shasta Dam, Lake (4.552 MAF capacity), and Power Plant; Keswick Dam, Reservoir, and Power Plant, and the Shasta TCD. 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.

Flood control limits releases to less than 79,000 cfs at the tailwater of Keswick Dam and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station (~100,000 cfs) to avoid inundating populated areas downstream. Flood control operations are based on regulating criteria developed by the USACE pursuant to the provisions of the Flood Control Act of 1944. Flood control may reserve up to 1.3 MAF of storage behind Shasta, leaving 3.2 MAF for storage management.

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with the River and Harbors Acts of 1935 and 1937. Although no commercial traffic persists, long-time water users diverting from the river have set their pump intakes based on minimum navigation flows; therefore, the CVP operates to approximately 5,000 cfs at the Wilkins Slough gage during periods when the intakes are being operated. This flow is often a challenge to meet under critical water supply conditions due to both water supply and cold water pool limitations, in which cases Reclamation has operated to approximately 4,000 cfs although impacts on senior diverters occur.

The intake for the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted from the Sacramento River through a 2,000 cfs pumping plant (with ability to expand to 2,500 cfs) into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal.

The ACID holds senior water rights and has a settlement contract with Reclamation. Water is diverted to its main canal (on the right bank of the river) from a diversion dam located in Redding about 5 miles downstream from Keswick Dam. Reclamation will coordinate with ACID to ensure safe operation of the diversion dam during the irrigation season, from April through October.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to Winter-Run Chinook Salmon. Under the orders, the water temperature compliance point may be modified to an upstream location when the objective cannot be met at Red Bluff Pumping Plant. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta TCD to improve the management of the limited cold water resources, and monitoring and coordination.

As a result, Shasta Dam is equipped with a TCD that allows temperature operations without impacting power generation. The TCD allows Reclamation to control the temperature of the water released from Shasta Dam. The TCD has four levels of gates from which water can be drawn, upper gates, middle gates, PRG gates (e.g., lower gates) and the Side Gates (coldest configuration). The last tool to reduce temperatures is to operate the TCD in the full side gate position, drawing 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 which can conflict with the goal of maintaining a cold water pool sufficient to meet species' needs toward end of spawning and incubation season in the fall.

To operate the Shasta TCD, a defined amount of reservoir elevation above each set of gates is required to ensure safe operation. This requirement is reflected in Table 4-7 as 35 feet of submergence above the top of the gates.

Table 4-7. Shasta Temperature Control Device Gates with Elevation and Storage

| TCD Gates | Shasta Elevation with 35 feet of Submergence of the TCD Gates (feet) | Shasta Storage (MAF) |
|--------------------------------------|-----------------------------------------------------------------------------|-----------------------------|
| Upper Gates | 1,035 | ~3.66 |
| Middle Gates | 935 | ~1.64 |
| Pressure Relief Gates | 840 | ~0.59 |
| Side Gates | 720 ¹ | ~0.08 |
| ¹ Low level intake bottom | | |

4.9.1.1 Seasonal Operations

Reclamation operates in the winter for flood control, including both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. The USACE is responsible for developing and maintaining the Water Control Manual (WCM) for Shasta Reservoir. The WCM provides that the top of conservation pool (TOC) will set the storage amount that Reclamation is not to exceed on a given date. Releases for flood control will vary dependent upon the current storage, the forecasted inflow, and the flow in the mainstem Sacramento River at Bend Bridge. Reclamation operates Shasta Dam releases to keep flows at Bend Bridge below 100,000 cfs, and therefore reservoir elevations may temporarily exceed the TOC storage to protect downstream populated areas. During the winter period, there can be significant flow fluctuations from Keswick Dam due to the flood control operations. 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. These minimum flows are held until irrigation demands require increased releases.

During the winter to spring period there are accretions (flows from unregulated creeks) into the Sacramento River below Shasta 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 for flood control and minimum instream requirements because of the large volumes of accretions to the Sacramento River. In drier years, these accretions may be lower and, therefore, require Reclamation to release a higher level of releases from the upstream reservoirs to meet state permit requirements as well as project exports in the Delta.

In the spring, releases are fairly steady (unless Shasta Reservoir is in flood control operations) until flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements. Releases for Delta Outflow requirements are balanced between Shasta Reservoir and Folsom Reservoir. Both reservoirs have substantial temperature control requirements, and both need to substantially fill to be able to fully meet their temperature control requirements. Therefore, releases must be carefully balanced to allow each reservoir to fill without negatively impacting the other. An

overarching goal for Reclamation when operating the CVP is to fill the reservoirs as much as possible by the end of the flood control season (end of May), while still meeting all other authorized project purposes.

Currently, the seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are utilized to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Reservoir elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource.

During the summer, operational considerations are mainly flows required for Delta outflows, instream demands, and temperature control. In river temperatures below Shasta Dam can be controlled via two methods. First is changing release volume or shifting releases between Trinity and Sacramento reservoirs, and the second is selective withdrawal through the TCD. Determination of which method to use is made on a daily basis as operators balance releases from multiple reservoirs to meet downstream needs.

Fall operations are dominated by temperature control and provision of fish spawning habitat. By late fall, the remaining cold water pool in Shasta Reservoir is usually limited. This can be a delicate balancing act in that if the early fall flows are too high then the fish may make their redds higher up on the edge of the river, and they become subject to the possibility of dewatering when the flows are reduced later in the fall. Sacramento River releases cannot be too low early in the fall as there are still significant instream diversion demands on the mainstem of the Sacramento River between Keswick Dam and Wilkins Slough, and depending on conditions, SWRCB Delta requirements may require upstream reservoir releases. This necessitates maintaining higher releases to support the instream demands until they fall off later in the season. At that time, Reclamation's objective is to drop Keswick releases to a lower level to conserve storage.

4.9.1.2 *Spring Pulse Flows*

Under the Core Water Operation, Reclamation would not release spring pulse flows unless the projected May 1 Shasta Reservoir storage is greater than 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a Spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

4.9.1.3 *Cold Water Pool Management*

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 control criteria throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta TCD upper shutters by the end of May, Reclamation can maximize the cold water pool potential. Storage of 3.66 MAF allows water to pass through the upper gates of the Shasta TCD, but historical relationships suggest that a storage of 4 MAF on May 1st generally provides enough storage to continue operating through the upper gates and develop a sufficient cold water pool to meet 53.5°F on the Sacramento River above Clear Creek (at the CCR gaging station) for Winter-Run Chinook Salmon spawning and egg incubation. Figure 4-2 provides an approximate rule of thumb for the relationship between temperature compliance, total storage in Shasta Reservoir, and cold water pool in Shasta Reservoir.

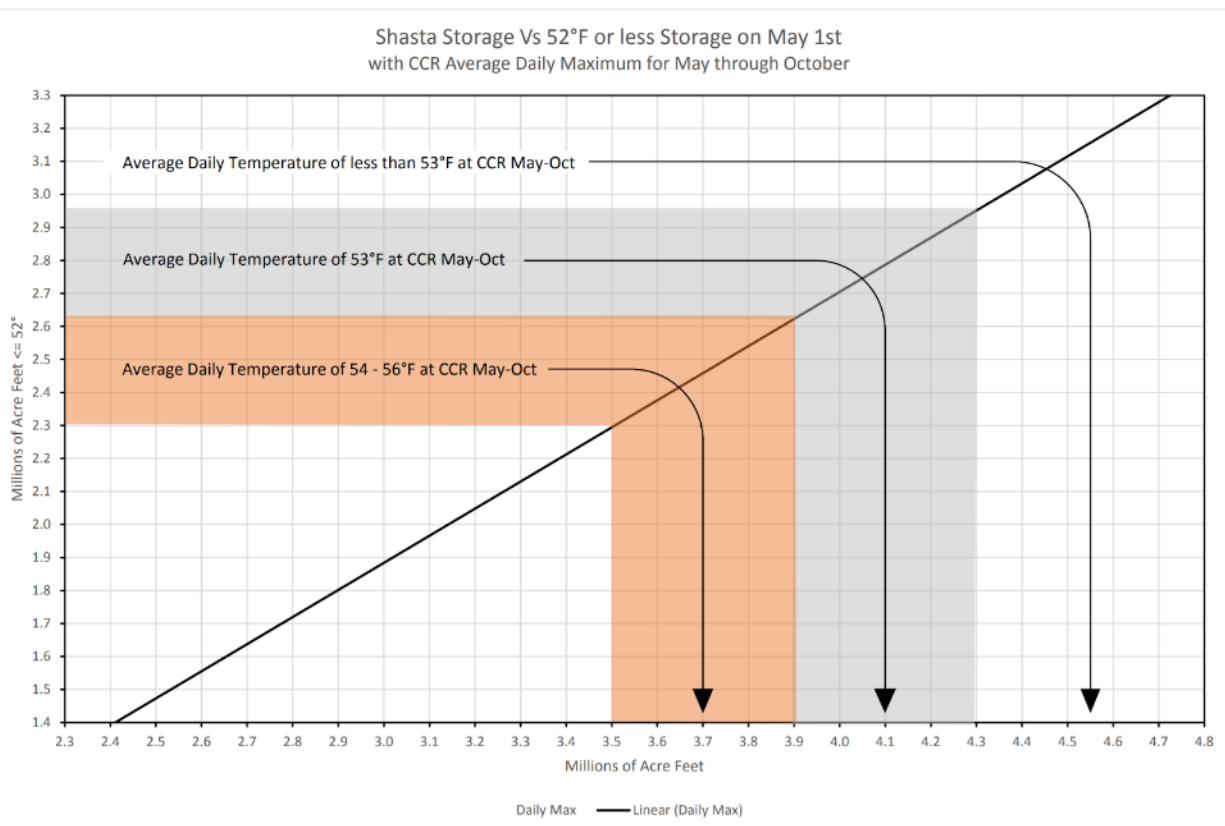


Figure 4-2. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Cold Water Pool in Shasta Reservoir

4.9.1.3.1 Summer Cold Water Pool Management

Reclamation proposes to operate the TCD 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 less than 52°F, which Reclamation would determine based on monthly (or more frequent) reservoir temperature profiles. The Sacramento River above Clear Creek (CCR) gage is a surrogate for the downstream extent of most Winter-Run Chinook Salmon redds. 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. Temperature management would end October 31, or when the monitoring working group determines based on real-time monitoring that 95 percent of Winter-Run Chinook Salmon eggs have hatched, and aelvin have emerged, whichever is earlier.

Reclamation proposes to address cold water management utilizing a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The tiered strategy recognizes that cold water is a scarce resource that can be managed to achieve desired water temperatures for fisheries objectives. Figure 4-3 below shows examples of water temperatures at CCR under the four tiers. The proposed tiers are described below, along with storage levels that are likely to provide for cold water management within the tier. Actual operations will depend upon the available cold water and modeling. In any given year, cold water pool and storage could result in Reclamation switching between tiers within the year if needed to optimally use the cold water pool.

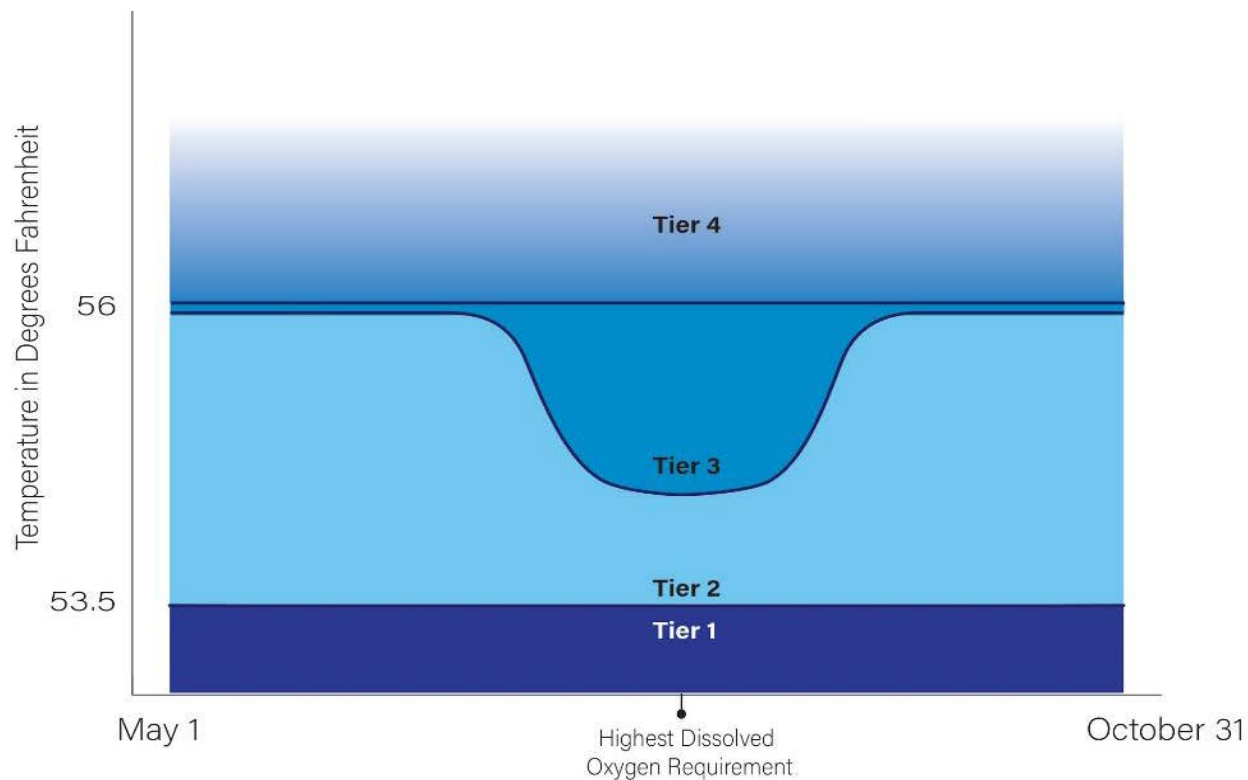


Figure 4-3. Tiered Temperature Management Strategy

- Tier 1. In years when Reclamation determines that cold water pool is sufficient (e.g., more than 2.8 MAF 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 CCR can be maintained from May 15 to October 31), Reclamation proposes to operate to a daily average temperature of 53.5°F at the CCR gaging station to minimize temperature dependent mortality.
- Tier 2. In years when cold water pool is insufficient to allow Tier 1 (e.g., less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5°F at CCR cannot be maintained from May 15 to October 31), Reclamation would optimize use of cold water for Winter-Run Chinook Salmon eggs based on life-stage-specific requirements, reducing the duration of time of operating to 53.5°F target temperatures. Water temperatures at CCR would vary based on real-time monitoring of redd timing and lifestage-specific temperature dependent mortality models, for example, Anderson (2017). The time period of 53.5°F at CCR would be centered around the projected time period when the Winter-Run eggs have the highest dissolved oxygen requirement (37–67 days post fertilization). At 2.79 MAF of cold water pool, Reclamation would 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. Reclamation will determine this time period by running different temperature scenarios through the latest egg mortality model(s) and real-time monitoring of redds. Reclamation would operate to daily average temperatures at CCR during the temperature management season outside of the stage-specific critical window no warmer than 56°F.

- Tier 3. When Reclamation determines that life-stage-specific temperature targets cannot be met per (2) above (e.g., less than 2.3 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that maintaining 53.5°F at CCR would have higher mortality than a warmer temperature), Reclamation proposes to use cold water pool releases to maximize Winter-Run Chinook Salmon redd survival by increasing the coldest water temperature target (see Figure 4-4 below). At the highest storage levels in Tier 3, the targeted temperature at CCR will be daily average 53.5°F and as storage decreases would warm in the life-stage-specific critical period up to 56°F. Reclamation would increase the temperature while minimizing adverse effects to the greatest extent possible, as determined by the latest egg mortality models, real-time monitoring, and expected and current water availability. This tier would be in effect until Reclamation could no longer meet 56°F at CCR at which point Reclamation would shift to tier 4.
- Tier 4. If there is less than 2.5 MAF of total storage (note the use of “total” storage as opposed to the “cold water pool” used in the previous criteria) in Shasta Reservoir at the beginning of May, or if Reclamation cannot meet 56°F at CCR, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time with technical assistance from NMFS and USFWS. Reclamation will explore improved coordination of downstream diversions, and the potential for demand shifting. In addition, Reclamation proposes to implement intervention measures (e.g., increasing hatchery intake and trap and haul, as described below).

At the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 MAF at the end of May, Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures should this low storage condition continue into April and May, as described in Tier 4. Reclamation proposes to perform the first temperature model run in April after the DWR Bulletin 120 has been received and the operations forecast completed. This is the first month that a temperature model run 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 used to develop an initial temperature plan for submittal to the SWRCB. 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. Figure 4-4 provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

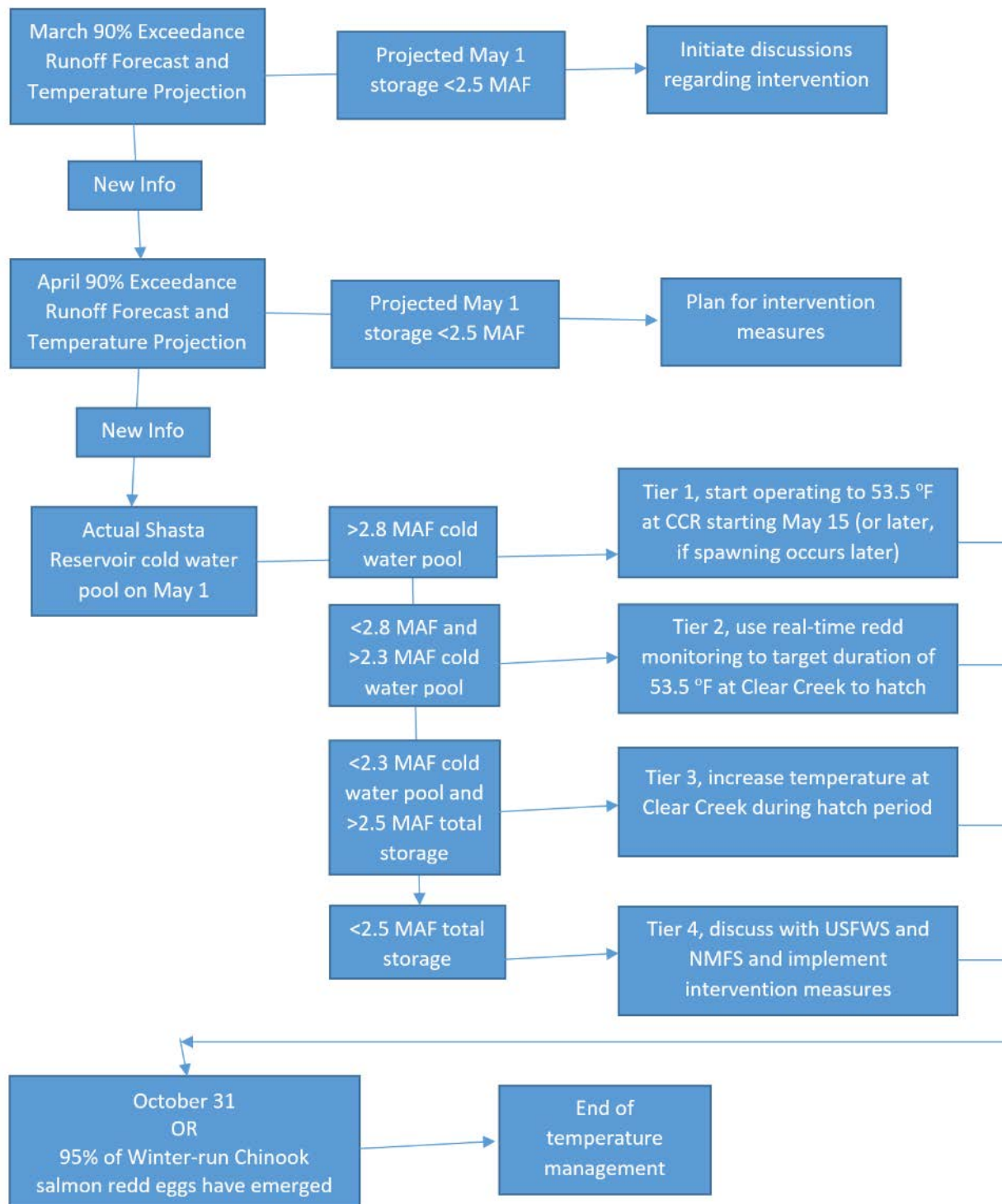


Figure 4-4. Decision Tree for Shasta Reservoir Temperature Management

Reclamation intends to provide temperature profile measurements for Shasta, Whiskeytown, and Trinity Reservoirs as shown in Table 4-8.

Table 4-8. Temperature Profile Measurements for Shasta, Whiskeytown, and Trinity Reservoirs

| Reservoir | Every Month | Every 2 Weeks | Every Week | Comment |
|------------------|---------------------------|----------------------------|-------------------|----------------------------------------------------------------------|
| Shasta | 01/01–03/01 12/1–12/31 | 03/01–05/01 11/15–12/01 | 05/01–11/15 | 25 ft intervals for “Every Month,” otherwise 5 ft intervals |
| Whiskeytown | 01/01–12/31 | | | 25 ft intervals |
| Trinity | 01/01–12/31 | | | 25 ft intervals |

Reclamation proposes to provide a draft temperature management plan to the SRTTG in April for its review and comment, consistent with WRO 90-5. Reclamation’s proposed April temperature management plan will describe which of the four tiers Reclamation forecasts for that year’s summer temperature management season, along with a temperature modeling scenario and the operations forecast. The SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

4.9.1.4 *Fall and Winter Refill and Redd Maintenance*

Reclamation proposes to rebuild storage and cold water pool for the subsequent year. Maintaining releases to keep late spawning Winter-Run Chinook Salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. 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 conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If maintaining flows puts the subsequent year class at a 10 percent or less risk, Reclamation will reduce releases to rebuild storage.

Demands by the National Wildlife Refuges, upstream CVP contractors, and the Sacramento River Settlement Contractors in October result in Keswick Dam releases that are generally not maintained throughout the winter due to needs to store water for beneficial uses the following year. These releases result in some early fall Chinook redds being dewatered at winter base flows. Targets for winter base flows (December 1 through the end of February) from Keswick would be set in October and would be based on the previous months’ Shasta Reservoir end-of-September storage. These targets would be set based on end-of-September storage and the current hydrology. Base flows would be set based on historic performance to accomplish improved refill capabilities for Shasta Reservoir to build cold water pool for the following year. Table 4-9 shows examples of possible Keswick Releases based on Shasta Reservoir storage condition; these would be refined through future modeling efforts as part of the seasonal operations planning.

Table 4-9. Keswick Dam Release Schedule for End-of-September Storage

| Keswick Release (cfs) | Shasta End-of-September Storage |
|-----------------------|---------------------------------|
| 3,250 | ≤ 2.2 MAF |
| 4,000 | ≤ 2.8 MAF |
| 4,500 | ≤ 3.2 |
| 5,000 | > 3.2 MAF |

4.9.1.4.1 Shasta Dam Raise

Reclamation proposes to enlarge Shasta Dam and Reservoir by raising the dam crest 18.5 feet under a separate ESA consultation for construction. The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for salmonids during drought years and increase water supply reliability.

Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report, for CVP operation only. CP4A focuses on increasing anadromous fish survival, while also increasing water supply reliability. An 18.5-foot raise would increase storage by approximately 634 TAF. Operation under scenario CP4A would include a dedicated cold water storage of 191 TAF. Operations for the remaining portion of increased storage (approximately 443 TAF) would be 120 TAF reserved in dry years and 60 TAF reserved in critical years to focus on CVP deliveries. Reclamation conducted modeling for CP4A that looked at CVP only, as shown in Table 4-10 below.

Table 4-10. Increases in Deliveries (average all years)

| | CP4A (acre-feet) CVP and SWP | CP4A CVP Only (acre-feet) (approximate) |
|-------------|------------------------------|-----------------------------------------|
| Agriculture | 31,700 | 65,500 |
| M&I | 19,900 | 4,700 |

4.9.1.4.2 Conservation Measures

Conservation measures are included to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment. These conservation measures include actions that benefit listed species without impacting water supply or other beneficial uses.

- Water Operations
 - Rice Decomposition Smoothing: Demands by the National Wildlife Refuges, upstream CVP contractors, and the Sacramento River Settlement Contractors in October result in Keswick Dam releases that are generally not maintained throughout the winter due to needs to store water for beneficial uses the following year. These releases result in some early Fall-Run Chinook Salmon redds being dewatered at winter base flows. Following the emergence of Winter-Run Chinook Salmon and prior to the majority of Fall-Run Chinook Salmon spawning, upstream Sacramento Valley CVP contractors and the Sacramento River Settlement 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 reductions (late October–early November) would balance the potential for dewatering late spawning Winter-Run Chinook Salmon redds and early Fall-Run Chinook Salmon dewatering.
 - Spring Management of Spawning Locations: Reclamation will coordinate with NMFS as part of adaptive management to establish experiments to determine if keeping water colder earlier induces earlier spawning, or if keeping April/May Sacramento River temperatures warmer induces later spawning, to refine the state of the science.
 - Cold Water Management Tools: Reclamation will explore additional opportunities as part of adaptive management to extend the cold water pool, options include:
 - *Battle Creek Restoration*: Reclamation would accelerate 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. Winter-Run Chinook Salmon are currently limited to a single population that spawns in a 5-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 this new population would benefit from the restoration efforts. An additional population of Winter-Run Chinook Salmon on Battle Creek would provide temperature compliance flexibility.
 - *Lower Intakes near Wilkins Slough*: Due to temperature requirements, Sacramento River flows at or near Wilkins Slough can drop below the 5,000 cfs minimum navigational flow set by Congress. As many of the fish screens at diversions in this region were designed to meet the 5,000 cfs minimum, they may not function properly at the lower flows and as a result, not meet state and federal fish screening requirements during the lower flows (NCWA 2014). This could result in take of state and federally protected species that use this section of the river. This action would provide grants to water users within this area to install new diversions and screens that would operate at lower flows, which would allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures for both water

users and wildlife, including listed salmonids (NCWA 2014). The authority for this action is 3406(b)(21). One example project under this program is screening of Meridian Farms.

- *Shasta Temperature Control Device Improvements*: Depending upon the type of dam raise proposed, the TCD would be either modified or replaced by Reclamation, informed by updated modeling. For relatively small raises of Shasta Dam, the existing TCD structure would be retrofitted to account for additional dam height, and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to, or replacement of, the existing structure are more likely to be necessary for increasingly higher dam raises. The authority for this action is 3406(b)(6).
- **Habitat Restoration**
 - **Spawning**: Reclamation proposes to create additional spawning habitat by injecting 40–55 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.
 - **Rearing**: 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.
 - **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.
- **Intervention**
 - **Winter-Run Chinook Salmon Conservation Hatchery Production**: In a Tier 4 year, Reclamation proposes to increase production of Winter-Run Chinook Salmon. Increased production during drought could help populations continue over multiple years. Increased production would aim to offset temperature dependent mortality on the Sacramento River. Reclamation would consider New Zealand or Great Lake Winter-Run Chinook Salmon stock for augmenting conservation hatchery stock to improve heterozygosity.
 - **Adult Rescue**: 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 would improve survival of the adults, leading to increased juvenile production in the following year and more flexibility with salvage.
 - **Trap and Haul**: If Reclamation projects a Tier 4 year (less than 2.5 MAF of storage at the beginning of May), Reclamation proposes implementation of a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and Steelhead in the Sacramento River watershed in drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream 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 (NMFS 2014), depending on hydrologic conditions. In the event of high river flows or potential flooding, the fish weirs would be removed.

4.9.2 Trinity River Division

Congress authorized the Trinity River Division in 1955 as an integrated component of the CVP in order to increase water supplies for irrigation and other beneficial uses in the Central Valley, recognizing that water “surplus” to the present and future needs of the Trinity and Klamath Basins could be diverted to the Central Valley “without detrimental effect to the [Klamath-Trinity Basin’s] fishery resources.” Accordingly, Reclamation operates the Trinity River Division both to export water to the Sacramento River system and to ensure necessary flow releases into the Trinity-Klamath Basin, such as through implementation of the Department of the Interior’s Trinity River Mainstem Fishery Restoration ROD (2000 ROD). Trans-basin exports transfer water from the Trinity River to the Sacramento River system through Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek tunnel.

4.9.2.1 Seasonal Operations

Diversion of Trinity Basin water to the Sacramento Basin (transbasin 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. Transbasin diversions are managed to support water supply and temperature objectives within the Sacramento system and are regulated by the ROD and Trinity Reservoir supply. The 2000 Trinity ROD strictly limits Reclamation’s transbasin diversions to 55 percent of annual inflow on a 10-year average basis to legal and trust mandates for the restoration and protection of the Trinity fishery which restrict the amount of water authorized for exportation to the Central Valley. Reducing transbasin diversions was intended to improve the cold water pool in Trinity Reservoir to improve conditions for fall spawning down the Trinity River. This limitation on transbasin diversions significantly impacts Reclamation’s temperature operations on the Sacramento River and Reclamation’s ability to satisfy senior water right holder and/or Settlement contractor commitments within the CVP system.

Trinity River exports are first conveyed through Carr Power Plant which flows directly into Whiskeytown Lake, a heavily used recreation facility. From Whiskeytown Lake, the exported water continues to flow into Spring Creek Power Plant and ultimately outflows into the Sacramento River below Keswick, or water is released from Whiskeytown to Clear Creek. Although Whiskeytown Lake is primarily used as conveyance system for transbasin transfers, operations at both Carr and Spring Power plants are done in a manner to maintain specified elevations for supporting recreation (based on season).

The amounts and timing of Trinity River basin exports into the Sacramento River basin are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity water supply. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10–15 percent of water years when Shasta Reservoir is also drawn down. Reclamation proposes to address end-of-water-year carryover on a case-by-case basis in dry and critically dry water year types described in the Water Operations Governance process below.

The seasonal timing of Trinity River exports is a result of determining how to make best use of a limited volume of Trinity River export (in concert with releases from Shasta Reservoir) to help conserve cold

water pools and meet water temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics.

These exports support better Trinity River temperatures by maintaining cold water and reducing residence time within Lewiston Reservoir. Transbasin diversions also typically help meet Sacramento River temperatures by providing additional cold water resources to the Sacramento River. As a result, Trinity River export operations are completely integrated with Shasta Dam operations.

4.9.2.2 *Trinity River Record of Decision*

The 2000 ROD prescribed increase flows to meet federal statutory and other responsibilities to protect and restore the basin's fishery resources, to be released from Lewiston Dam down the Trinity River. Specifically, it entails: (1) variable annual instream flows for the Trinity River from the Trinity River Division based on forecasted hydrology for the Trinity River Basin; (2) mechanical habitat rehabilitation projects along with sediment management and watershed restoration efforts; and (3) an adaptive management program. The 2000 ROD flow release schedules vary among water-year classes and were designed to address the environmental requirements of anadromous fish and fluvial geomorphic function. The following five water year classes and associated annual water volumes for release to the Trinity River are identified as: Critically Dry (369 TAF); Dry (453 TAF); Normal (636 TAF); Wet (701 TAF); and Extremely Wet (815 TAF).

Total river release can reach up to 11,000 cfs below Lewiston Dam (flood criteria) due to local high water concerns in the floodplain and local bridge flow capacities. Flood criteria provides seasonal storage targets and recommended releases November 1 to March 31.

4.9.2.2.1 Long-Term Plan to Protect Adult Salmon in the Lower Klamath River

In addition, in various years since 2003, and particularly since 2013, certain fishery agencies, together with the Tribal Governments, have been requesting additional late-season flows in the Trinity River above the 2000 ROD baseline flows (primarily in August and September) to prevent fish illness from instream crowding and warm waters in the lower Klamath River in drier years. In some cases, these releases were made in successive dry years and therefore had cumulative effects year to year, leading to lower storage in Trinity Reservoir and water supply and temperature impacts in the Sacramento and Trinity Rivers and Clear Creek.

Reclamation released a Record of Decision for the Long Term Plan to Protect Adult Salmon in the Lower Klamath River in 2017 (2017 ROD), which identified a process and criteria for Reclamation to provide supplemental flows from mid-August to late September from Lewiston Dam to prevent an episodic disease outbreak in the lower Klamath River in years when the criteria for such flows are met. These flows include a Preventative Base Flow component of a supplemental release of up to 40 TAF from Lewiston Dam over the course of approximately 30 days, beginning on or about August 23, with the intent of meeting and/or maintaining a target of up to 2,800 cfs in the lower Klamath River; a Preventative Pulse Flow component of up to 10 TAF release over 4 days to achieve a peak of 5,000 cfs in the lower Klamath River; and an Emergency Flow component which would be up to 34 TAF from Lewiston Dam over no more than 8 days, beginning on or about September 20 to meet a target of 5,000 cfs in the lower Klamath River. The 2017 ROD cited proviso 1 of Section 2 of the 1955 Act as authority for the releases. Another proviso of Section 2 states that "not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream water users."

4.9.2.3 *Grass Valley Creek Flows from Buckhorn Dam*

Reclamation proposes to release water from Buckhorn Dam to Grass Valley Creek in accordance with requirements published in the Buckhorn dam and reservoir standard operating procedures manual for water rights permit 18879 issued to DWR, which establishes the timing and magnitude of minimum flows and flushing flows from the dam.

In addition, Reclamation proposes to increase flow from the dam outlet works for maintenance of the outlet channel and to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Reclamation proposes to release pulse flows when the reservoir water elevation exceeds 2,803.13 ft above sea level between March 1 and April 15 to the extent feasible.

Reclamation also proposes to increase flow in the outlet channel when necessary in October and November to provide adult Coho sufficient flow for upstream migration and spawning, to the extent feasible.

4.9.2.4 *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. 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.

Whiskeytown Lake is annually drawn down by approximately 35 TAF of storage space during November through April to regulate flows for winter and spring flood management. Heavy rainfall events occasionally result in spillway discharges to Clear Creek. Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin. Joint temperature control objectives also similarly interact among the Trinity River, Clear Creek, and Sacramento River.

4.9.2.5 *Clear Creek Flows*

Reclamation proposes to release Clear Creek flows in accordance with the 1960 MOA with CDFW, and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation proposes a minimum base flow in Clear Creek of 150 cfs year-round in all year types except Critical year types. In Critical years, Clear Creek base flows may be reduced below 150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall.

In addition, Reclamation proposes to create pulse flows for both channel maintenance and spring attraction flows. 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 CVO. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown, with a daily release up to the safe release capacity, in all year-types except for Dry and Critical year-types (based on the Sacramento Valley index) to be shaped by the Clear Creek Implementation Team in coordination with CVO. Pulses would be scheduled with CVO. No channel maintenance flows would be scheduled before January 1. For each

storm event that results in a Whiskeytown Gloryhole spill of at least 3,000 cfs for 3 days, Reclamation will reduce the channel maintenance flow volume for this year or the following year by 5,000 acre-feet. If two Gloryhole spills occur that meet this criterion in a year, additional channel maintenance flows would not be released in that year. In Critical years, Reclamation would release one spring attraction flow of up to the safe release capacity (approximately 900 cfs) for up to 3 days and would not release any channel maintenance flows. Reclamation could instead, or in addition, use mechanical methods to mobilize gravel if needed to meet biological objectives as part of adaptive management.

The outlet from Whiskeytown Reservoir to Clear Creek is equipped with outlets at two different elevations. Releases can be made from either or both outlets to manage downstream temperature releases. Reclamation proposes to manage Whiskeytown releases to meet a daily average water temperature of: (1) 60°F at the IGO gage from June 1 through September 15; and (2) 56°F at the IGO gage from September 15 to October 31. Reclamation may not be able to meet these temperatures in Critical or Dry water year types. In these years, Reclamation will operate to as close to these temperatures to the extent possible.

4.9.2.6 *Spring Creek Debris Dam*

The Spring Creek Debris Dam (SCDD) was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5,800 acre-feet of water. Operation of SCDD and Shasta Dam has allowed some control of the toxic wastes with dilution criteria. In January 1980, Reclamation, CDFW, and SWRCB executed an MOU to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds. In the operational situation when heavy rainfall events will fill SCDD and Shasta Reservoir will not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

4.9.2.7 *Clear Creek Restoration Program*

Reclamation and DWR propose to continue channel maintenance under the Clear Creek Restoration Program.

4.9.3 *Feather River*

DWR will operate Oroville Dam consistent with the NMFS, USFWS, and CDFW environmental requirements applicable for the current FERC License for the Oroville Complex (FERC Project #2100-134). The downstream boundary of FERC's Oroville Project area is the Feather River above the city of Gridley. During the summer, DWR typically releases water from Lake Oroville to meet the requirements of instream flows and D-1641. Additional releases are made for local deliveries and exports at Banks Pumping Plant. DWR balances the cumulative storage between Lake Oroville and San Luis Reservoirs so as to meet its flood control requirements, Sacramento-San Joaquin Delta requirements, and deliver water supplies to its contracted water agencies consistent with all environmental constraints. Lake Oroville may be operated to convey water through the Delta to San Luis Reservoir via Banks under different schedules depending on Delta conditions, reservoir storage volumes, storage targets and regulatory requirements. Decisions as to when to move water from Lake Oroville to San Luis Reservoir are based on many real-time factors.

4.9.4 American River Division

Reclamation operates the CVP American River Division for flood control, M&I and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include the Folsom Dam, reservoir (977 TAF 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 main storage and flood control reservoir on the American River. Numerous other smaller reservoirs in the upper basin provide hydroelectric generation and water supply without specific flood control responsibilities. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF and these reservoirs are operated primarily for hydropower production. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation coordinates with the operators of these reservoirs to aid in planning for Folsom Reservoir operations. Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Power Plant, or the spillway gates at flows in excess of 5,000 cfs. Because Folsom Reservoir is the closest reservoir to the Delta, releases from Folsom can more quickly address Delta water quality requirements under D-1641.

Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017. Flows range from 500 to 2000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold water pool and habitat conditions for Steelhead and Fall-Run Chinook Salmon. Specific flows are determined using an index intended to define the current and recent hydrology. Although Reclamation has assumed the index proposed by the Water Forum in 2017 for the purposes of modeling and analysis within this biological assessment, Reclamation intends to continue discussions with the Water Forum to ensure the index used for implementation is appropriate to meet the intended objectives under continuously changing hydrology.

Reclamation proposes to work together with the American River Stakeholders 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 objective of the planning minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible. 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.

Reclamation expects infrequent scenarios where the forecasted storage may fall below the “planning minimum” due to a variety of circumstances and causes. In those instances, Reclamation and the American River stakeholders will develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. In its forecasting process for

guiding seasonal operations, Reclamation will plan to maintain or exceed the planning minimum at the end of the calendar year. When Reclamation estimates, using the forecasting process, that it would not be able to maintain Folsom Reservoir storage at the end-of-December “planning minimum” for that year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River Division contractors would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River stakeholders would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom Dam operations would have impacts on other aspects of the CVP and SWP or the entire integrated system, Reclamation will meet and discuss these potential changes and impacts with water contractors. Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

4.9.4.1 *Seasonal Operations*

In the winter and spring, flood control releases typically dominate the flow regime in the American River Division. Flood control operations occur to safely pass large storm events without exceeding the identified downstream levee capacity. This includes making dry-weather releases to ensure that the maximum storage adheres to the flood control elevation identified in the applicable Water Control Manual. Reclamation proposes to not reduce flows more than 500 cfs/day and not more than 100 cfs per hour except if necessary for flood control operations. Reclamation will minimize releases above 4,000 cfs during sensitive life stages (e.g. eggs, incubation, rearing) of salmonids and Steelhead to the extent feasible.

As part of implementing the 2017 Flow Management Standard, Reclamation proposes redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period. Redd dewatering protective adjustments should limit the amount of dewatering due to a reduction of the minimum release, not the actual river release, and, as such, would not always minimize dewatering impacts to the same extent. In January and February, there is a Chinook Salmon redd dewatering protective adjustment, and in February through May there is a Steelhead redd dewatering protective adjustment.

During non-flood control operations within the fall and winter months, Reclamation proposes to operate to build storage by making minimum releases and capturing inflows, although drier conditions may also require releases for Delta requirements. To the extent possible, releases will be held relatively consistent to minimize potential redd dewatering.

Spring releases will be controlled by flood control requirements or, in drier hydrology, Delta requirements and water supply. Reclamation proposes to operate Folsom Dam in a manner designed to maximize capture of the spring runoff to fill as close to full as possible. To the extent practicable, Reclamation proposes to accommodate requests for spring pulse flows by re-shaping previously planned releases; however, these requests will not be accommodated in times when they may compromise temperature operations later in the year. Reclamation proposes to follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 timeframe. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.

Reclamation proposes to continue to make summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the cold water pool. The primary way to provide additional instream cooling is to release water from the lower outlet works. This operation bypasses the power penstocks and has a significant impact on power generation. In order to optimize power generation, Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California.

4.9.4.2 *Temperature Management*

Reclamation proposes to prepare a draft Temperature Management Plan by May 15 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The information provided by the Operations Forecast will be used in the development of the Temperature Plan. The draft plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will use an iterative approach, varying shutter configurations, with the objective to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. The draft plan will be shared with the American River Group (ARG) before finalization, and may be updated monthly based on system conditions.

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. If the temperature is exceeded for 3 consecutive days, Reclamation will notify NMFS and outline steps being taken to bring the water temperature back into compliance. 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.

4.9.4.3 *Conservation Measures*

Conservation measures are included to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses.

- Spawning and Rearing Habitat Named Projects: Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar—North, El Manto, Sacramento Bar—South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction.
- Reclamation proposes to continue maintenance activities at Nimbus Basin, Upper Sailor Bar, and River Bend restoration sites.

- **Drought Temperature Management:** In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility as part of adaptive management.

4.9.5 Delta

CVP and SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta, and to regions south of the Delta. The major CVP features are the DCC, Contra Costa Canal and Rock Slough Intake facilities, Jones Pumping Plant, and TFCF. The main SWP Delta features are Suisun Marsh facilities, Banks Pumping Plant, CCF, Skinner Fish Facility, and Barker Slough Pumping Plant. These facilities and their operation under the proposed action are described in subsequent sections.

The CVP Jones Pumping Plant, located about 5 miles north of Tracy, has six fixed-speed pumps. It has a permitted diversion capacity of 4,600 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. The Jones Pumping Plant discharges into the head of the Delta Mendota Canal (DMC). The upper portion of the DMC is heavily impacted by subsidence which limits the maximum pumping rates to less than the permitted capacity. The SWP Banks Pumping Plant, located near the Jones Pumping Plant, has 11 variable speed pumps that allow for more control over the diversion rate. Pumping is limited to a maximum permitted capacity of 10,300 cfs per day. The Banks Pumping Plant discharges into the California Aqueduct. The Delta Mendota Canal Intertie (capacity 467 cfs from DMC to California Aqueduct; Capacity 900 cfs from California Aqueduct to DMC) is used to move water between the California Aqueduct and the Delta Mendota Canal. This structure was built to help both projects more effectively move water from the Delta into the San Luis Reservoir. This helps both projects when there are system restrictions that may prevent one party from moving water.

Banks pumps water directly from storage in CCF. The CCF radial gates are closed during critical periods of the ebb/flood tidal cycle to protect water levels experienced by local agricultural water diverters in the south Delta area. As a practical matter, Banks pumping rates are constrained operationally by limits on Clifton Court diversions from the Delta. The maximum daily diversion limit from the Delta into CCF is 13,870 acre-feet per day (6,990 cfs/day) and the maximum averaged diversion limit over any 3 days is 13,250 acre-feet per day (6,680 cfs/day). In addition to these requirements, DWR may increase diversions from the Delta into CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in the USACE Public Notice 5820A Amended (Oct. 13, 1981).

During July through September, the maximum daily diversion limit from the Delta into CCF is increased from 13,870 acre-feet per day (6,990 cfs/day) to 14,860 acre-feet per day (7,490 cfs/day) and the maximum averaged diversion limit over any 3 days is increased from 13,250 acre-feet per day (6,680 cfs/day) to 14,240 acre-feet per day (7,180 cfs/day). These increases are for the purpose of recovering water supply losses incurred earlier in the same year to protect ESA-listed fish species. Those increases are a separate action permitted for short-term time periods. Further, Banks Pumping Plant will pump 195,000 acre-feet to the CVP in accordance with the 2018 COA Addendum.

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct for delivery to the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA entitlement holders).

4.9.5.1 *Seasonal Operations*

Winter and spring pumping operations generally maximize exports of excess, unregulated, unstored water to help meet project demands later in the season and for Delta water quality. In order to minimize and avoid adverse effects on listed species, actions have been taken or imposed in the past to protect fish migration and minimize fish entrainment at Jones and Banks Pumping Plants. These restrictions limit the projects' ability to export excess water in the winter and spring and place a higher reliance on exporting previously stored water in the summer and fall.

Summer is generally a period of higher export potential. During the summer the CVP and SWP typically operate to convey previously stored water across the Delta for exporting at the Project pumps or other Delta facilities. Delta concerns during the summer are typically focused on maintaining salinity and meeting 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. Exports are typically maximized to export available water in the system and may decrease if the fall remains dry. As precipitation begins to fall within the Sacramento and San Joaquin Basins, the reservoirs focus on building storage and managing for flood control. The enactment of D-1641 required higher spring releases; as a result, reservoir storage levels were lower in the fall and Reclamation and DWR had less need for flood releases. The 2008 biological opinion included an adaptive management action requiring an increase in fall flows to manage salinity in years following wet and above-normal years. However, lower fall outflows would better mimic historical (pre-project) conditions, and analyses indicate that the CVP and SWP have had negligible effects on fall outflows measured using X2 as a proxy (Hutton et al. 2017).

4.9.5.2 *Minimum Export Rates*

Water rights, contracts, and agreements specific to the Delta include D-1641, COA and other related agreements pertaining to CVP and SWP operations and Delta watershed users. In order to meet health and safety needs, critical refuge supplies, and obligations to senior water rights holders, the combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant will not be required to drop below 1,500 cfs. Reclamation and DWR propose to use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the south Delta.

4.9.5.3 *Delta Cross Channel*

The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When DCC 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.

Reclamation operates the DCC in the open position to (1) improve the movement of 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 are often 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 (on a sustained basis), the gates are 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 DCC 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, 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 4-11 and Table 4-12 to determine whether to close the DCC gates and for how long. From December 1 to May 20, the DCC gates will be closed, unless Reclamation determines that it can avoid D-1641 water quality exceedances by opening the DCC gates for up to 5 days for up to two events within this period. If there is a conflict between water quality and species in the December / January period due to drought, Reclamation and DWR propose to coordinate with USFWS and NMFS through the Fish Monitoring Working Group. From May 21 to June 15, Reclamation will close the DCC gates for 14 days during this period, consistent with D-1641. Reclamation and DWR’s risk assessment will consider the Knights Landing RST, 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 DCC 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 DCC.

Table 4-11. Delta Cross Channel October 1–November 30 Action

| Date | Action Triggers | Action Responses |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| October 1– November 30 | 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 DCC 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, DCC 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 DCC closure and there is no observed deterioration of interior Delta water quality | Within 48 hours of start of LMR attraction flow release, close the DCC gates for up to 5 days (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 DCC closure | No closure of DCC gates |
| | The KLCI or SCI 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 4-12. Water Quality Concern Level Targets

| Water Quality Concern Level Targets (Water Quality Model simulated 14-day average Electrical Conductivity) | |
|-------------------------------------------------------------------------------------------------------------------|---------------|
| Jersey Point | 1800 umhos/cm |
| Bethel Island | 1000 umhos/cm |
| Holland Cut | 800 umhos/cm |
| Bacon Island | 700 umhos/cm |

4.9.5.4 Agricultural Barriers

DWR proposes to continue to install three agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year when necessary. The barriers are installed between April to July and removed in November. Barriers would include at least one culvert open to allow for fish migration when water temperatures are less than 22°C. The barriers provide an adequate agricultural water supply in terms of quantity, quality, and channel water levels to meet the needs of water users in the south Delta area.

4.9.5.5 North Bay Aqueduct

The proposed operation of Barker Slough Pumping Plant is a maximum 7-day average diversion rate that shall 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 larval Delta Smelt are detected at Station 716 during the annual Smelt Larval Survey.

4.9.5.6 Contra Costa Water District Operations

The CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District's pre-1914 water right. The CCWD 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 owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD. Operations at CCWD's intakes and Los Vaqueros Reservoir are governed by biological opinions from NMFS (NMFS 1993, 2007, 2010, 2017) and USFWS (USFWS 1993a, 1993b, 2000; 2007, 2010, 2017), an MOU with CDFW (CDFG 1994), and an incidental take permit from CDFW (CDFW 2009), which are separate from the biological opinions for the coordinated long-term operation of the CVP and SWP. Reclamation is not consulting on the biological opinions that govern CCWD's intakes and Los Vaqueros Reservoir, nor will this consultation amend or supersede those separate biological opinions. For the proposed action in this consultation, CCWD's operations are consistent with the current implementation of the operational criteria specified in those separate biological opinions.

Reclamation will work with CCWD to ensure that implementation of the proposed action will not restrict CCWD operations beyond the restrictions of the separate biological opinions, allowing CCWD to have opportunities to fill Los Vaqueros Reservoir that are at least comparable to the current conditions.

Rock Slough Intake is located on Rock Slough at the head of the Contra Costa Canal, approximately 3.5 miles west of the junction of Rock Slough and Old River. The Rock Slough Fish Screen (RSFS) was constructed in 2011 at the Rock Slough Intake for the protection of listed species, in accordance with provisions specified in the 1993 USFWS biological opinion for the Los Vaqueros Project (USFWS 1993).

The 2008 USFWS biological opinion for the coordinated long-term operation of the CVP and SWP (USFWS 2008) and the 2009 CDFW ITP for the CCWD operations (CDFG 2009) considered the effects of the diversion of water at Rock Slough intake before the RSFS was constructed. In accordance with the 2009 ITP, CCWD obtained 36 acres of aquatic species habitat mitigation credits intended to address all of CCWD's intakes, assuming that Rock Slough was unscreened. Aquatic species impacts are now less given that the RSFS has been constructed (Reclamation 2016).

USFWS 2008 quantified incidental take and exempted prohibitions associated with all CCWD diversions as all Delta Smelt inhabiting the water diverted in the assumed 195 thousand acre feet (TAF) maximum diversion amount (USFWS 2008, 2017). In a 2009 letter from USFWS regarding the effects of the RSFS on delta smelt and its critical habitat, USFWS acknowledges that “[s]ince the Rock Slough diversion will now be screened, less entrainment will be expected than what was described in the 2008 biological opinion and the expected incidental take remains the same.”

In the proposed action, CCWD's operations are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993, 2007, 2010, 2017; USFWS 1993a, 1993b, 2000, 2007, 2010, 2017; CDFG 1994, 2009) and remain unchanged from the current operations scenario.

Reclamation is not consulting on the NMFS 2017 biological opinion at this time and is not requesting any amendments to that biological opinion. However, the NMFS 2017 biological opinion indicates that the NMFS 2009 biological opinion on the long-term coordinated operations of the CVP and SWP, which is the subject of this consultation, analyzed the actual diversion of water through the Rock Slough Intake (NMFS 2017: 87). Consistent with the 2008 USFWS biological opinion, 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 TAF.

4.9.5.7 Water Transfers

Reclamation and DWR propose to transfer project and non-project water supplies through CVP and SWP facilities. Water transfers would occur through various methods, including, but not limited to, groundwater substitution, release from storage, and cropland idling, and would include individual and multi-year transfers. 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 4-13.

Table 4-13. Proposed Water Transfers

| Water Year Type | Maximum Transfer Amount (TAF) |
|--------------------------|-------------------------------|
| Critical | Up to 600 |
| Dry (following Critical) | Up to 600 |
| Dry (following Dry) | Up to 600 |
| All other years | Up to 360 |

As part of this proposed action, Reclamation and DWR will provide a transfer window from July 1 through November 30. Allowing fall transfers is expected to have water supply benefits and may provide flexibility to improve Sacramento River temperature operations, such as occurred during the 2014–2015 drought conditions. 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.

4.9.5.8 *Clifton Court Aquatic Weed Removal*

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Aquathol K, Komeen®, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique®, a copper carbonate compound, or other copper-based herbicides. Algaecides may include peroxygen-based algaecides (e.g. PAK 27). These products are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of algal toxins. Dense growth of submerged aquatic weeds, predominantly *Egeria densa*, can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trashracks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the pumping rate of water to prevent potential equipment damage through cavitation at the pumps. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the SWP. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF.

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HAB), or concentration of taste and odor compounds. The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in CCF:

- Apply aquatic pesticides, as needed, after temperatures within CCF are above 25°C or after June 28 (as July 1 is a critical operational timeframe) and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter.
- Apply aquatic pesticides within CCF during periods of activated Delta Smelt and salmonid protective measures if the following conditions are met:

- The herbicide application begins after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within CCF (e.g. temperatures within CCF are above 25°C) has been exceeded, and
 - The radial gates remain closed for 24 hours after the completion of the application, or
 - The applied herbicide is PAK 27. There are no anticipated impacts on fish with the use of PAK 27 during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in CCF.
 - Close the radial intake gates at the entrance to CCF prior to the application of herbicides to allow fish to move out of the proposed treatment areas and toward the salvage facility and to prevent any possibility of aquatic herbicide diffusing into the Delta.
 - For Aquathol K and copper compounds, the radial gates will remain closed for 12–24 hours after treatment to allow for the recommended duration of contact time between the aquatic herbicide or algaecide and the treated vegetation or cyanobacteria in the forebay. (Contact time is dependent upon herbicide type, applied concentration, and weed assemblage). Radial gates would be reopened after a minimum of 24 hours.
 - For peroxide-based algaecides, 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.
 - Application would be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
 - Aquatic herbicides and algaecides would be applied by boat, starting at the shore and moving systematically farther offshore in its application.
 - Application would be to the smallest area possible that provides relief to SWP operations or water quality.
 - Monitoring of copper and endothall concentration in the water column will occur during and after application. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
 - No monitoring of peroxide (PAK 27) 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 immediately following application within and adjacent to the treatment zone.
 - No aerial spray applications will occur during rain or within 48 hours of forecasted precipitation.
 - A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and Steelhead in the Central Valley's Delta region and of Delta Smelt. Migrations of juvenile Winter-Run Chinook Salmon and Spring-Run Chinook Salmon primarily occur outside of the summer period in the Delta. Central Valley Steelhead have a low probability of being in the south Delta during late June when temperatures exceed 25°C through the first rainfall flush event, which can occur as late as December in some years (Grimaldo 2009). Delta Smelt are not expected to be in CCF during this time period. Delta Smelt are not likely to survive when temperatures reach a daily average of 25°C, and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook Salmon, Central

Valley Steelhead, and Delta Smelt during the proposed herbicide treatment timeframe in CCF is negligible.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed assemblage. Additionally, prior to aquatic herbicide applications following gate closures, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, and it lowers the water level in the CCF to decrease the total amount of herbicide that would need to be applied, per volume of water.

4.9.5.9 Suisun Marsh Preservation Agreement

The SMPA among DWR, Reclamation, CDFW, and Suisun Resource Conservation District (SRCD) contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since 1988 and have proven to be a highly reliable method for meeting standards.

The SMSCG are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west through Suisun Marsh.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The boat lock portion of the gate is now held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility. Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations will remain at current levels (17–69 days per year) except perhaps during the most critical hydrologic conditions.

The Roaring River Distribution System (RRDS) was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of CDFW managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands. The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. The intake to the RRDS is screened to prevent entrainment of fish

larger than approximately 25 mm. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.7 ft/second at the intake fish screen.

The Morrow Island Distribution System (MIDS) allows Reclamation and DWR to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough. The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor.

4.9.5.10 OMR Management

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 flow OMR provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. The management of OMR, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the south Delta and at CVP and SWP 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 OMR 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 the trigger when monitoring, modeling, and criteria indicate protection for fish is necessary.

- Reclamation and DWR propose to operate to an OMR index computed using an equation. An OMR index allows for short-term operational planning and real-time adjustments.
- OMR Management: From the onset of OMR management to the end, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of -5,000 cfs unless a storm event occurs (see below for storm-related OMR flexibility). Grimaldo et al. (2017) indicate that -5,000 cfs is an inflection point in OMR for fish entrainment. OMR could be more positive than -5000 cfs if additional real-time OMR restrictions are triggered as described below.
- Onset of OMR Management: Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:
 - Integrated Early Winter Pulse Protection (“First Flush” Turbidity Event): 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, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polanksy et al. 2018). As it relates to delta smelt, the Integrated Early Winter Pulse Protection action is intended to minimize Project influence on migration (or dispersal) that occurs coincident with “First Flush” conditions in the Delta. 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 OMR index for the period shall not be more negative than -3,500 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 degrees Celsius 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 (wild young-of-year Winter-Run, wild young-of-year Spring-Run, or wild 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 OMR Restrictions: Reclamation and DWR shall manage to a more positive OMR 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 not evidence that large, population-scale movements continue. The turbidity avoidance action described below reflects current understanding about how to protect delta smelt from damaging levels of entrainment after a Flush Flush and in years when a First Flush does not occur. The proposed additional OMR Management is meant to supplement the protection provided to pre-spawning adult Delta smelt that have migrated up the San Joaquin River shipping channel. 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 (OBI) at a level of less than 12 NTU. If turbidity does not exceed 12 NTU at OBI, then there will be no explicit limit on OMR flow for the purposes of protecting delta smelt. If daily average turbidity at OBI cannot be maintained less than 12 NTU, the 3-day averaged OMR index shall not be more negative than -5000 cfs, until the 3-day average turbidity at OBI drops below 12 NTU. The OBI site shall be redundantly telemetered to avoid data gaps. The action is to be taken from February 1-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 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 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).
 - Wild Central Valley Steelhead Protection: Reclamation and DWR would operate to OMR 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 TAF. The timing of this action is intended to provide protections to San Joaquin origin Central Valley 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 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 JPE (genetically confirmed or 2 percent based

on length at date); 1 percent of the Spring-Run Chinook Salmon JPE (or 0.5 percent of Spring-Run surrogates); 3,000 juvenile Central Valley Steelhead, and 100 juvenile Green Sturgeon. Reclamation and DWR may operate to a more positive OMR when the daily salvage loss indicates that continued OMR of -5,000 cfs may exceed the cumulative salvage loss thresholds as described below:

- Restrict OMR to a 14-day moving average OMR index of -3,500 cfs when a species-specific cumulative salvage or loss threshold exceeds 50 percent of the threshold. The OMR restriction to -3,500 cfs will persist until the species-specific offramp is met.
- Restrict OMR to a 14-day moving average OMR index of -2,500 cfs (or more positive if determined by Reclamation) when cumulative salvage or loss threshold for any of the above species exceeds 75 percent of the threshold. The OMR restriction to -2,500 cfs will persist until the species-specific offramp is met.

Species specific OMR restrictions will end when the individual species-specific off ramp from “End of OMR management criteria,” below, are met.

- Storm-Related OMR Flexibility: If Reclamation and DWR are not implementing additional real-time OMR restrictions, consistent with other applicable legal requirements, Reclamation and DWR may operate to a more negative OMR 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 OMR 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 OMR Restrictions,” above.
- End of OMR Management: OMR criteria may control operations until June 30, or when both of the following have occurred, whichever is earlier:
 - Delta Smelt: when the daily mean water temperature at CCF 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).

Figure 4-5 shows OMR management in a decision tree.

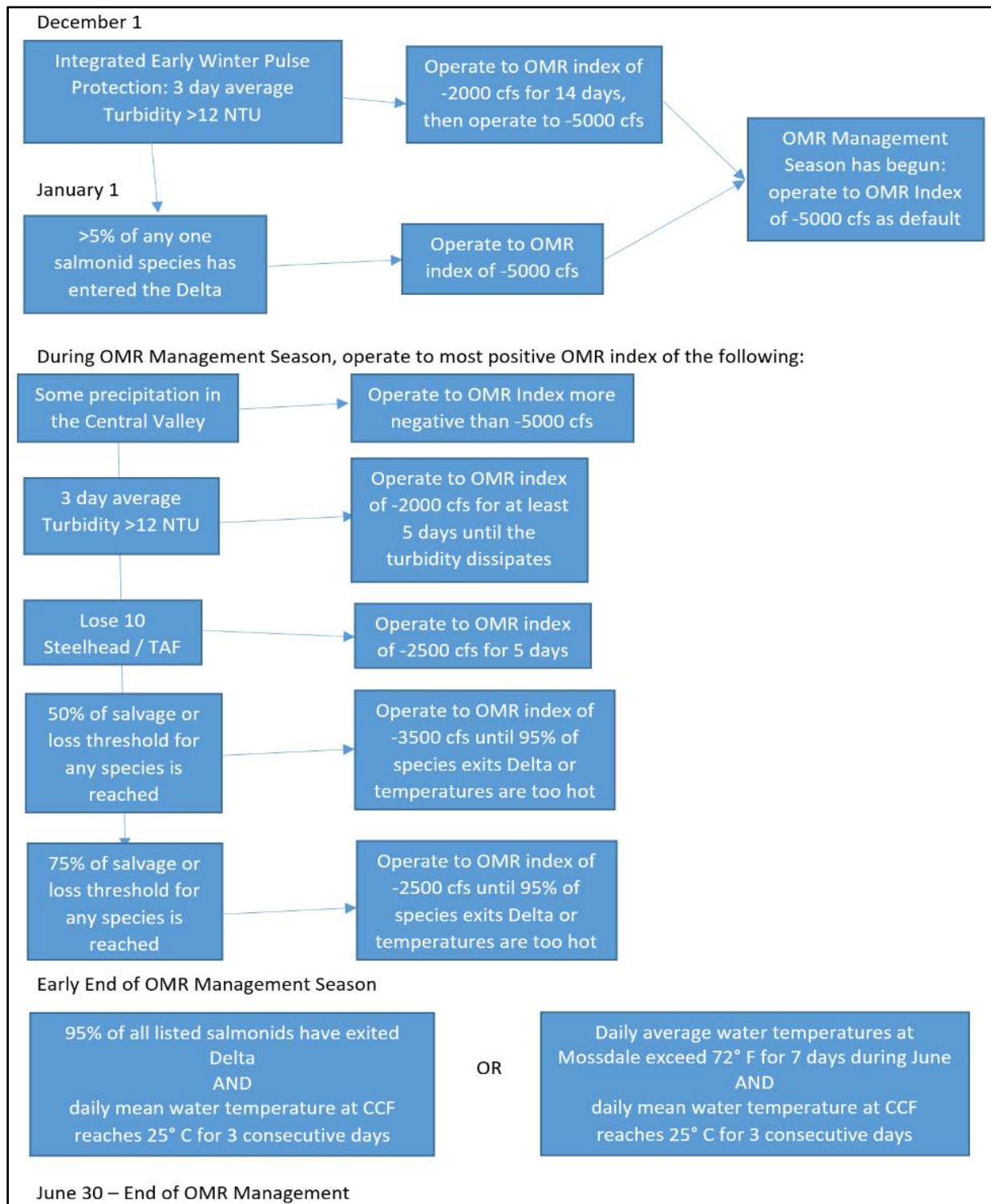


Figure 4-5. Decision Tree for Old and Middle River Reverse Flow Management

Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if the Additional Real-Time OMR Restrictions are not required for the protection of species and Reclamation and DWR

desire to operate to a more negative OMR. The Directors of NMFS and USFWS may authorize Reclamation to operate to a more negative OMR. The Director of CDFW may authorize DWR to operate to a more negative OMR.

4.9.5.11 Conservation Measures

Conservation measures are included to further avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. The TFCF and the Skinner Fish Facility are identified specifically due to their significance as project features and then additional measures are listed.

4.9.5.11.1 Tracy Fish Collection Facility

Reclamation proposes to continue to screen fish from Jones Pumping Plant with the TFCF. The TFCF uses behavioral barriers consisting of primary louvers and four traveling screens in the secondary channel, to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The primary louvers are located in the primary channel just downstream of the trashrack structure. The secondary traveling screens are located in the secondary channel.

Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge. As a conservation measure, Reclamation proposes to increase the number of release sites to reduce predation.

Predator Removal: Reclamation proposes to install a carbon dioxide injection device to allow remote controlled anesthetization of predators in the secondary channels of the TFCF.

4.9.5.11.2 Skinner Fish Facility

DWR proposes to continue to screen fish from Banks Pumping Plant with the Skinner Fish Facility, located west of the CCF, 2 miles upstream of the Banks Pumping Plant. The Skinner Fish Facility has behavioral barriers to keep fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash rack. Smaller fish are diverted from the intake channel into bypasses by a series of behavioral barriers (metal louvers), while the main flow of water continues through the louvers and toward the pumps. These fish pass through a secondary system of louvers or screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks. The sampling frequency at TFCF will be maintained at the Skinner Fish Facility.

4.9.5.11.3 Additional Measures

- Operations
 - *Suisun Marsh Salinity Control Gates Operation*: In addition to the October through May operation to meet Suisun water quality standards, Reclamation and DWR propose operating the SMSCG on the tidal cycle to meet the physical and biological features of Delta Smelt critical habitat in below-normal and above-normal Sacramento Valley Index year types in June through September for 60 days, not necessarily consecutive, as part of the adaptive management framework, based on data gathered over time to allow for assessment of the action. A Delta scheduling

group would meet to provide scheduling recommendations to Reclamation and DWR in late spring. Slater and Baxter (2014) posit that food is limited for Delta Smelt in August and September. Reclamation and DWR would increase tidal operations of the SMSCG to direct more fresh water in Suisun Marsh, which is intended to reduce salinities in Suisun Marsh, increase food, and improve habitat conditions for Delta Smelt in the region. This would be combined with Roaring River Distribution System management for food production and flushing fresh water 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, which will require additional Delta outflow. Reclamation and DWR would implement monitoring of physical factors to evaluate this action as part of the adaptive management plan.

- *Fall Delta Smelt Habitat*: Reclamation proposes to manage for Delta Smelt habitat in the fall of Above Normal and Wet years (between D-1641 and the 2008 biological opinion). Delta Smelt habitat would be defined in terms of all of the physical and biological features of critical habitat.
- *San Joaquin Basin Steelhead Telemetry Study*: Continuation of the 6-Year Steelhead telemetry study for the migration and survival of San Joaquin Origin Central Valley Steelhead.
- *Sacramento Deepwater Ship Channel*: Reclamation proposes to partner with the City of West Sacramento and West Sacramento Area Flood Control Agency to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. When combined with an ongoing foodweb study, the reconnected ship channel has the potential to flush food production into the north Delta. An increase in food supply is likely to benefit Delta Smelt and their habitat.
- *North Delta Food Subsidies / Colusa Basin Drain*: DWR, Reclamation, and water users propose 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 (i.e., nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Tule Canal to Cache Slough, improving the aquatic foodweb in the north Delta for fish species. 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 fish food production.
- *Suisun Marsh Food Subsidies*: Water users propose to add fish food to Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, Roaring River Distribution System food production, and reoperation of the Suisun Marsh Salinity Control Gates. As noted in the Delta Smelt Resiliency Strategy, this management action may attract Delta Smelt into the high-quality Suisun Marsh habitat in greater numbers, reducing use of the less food-rich Suisun Bay habitat (California Natural Resources Agency 2016). Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area. In addition, managed wetland flood and drain operations can promote food export from the managed wetlands to adjacent tidal sloughs and bays.

- Habitat Restoration: DWR and Reclamation propose to continue to implement existing restoration efforts that are part of the environmental baseline but are not yet complete, including:
 - Completing the remaining approximately 6,000 acres of tidal habitat restoration in the Delta of the 8,000 acres DWR has begun.
 - *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project*: Reclamation and DWR will provide increased acreage of seasonal floodplain rearing habitat available in the lower Sacramento River basin.
 - Reclamation would coordinate with water users to remove predator hot spots in the Bay-Delta. This includes minimizing lighting at fish screens and bridges, and possibly removing abandoned structures.
- Facility Improvements: Reclamation and DWR would continue implementation of projects to reduce mortality of ESA-listed fish species:
 - *Delta Cross-Channel Gate Improvements*: The DCC is more than 65 years old and its gates rely on remote operators to travel to the facility to change their position. When the gates are open, they provide a critical diversion structure for freshwater reaching the CVP south Delta pumping station. The gates are closed to prevent scouring (during high flows), reduce salinity intrusion in the western Delta, and protect Sacramento River ESA-listed and non-listed salmonids. Additional DCC operation would allow for improved exports and water quality without additional adverse effects on salmonids. Reclamation proposes to evaluate improvements to automate and streamline operation of the Delta Cross-Channel gates. Reclamation would modernize DCC's gate materials and mechanics to include adding industrial control systems, increasing additional staff time, and improve physical and biological monitoring associated with the DCC daily and/or tidal operations as necessary to maximize water supply deliveries.
 - *Tracy Fish Facility Improvements*: Reclamation would improve the TFCF to reduce loss 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. Facility improvements will improve survival of fish salvaged and potentially reduce the loss factors to allow for additional certainty on OMR management with low impacts from salvaging salmonids.
 - *Skinner Fish 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. Please see Appendix G, *Clifton Court Forebay Predation Studies* for study results from the last decade.
 - *Release Sites*: Reclamation proposes to continue work with DWR to incorporate flexibility in salvage release sites, using DWR's sites, or sites on a barge.
 - *Small Screen Program*: Reclamation and DWR propose to continue to work with existing authorities (Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.

- Intervention
 - *Delta Fish Species Conservation Hatchery*: Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta Smelt. The conservation hatchery would breed and propagate a stock of fish with equivalent genetic resources of the native stock and at sufficient quantities to effectively augment the existing wild population, so that they can be returned to the wild to reproduce naturally in their native habitat.
 - The existing Fish Conservation and Culture Laboratory (FCCL) will be used in the interim to begin supplementation prior to construction of the new conservation hatchery. Reclamation will support development of a supplementation strategy in coordination with and subject to approval by USFWS. This strategy will include studies to develop necessary information to begin a supplementation program, a focus on capturing existing genetic diversity and expansion of FCCL to produce maximum numbers of Delta Smelt. Current production is approximately 50,000 adult Delta Smelt; the strategy will have a goal of increasing production by 2025 to a number and the life stages necessary to effectively augment the population as determined by USFWS. The strategy will be in place 1 year from issuance of the biological opinion. Work done at the FCCL will guide construction and operation of the Conservation Hatchery described above.

4.9.6 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. In the Stanislaus River watershed, Reclamation owns and operates New Melones Dam and Reservoir (2.4 MAF capacity). The Tri-Dam Project, a partnership between the Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID), consists of Donnell and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River. Releases from Donnell and Beardsley Dams affect inflows to New Melones Reservoir. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 2 miles downstream of Tulloch Dam. OID and SSJID manage the Tulloch and Goodwin Dam infrastructure through separate agreements with both Reclamation and Reclamation's CVP water service contractors (Stockton East Water District and the Central San Joaquin Water Conservation District) to meet Reclamation's Stanislaus River objectives, CVP contractor deliveries, and deliveries to the OID and SSJID service areas.

The Stanislaus River watershed has annual obligations that exceed the average annual runoff in a given year due to a number of factors, including SWRCB water rights decisions D-1641, D-1422 and D-1616, the 1987 CDFG agreement, CVPIA objectives, the 2009 biological opinion, the 1988 Agreement and Stipulation with OID and SSJID, riparian water right diverters, and CVP water delivery contracts.

Over the past decade, Reclamation has worked with Stanislaus River water users and related agencies in developing a revised operating plan for New Melones Reservoir that addresses multiple objectives, including a more predictable and sustainable operation, minimizing low storage conditions in successive drought years, and providing flows to support listed species and critical habitat. These efforts have allowed multiple agencies and stakeholders to provide input on potential solutions; however, a final plan has not been completed.

The operating plan described below is intended to replace often overlapping and conflicting operational components of previous federal and state flow requirements, and is representative of Reclamation's contribution to any current or future flow objectives on the Lower San Joaquin River at Vernalis.

4.9.6.1 **Seasonal Operations**

Reclamation proposes to meet water rights, contracts, and agreements that are specific to the East Side Division and Stanislaus River. Senior water right holders (OID and SSJID) will receive annual water deliveries consistent with the 1988 Agreement and Stipulation, and water will be made available to CVP contractors in accordance with their contracts and applicable shortage provisions.

In high storage, high inflow conditions, Reclamation will operate for flood control in accordance with the USACE flood control manual. Because New Melones is a large reservoir relative to its annual inflow, flood control is relatively infrequent; however, Tulloch Lake, located downstream of New Melones Reservoir, is subject to high local inflows, and may be in flood control operations for brief periods when New Melones Reservoir is not. During these periods, releases from Tulloch may be used to meet flow objectives, schedules, or requirements on the lower Stanislaus River below Goodwin Dam.

Reclamation proposes to operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a Stepped Release Plan (SRP) that varies by hydrologic condition/water year type as shown in Table 4-14.

Table 4-14. New Melones SRP Annual Releases by Water Year Type

| Water Year Type | Annual Release (TAF) |
|------------------------|-----------------------------|
| Critical | 184.3 |
| Dry | 233.3 |
| Below normal | 344.6 |
| Above normal | 344.6 |
| Wet | 476.3 |

The New Melones SRP will be implemented similarly to current operations under the 2009 biological opinion with a default daily hydrograph, and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under current operations for critical, dry, and below normal water year types. The difference occurs in above normal and wet years, where the minimum requirement for larger releases is reduced from current operations to promote storage for potential future droughts and preserve cold water pool. When compared to minimum daily flows from Appendix 2-E of the 2009 biological opinion (2-E), the daily hydrograph for the New Melones SRP is identical for critical, dry, and below normal year types; above normal and wet year types follow daily hydrographs for below normal and above normal year types from 2-E, respectively. The complete daily hydrograph for the New Melones SRP is available in Appendix B, *New Melones Stepped Release Plan Daily Hydrographs for Critical, Dry, Below Normal, Above Normal, and Wet Year Types*.

For the New Melones SRP, Reclamation proposes to classify water year types using the San Joaquin Valley “60-20-20” Water Year Hydrologic Classification (60-20-20) developed for D-1641 implementation. Previous operating plans for New Melones Reservoir relied on the New Melones Index (NMI) to determine water year type, calculated by summing end-of-February storage and forecasted inflow through September. Because the reservoir can store more than twice its average inflow, the NMI resulted in a water year type determination that was more closely tied to storage rather than hydrology. Changing from the NMI to 60-20-20 is expected to provide operations that better represent current hydrology and correlate more closely to water year types for other nearby tributaries.

Reclamation proposes to convene the Stanislaus Watershed Team (successor to the Stanislaus Operating Group), consisting of agency representatives and local stakeholders having direct interest on the Stanislaus River, at least monthly to share operational information and improve technical dialogue on the implementation of the New Melones SRP. The Stanislaus Watershed Team will also provide input on the shaping and timing of monthly or seasonal flow volumes to optimize biological benefits.

During the summer, Reclamation is required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

4.9.6.2 Conservation Measures

Conservation measures are included to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses.

- 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.
- Temperature Management: Reclamation 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.

4.9.7 San Joaquin River (Friant Division)

Reclamation operates the Friant Division for flood control, irrigation, M&I, and fish and wildlife purposes. Facilities include Friant Dam, Millerton Reservoir, and the Friant-Kern and Madera Canals. Friant Dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Gravelly Ford, provides Restoration Flow releases under Title X of Public Law 111-11, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals for water supply. Water is delivered to about a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla Irrigation Districts. A minimum of 5 cfs is required to pass the last holding contract diversion located about 40 miles downstream of Friant Dam near Gravelly Ford.

The SJRRP implements the San Joaquin River Restoration Settlement Act in Title X of Public Law 111-11. USFWS 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.

The Stipulation of Settlement of NRDC vs. Rogers, is based on two goals—the Restoration Goal and the Water Management Goal. To achieve the Restoration Goal, the Settlement calls for, among other things, releases of water from Friant Dam to the confluence of the Merced River (referred to as Restoration Flows) according to the hydrographs in Settlement Exhibit B. To achieve the Water Management Goal, the Settlement calls for the development and implementation of a plan for recirculation, recapture, reuse, exchange or transfer of Restoration Flows for the purpose of reducing or avoiding impacts on water deliveries to all of the Friant Contractors caused by Restoration Flows. Recapture of Restoration Flows may occur upstream of a capacity restricted reach, or downstream of the Merced River confluence. Recapture can occur at Banta-Carbona, Patterson, or West Stanislaus Irrigation District facilities, or at Jones or Banks Pumping Plants. Recapture of Restoration Flows in the Sacramento San Joaquin Delta under this proposed action would average 65 TAF, ranging from approximately 25 TAF to 78 TAF depending on the yeartype.

4.9.7.1 Conservation Measures

Lower SJR Rearing Habitat: 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. This stretch of the San Joaquin River is cut-off from its floodplain due to an extensive levee system, with two notable exceptions at Dos Rios Ranch (1,600 acres) and the San Joaquin River National Wildlife Refuge (2,200 acres). In recent years, there has been growing interest in multi-benefit floodplain habitat restoration projects in the Central Valley that can provide increased flood protection for urban and agricultural lands, improved riparian corridors for terrestrial plants and wildlife, and enhanced floodplain habitat for fish. The resulting restoration could include thousands of acres of interconnected (or closely spaced) floodplain areas with coordinated and/or collaborative funding and management. 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.

4.9.8 South of Delta

San Luis Reservoir is an offstream storage facility located along the California Aqueduct downstream of Jones and Banks Pumping Plants. The CVP and SWP share San Luis Reservoir storage roughly 50/50 (CVP has 966 TAF of storage, SWP has 1062 TAF of storage). San Luis Reservoir is used by both Projects to meet deliveries to their contractors during periods when Delta pumping is insufficient to meet demands. San Luis Reservoir is also operated as a conveyance facility to supply water to the CVP San Felipe Division in San Benito and Santa Clara Counties.

San Luis Reservoir operates as a regulator on the CVP/SWP system, accepting any water pumped from Banks and Jones that exceeds contractor demands, then releasing that water back to the aqueduct system when the pumping at Jones and Banks is insufficient to meet demands. The reservoir allows the CVP/SWP to meet peak-season demands that are seldom balanced by Jones and Banks pumping.

As San Luis Reservoir is drawn down to meet contractor demands, it usually reaches its low point in late August or early September. From September through early October, demand for deliveries usually drops

to be less than the Jones and Banks diversions from the Delta, and the difference in Jones and Banks pumping is then added to San Luis Reservoir, reversing its spring and summer decline and eventually filling the San Luis Reservoir - typically before April of the following year.

4.10 Items Not Included in This Consultation

This document includes context on the entirety of operations of the CVP and SWP. However, not all of these actions are being consulted on, either because they were the subject of prior consultations or due to other legal authority. Reclamation and DWR are consulting on the exercise of discretion in operational decision making, including how to comply with the terms of their respective existing water supply and settlement contracts (which includes the impacts of maximum water diversions under the terms of these contracts), and other legal obligations. Reclamation and DWR are not consulting on:

- Flood control
- Folsom Water Control Manual
- Oroville Dam and Feather River operations
- Execution of new CVP water service or repayment contracts, or the prior execution of existing contracts that were the subject of separate but parallel prior consultations
- Execution of new settlement contracts and agreements, or the prior execution of existing contracts that were the subject of separate but parallel prior consultations
- Contract conversion
- Operations and maintenance activities of CVP minor facilities
- Exchange Contractor deliveries from Friant Dam
- SJRRP flows and lower SJR recapture
- TRRP flows
- Coordinated Operation Agreement
- D-1641
- Contra Costa Water District Operations
- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
- Suisun Marsh Preservation Agreement
- California WaterFix
- Battle Creek Restoration Program

4.11 Governance

The Core Water Operation serves as the foundation for meeting the requirements of D-1641 and providing for Reclamation and DWR to operate the CVP and SWP, while reducing the stressors on listed species influenced by those ongoing operations. The Core Water Operation consists of operational actions that do not require subsequent concurrence or extensive coordination to define annual operation. For the Core Water Operation, Reclamation would implement activities, monitor performance, and report on

compliance with the commitments in the proposed action. The CVP and SWP Water Operations Charter, Appendix C, *ROC Real Time Water Operations Charter*, describes how Reclamation and DWR will monitor and report on ESA Section 7 commitments under the proposed action and how the five agencies, public water agencies, and other participants will plan, communicate, and coordinate real-time water operations decisions on the Core Water Operation. The Charter describes the deliverables, schedule, and processes.

Portions of the Core Water Operation rely upon real-time monitoring to inform Reclamation and DWR on how to minimize and/or avoid stressors on listed species. Some elements of the Core Water Operation provide for seasonal input by the federal and state fish agencies on the scheduling and routing of certain flow volumes to benefit fisheries. The Core Water Operation also provides for regulatory coordination in the event conditions exceed the ability to anticipate how Reclamation and DWR would operate (i.e., “outliers”). Reclamation and DWR must demonstrate compliance with the commitments in the proposed action and provide sufficient information for an evaluation of reinitiation triggers through regular monitoring and reporting.

Aspects of the proposed action that are adaptively managed will require additional coordination that occurs more than once, for example, implementing spawning and rearing projects annually. Reclamation and DWR will form program teams with fish agency and stakeholder representatives on adaptively managed commitments. The governance of project teams will remain consistent with requirements under the ESA and CESA; however, within the program teams, fish agencies may also participate in a capacity as action agencies for specific projects under their authorities and resources, where appropriate.

Within the Core Water Operation, several different types of coordination occur on different time scales:

- **Real-Time Species Distribution and Life Stage Monitoring:** Fish agencies provide information to Reclamation and DWR on the real-time disposition of species through specific monitoring workgroups. This information informs the risk analysis performed by Reclamation and DWR. This coordination occurs seasonally. Examples: OMR Management, Shasta cold water pool management.
- **Flow Scheduling:** Fish agencies and other stakeholders in watershed-based groups provide scheduling recommendations to Reclamation and DWR on specific blocks of water. Reclamation and DWR will evaluate and consider the recommendations and operate the CVP and SWP to these schedules as feasible. Examples: Clear Creek, Stanislaus River, Suisun Marsh Salinity Control Gates.
- **Outlier Years:** In outlier years, fish agencies would work with Reclamation and DWR to identify options and intervention measures. Examples: Tier 4 of Shasta cold water pool management, extreme drought, emergency conditions.
- **Seasonal and Annual Reviews:** Reclamation and DWR will report on activities to fish agencies and determine whether to reinitiate on one or more components (although either party may also trigger reinitiation in real-time).
- **Project Teams:** Programmatic activities will have program teams that develop the specific project descriptions and obtain the appropriate permits. Examples: Spawning and rearing habitat, Delta Fish Conservation Hatchery.

Under the CVP and SWP Water Operation Charter, decisions shall be made consistent with authorizing legislation and the regulations and policies under the ESA and CESA, as appropriate.

Reclamation and DWR shall retain sole discretion for:

- Water operations of the CVP and SWP, including allocations, under Reclamation Law and the SWP authorization.
- Agency appropriations (budget requests, fund alignment, contracting, etc.).
- Section 7 action agency and applicant (consultation).
- Coordination and cooperation with PWAs as required by contracts and agreements.

CDFW, USFWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate, Incidental Take Statements/Permits, and enforcement.
- Agency appropriations.

SWRCB

- Enforcement as allowable under federal and state law.

Operating Entities other than CVP and SWP shall retain sole discretion for:

- Operation of non-CVP and non-SWP diversion facilities.
- Meeting the the terms of contracts and/or agreements.
- Participating in the cooperation and coordination provisions under the WIIN Act.

Reclamation and DWR will annually report on water operations and fish performance seasonally and in an annual summary. The monitoring programs and schedule for reporting are described in the Charter. Changes to the proposed action would occur based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

- (a) If the amount or extent of taking specified in the incidental take statement is exceeded;
- (b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
- (c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or
- (d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Reclamation will monitor take for the purpose of evaluating trigger (a) above; Reclamation will monitor the effects of the proposed action for the purpose of evaluating trigger (b) above. If, through adaptive management, Reclamation decides to modify the proposed action, Reclamation will evaluate the changes to the proposed action based on trigger (c) above. Consistent with 50 CFR 402.16, the USFWS and/or NMFS may also reinitiate formal consultation as appropriate. Reclamation will coordinate with DWR as an “applicant” and support DWR’s coordination with CDFW.

Chapter 5 Effects

The potential effects of the proposed action on listed species are evaluated in this section. Under Section 7 of the ESA, Reclamation must ensure that the proposed action will not “jeopardize the continued existence of any endangered or threatened species, by reducing appreciably the likelihood of survival or recovery of a listed species in the wild or adversely modifying listed habitat appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species.” The analyses in this section thus consider the potential effects the proposed action is likely to cause to listed species, including effects at all life stages, anticipated response, and cumulative effects.

Reclamation established a without action scenario as part of the environmental baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action causes. The model run representing this scenario does not include CVP and SWP operations, but does include the operations of non-CVP and non-SWP facilities, such as operation of public and private reservoirs on the Yuba, Tuolumne, and Merced rivers. The without action scenario plays the crucial role in the effects analysis of establishing the likelihood of species survival and recovery under the environmental baseline (i.e., the effects on survival and recovery from all non-proposed action causes).

The additional metrics of habitat restoration, predation from invasives, water quality, and other effects on species from federal, state, and private actions are also analyzed. These effects are part of the baseline. However, 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 in order to isolate 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.

Included for context in the effects analysis is a current operations scenario that represents current operations of the CVP and SWP (including the 2008 and 2009 biological opinion requirements), along with federal, state, and private operations on other rivers (e.g., Yuba, Tuolumne, and Merced Rivers). The current operations scenario is included for context in the effects analysis. When appropriate, the analysis considers differences between the effects of current operations and the proposed action, because the effects of current operations provide a reasonable measure of likely future effects of similar measures in the proposed action.

The Secretary has a wide degree of discretion in determining the analytic framework and tools used to develop the biological assessment. The ESA does not impose a mandatory duty to use any specific model or scientific methodology, but merely requires that Reclamation provide to the Services “the best scientific and commercial data available or which can be obtained during the consultation for an adequate review of the effects that an action may have upon listed species or critical habitat.” 50 C.F.R. § 402.14(d). In previous analyses, Reclamation has utilized a variety of technical models and other tools in preparing its biological assessment. Those efforts were not required by the ESA, which does not set a standard of absolute scientific certainty, and nor does it demand that an agency obtain new information to make its determination. Rather, the “best available data” standard only requires the agency to consider scientific information presently available. Reclamation determined that the modeling and other analytical efforts used in this biological assessment provide ample basis for the Services to conduct an adequate review of the effects of the action on the species.

5.1 Analytical Approach – Aquatic Species

The effects analysis herein is organized into potential effects from the proposed action on listed species, listed species' designated critical habitat, and Essential Fish Habitat (EFH). For the purposes of analysis of Pacific Coast Salmon EFH and effects to Southern Resident Killer Whale, also included are analyses of potential effects of the proposed action on unlisted Central Valley Fall-run/Late Fall-run Chinook Salmon ESU, Upper Klamath-Trinity Rivers Fall-run Chinook Salmon ESU, and Upper Klamath-Trinity Rivers Spring-run Chinook Salmon ESU.

For each species, the effects analysis is broken into three sections: 1) operations and maintenance, 2) conservation measures, and 3) critical habitat. In the proposed action, operations and maintenance is the Core Water Operation and includes all aspects of operating and maintaining the CVP and SWP, as described in seasonal operation to meet flood control, navigation, water supply (water right obligations, contracts, and agreements), fish and wildlife, power generation, and recreational purposes. Operation and maintenance includes the Shasta Temperature Control Device, spring pulse flows, fall and winter refill, Delta Cross Channel operations, the Tracy Fish Collection Facility and Skinner Fish Facility, and OMR management. Components of operations and maintenance also include, for example, agricultural barriers, Rock Slough intake, water transfers, and aquatic weed removal. Enhanced real-time monitoring and predictive tools also are part of operation and maintenance of the proposed action. Operations and maintenance also includes operation of a raised Shasta Dam in accordance with the criteria in the proposed action.

Conservation measures are additional actions included to address the effects of the operations and maintenance on listed species. Conservation measures include spawning and rearing habitat, cold water pool management tools, Fall Delta Smelt Habitat, Suisun Marsh Salinity Control Gate operations, Yolo Bypass, Small Screen Program, predator hot spot removal, Delta Fish Species Conservation Hatchery, Delta Cross Channel, Tracy Fish Facility, Skinner Fish Facility, and Shasta TCD improvements.

In the figures, WOA is the without action scenario, PA is the proposed action scenario, and COS is the current operations scenario, as modeled in CalSim. The buffers around WOA and the PA represent uncertainty.

5.2 Analytical Approach – Species Analyses

The effects analyses evaluate potential effects to life stages (for example, egg, alevin, fry, juvenile, adult) of each species based on species-specific conceptual models. The effects section is arranged by species beginning with a brief summary of the relevant conceptual model, followed by consideration of the potential effects of the proposed action.

The sub-section for each proposed action component considers the exposure of each life stage to the component, largely based on species timing summaries included in the introduction to each species section and other sources cited in the text. Consideration of exposure focuses on the extent to which a component overlaps in time and location with the life stage. Potential effects of exposure to the proposed action component on individuals of the species are then analyzed. This analysis is generally qualitative, although the potential effects of flow-dependent actions are informed to the extent possible by modeling of the various operational scenarios, and is related to the conceptual model for the life stage transition being analyzed.

5.3 Analytical Approach – Critical Habitat Analyses

The analyses of potential effects on species' designated critical habitat follow the species analyses. Potential positive and negative effects to primary constituent elements (PCEs)/physical and biological features (PBFs) of critical habitat are analyzed for the relevant components of the proposed action. These analyses often draw on the foundation provided in the species analyses. Analysis of effects to critical habitat is guided by consideration of recent analyses by USFWS (2017a) and NMFS (2017), which included refined interpretation of critical habitat PCEs/PBFs relative to the original descriptions at the time critical habitat was designated.

5.4 Analytical Approach – Essential Fish Habitat Analyses

The analysis of EFH focuses on three species groups represented by fishery management plans (NMFS 2017): Pacific Coast Salmon, Coastal Pelagic Species, and Pacific Coast Groundfish. For Pacific Coast Salmon, the analysis is informed by the species and critical habitat analyses for listed salmon, and is augmented by analysis of potential effects to unlisted Central Valley Fall-run/Late Fall-run Chinook Salmon ESU, Upper Klamath-Trinity Rivers Fall-run Chinook Salmon ESU, and Upper Klamath-Trinity Rivers Spring-run Chinook Salmon ESU. The analysis of potential effects to Coastal Pelagic Species focuses on Northern Anchovy as it is the main representative of that group that could be affected by the proposed action. Similarly, the analysis of potential effects to Pacific Coast Groundfish focuses on Starry Flounder. Potential effects of the proposed action to designated Habitat Areas of Particular Concern (HAPC) are also considered, namely complex channels and floodplain habitats, thermal refugia, spawning habitat, estuaries, and marine and estuarine submerged aquatic vegetation (NMFS 2017, p.1210).

5.5 Without Action Scenario

Under WOA conditions Sacramento River water would flow through Shasta and Keswick reservoirs with gates and river valves open, resulting in minimal storage and no control of flow release volumes or water temperatures. Water would not be transferred from the Trinity River. Sacramento River flows under the WOA scenario would generally be lower in summer and fall and higher in the winter and spring than current conditions. Similar conditions would occur on the Feather, American, Stanislaus, and San Joaquin Rivers. Higher, flashier, Delta outflows would occur in the winter and spring with lower Delta outflows in the summer and fall than current conditions. Jones and Banks Pumping Plants in the Delta would not operate. Flows would rapidly pass through channelized pathways.

Higher WOA 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 (DO), 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. Impacts from higher flows including higher stranding risk because of greater flow fluctuations, and higher contaminants loading from stormwater runoff.

Reduced flows under WOA conditions during dry fall months would have impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juveniles growth rate and higher mortality of the juveniles, and a reduced population abundance. Impacts of low flows include (Windell et al. 2017):

- Higher water temperatures and lower DO

- Reduced habitat complexity
- Less side-channel rearing habitat
- Less floodplain habitat and less connectivity of floodplains with the river mainstem
- Less refuge habitat
- Reduced availability and quality of prey organisms
- Greater crowding and competition
- Greater predation risk
- Greater entrainment risk
- Greater potential for pathogens and diseases
- Higher concentrations of toxic contaminants
- Reduced emigration cues

Under the WOA conditions, storage levels would be low and, assuming stratification developed, cold water pools would be small and unmanaged. However, unlike flows, which as noted above are expected to be similar under WOA conditions to those of an uncontrolled hydrology, water temperatures may differ from those of an uncontrolled hydrology because the shallow reservoir that would remain behind dams would absorb significant heat during warm, sunny days.

5.6 Chinook Salmon, Sacramento River Winter-run ESU

In the proposed action, the effects of the seasonal operation, as compared to WOA, include lower, more stable, flows in the fall and winter for emergence, rearing, and migration; lower flows in the spring; and higher flows in the summer. Higher flows in the summer lead to improved temperatures for Winter-run spawning, egg incubation, and emergence. Operation of the Shasta Temperature Control Device (TCD) provides for Winter-run Chinook Salmon egg incubation water temperature needs. The restoration of spawning and rearing habitat in the Upper Sacramento River, operation of weirs to inundate floodplain rearing habitat in the Yolo Bypass, tidal habitat restoration, and predator hot spot removal further increases growth and survival of Winter-run Chinook Salmon. Delta Cross Channel operations and OMR management, as part of the Core Water Operation under the proposed action, seeks to minimize and/or avoid entrainment risk. Improvements at the Tracy Fish Collection Facility and Skinner Fish Facility as part of the conservation measures associated with the proposed action reduce facility loss, a direct adverse effect of facility entrainment.

Construction of Shasta and Keswick Dams blocked access to areas of suitable temperatures for egg incubation. Temperature dependent mortality plays an important role in egg incubation and emergence. Operation of Shasta Dam for cold water pool management is required to avoid the 100 percent temperature dependent egg mortality that would occur under the WOA scenario; however, Reclamation's ability to meet temperature needs is limited to the available cold water in any given year. In addition, reservoir releases can affect temperature only so far downstream in the Sacramento River before ambient air temperature controls. The proposed action provides for considering the primary location of Winter-run Chinook Salmon redds in most years (above the Clear Creek confluence), the critical stages within egg incubation for cold water, building cold water for the water temperature management season, and avoiding exhausting the supply of cold water before the end of the water temperature management season. The approach provides for operable parameters that incorporate the limitations on managing cold water in

light of hydrologic uncertainty, balancing risks, and management experience during the most recent drought. The proposed action increases Winter-run Chinook Salmon egg to fry survival more reliably compared to the COS while minimizing restrictions on meeting project obligations to water supply, water quality, and other species.

Bank protection, dams, and lower peak flows prevents the natural replenishment and maintenance of suitable spawning habitat. Gravel augmentation and the restoration of spawning habitat under the proposed action addresses the lack of sediment continuity with dams in the degraded baseline. Flood protection reduced the historical off-channel rearing habitat of Winter-run Chinook Salmon to the limited channel areas between levees. Lower fall and winter flow reduces the inundation of potential rearing habitat for Winter-run Chinook Salmon; therefore, the proposed action restores rearing habitat in areas inundated by proposed action flows to reduce the effects from the Core Water Operation.

Real-time monitoring informs when Winter-run Chinook Salmon are likely to pass the Delta Cross Channel and provides for closures to prevent entrainment into the central and south Delta. OMR management for Winter-run Chinook Salmon establishes generally protective criteria to avoid entrainment.. Additional protective measures occur based on salvage. Enhanced monitoring in real-time and predictive tools provide additional information that allows for a more flexible water operation under the proposed action when environmental criteria indicate that entrainment is less likely based on fish behavior and the effects of behavioral cues. Operation of the salvage facilities reduces the effects of entrainment due to export operations. Improvements at fish collection facilities will further reduce impacts of the proposed action as compared to WOA

Other stressors continue to impact Winter-run Chinook Salmon including harvest, contaminants, invasive species, disease, climate change. These factors will continue to reduce the ability of Winter-run Chinook Salmon to reproduce and rebuild populations in the river. Continued operation of the Livingston-Stone National Fish Hatchery provides a buffer against external risks and protects against extinction.

5.6.1 Life Stage Timing

General life stage timing and location information for Winter-run Chinook Salmon is provided in Table 5.6-1 to identify where the proposed action overlaps with the species. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*.

Table 5.6-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Winter-run Chinook Salmon in the Sacramento River and Delta (NMFS 2017, p.67).

| Relative Abundance | High | | | Medium | | | | Low | | | | |
|--------------------------------------------------|------|-----|-----|--------|-----|-----|-----|-----|-----|-----|-----|-----|
| a) Adults freshwater | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sacramento River basin ^{a,b} | | | | | | | | | | | | |
| Upper Sacramento River spawning ^c | | | | | | | | | | | | |
| Delta | | | | | | | | | | | | |
| b) Juvenile emigration | | | | | | | | | | | | |
| 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 ^g | | | | | | | | | | | | |

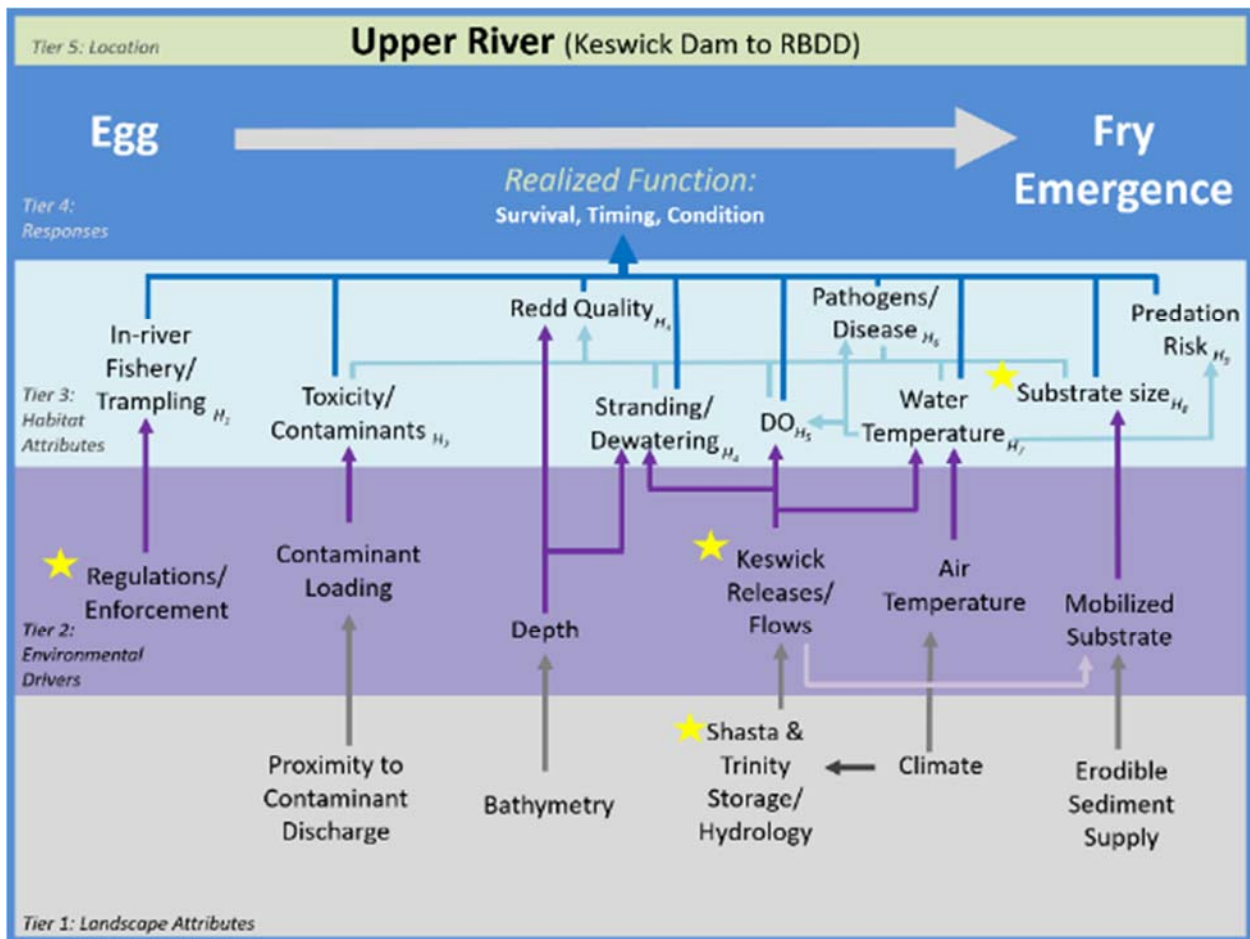
Sources: ^a(Yoshiyama et al. 1998); (Moyle 2002); ^b(Myers et al. 1998) ; ^c(Williams 2006) ; ^d(Martin et al. 2001); ^eKnights Landing Rotary Screw Trap Data, CDFW (1999-2011); ^{f,g}Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

Note, it is likely that juvenile emigration in the Sacramento trawl at Sherwood Harbor is also high in January, as it is in December and February.

5.6.2 Conceptual Model Linkages

The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Winter-run Chinook Salmon. SAIL life stage transitions include egg and alevin mortality, egg to fry emergence, juvenile rearing to outmigrating, adult migration, and adult holding.

In the upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the SAIL conceptual model 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 transition are illustrated in Figure 5.6-1.

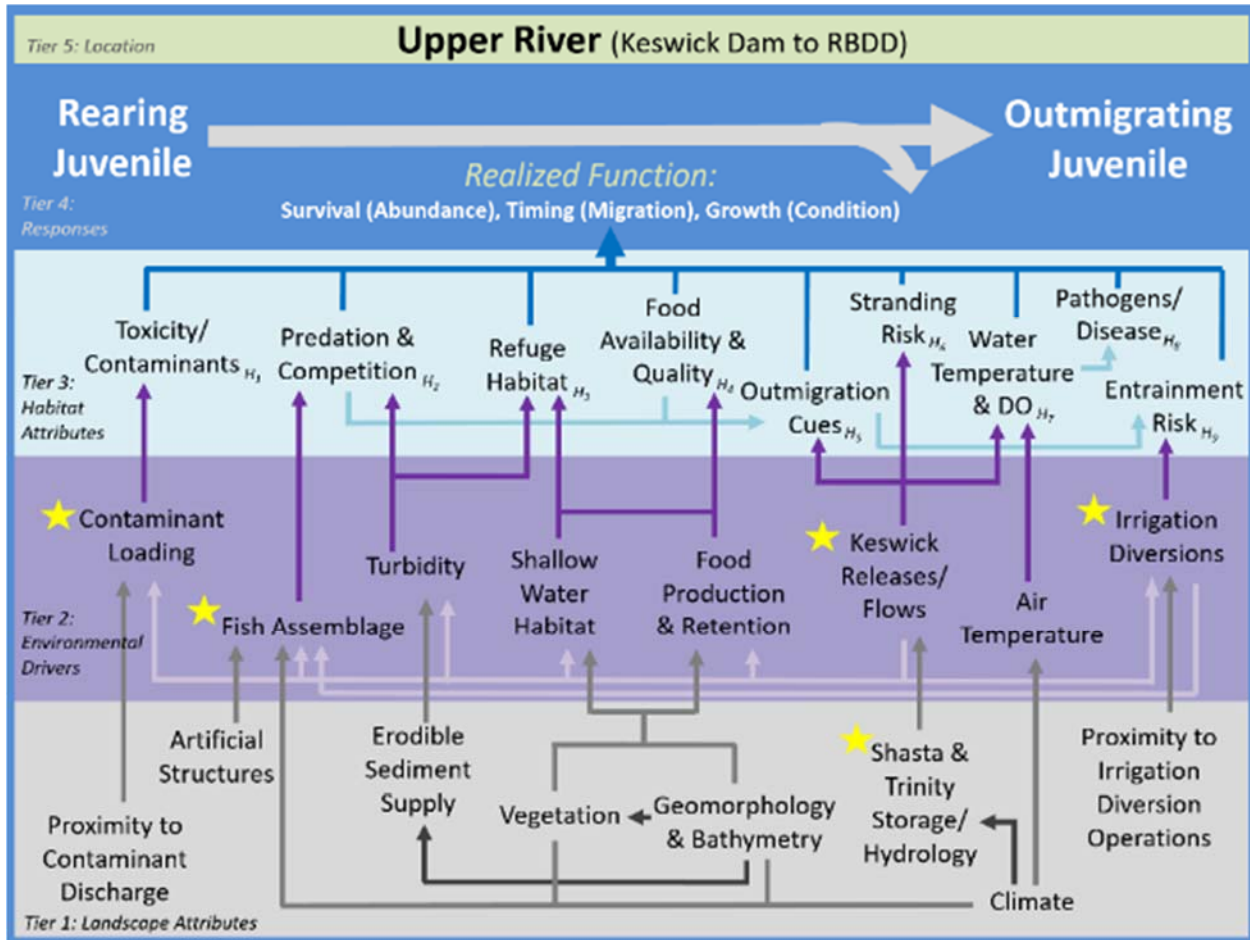


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-1. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Egg to Emerging Fry in the Upper Sacramento River.

As compared to WOA, egg to fry attributes relevant to the proposed action include bathymetry and redd quality (modified by habitat restoration), and the effects of Keswick releases on redd dewatering, temperature and DO (cold water pool management). Effects in the baseline include trampling, contaminants, habitat degradation, disease, air temperatures, water temperatures, and predation.

In the upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam), the SAIL conceptual model defines juvenile rearing and out migration as the duration from emergence as fry to down river migration (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-2.

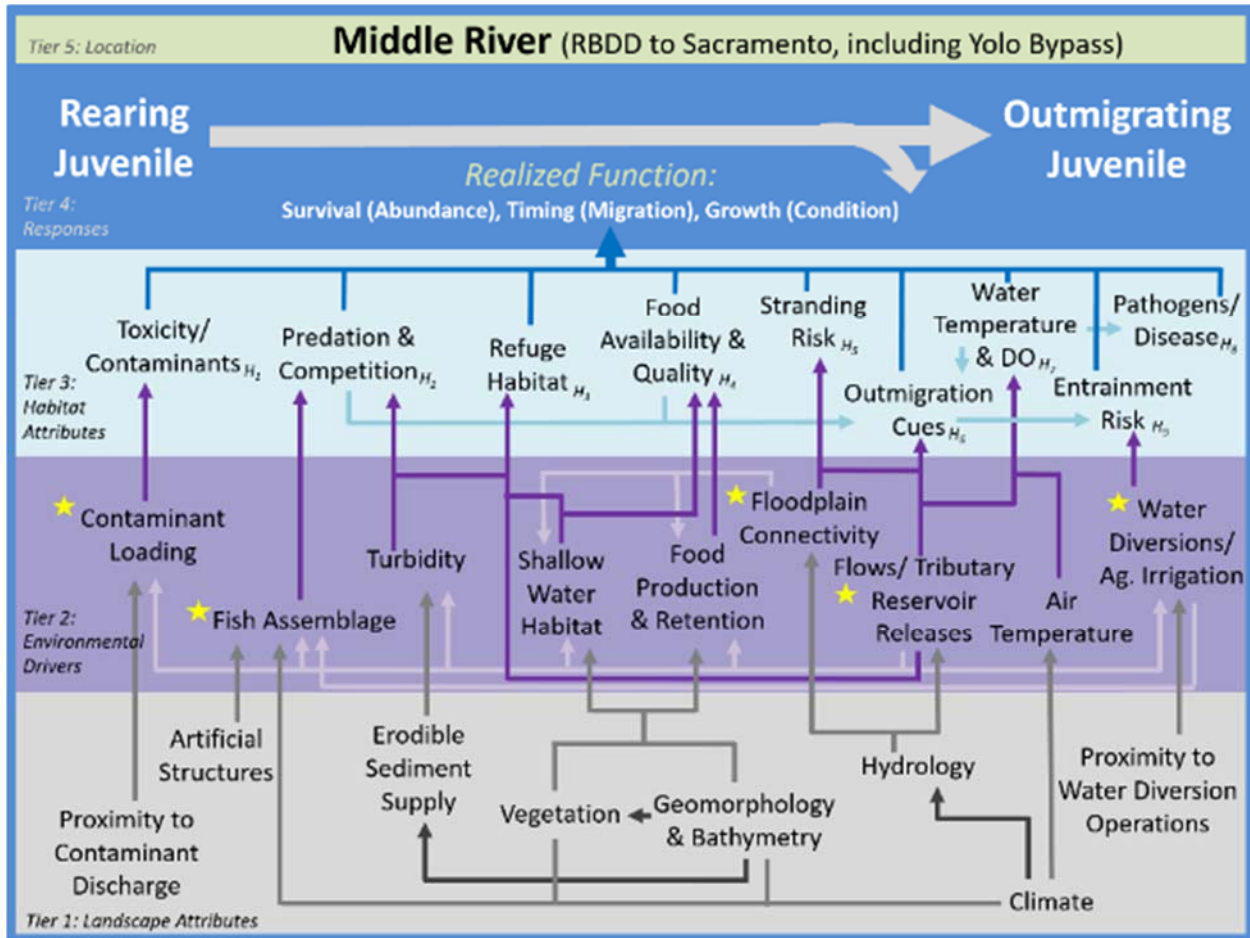


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-2. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Upper Sacramento River.

Upper Sacramento River rearing to outmigrating juvenile attributes relevant to the proposed action include dilution (e.g., toxicity and contaminants), water temperatures (which also affect DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Juvenile rearing and migration in the middle Sacramento River from Red Bluff Diversion Dam to the I Street Bridge and the hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-3.

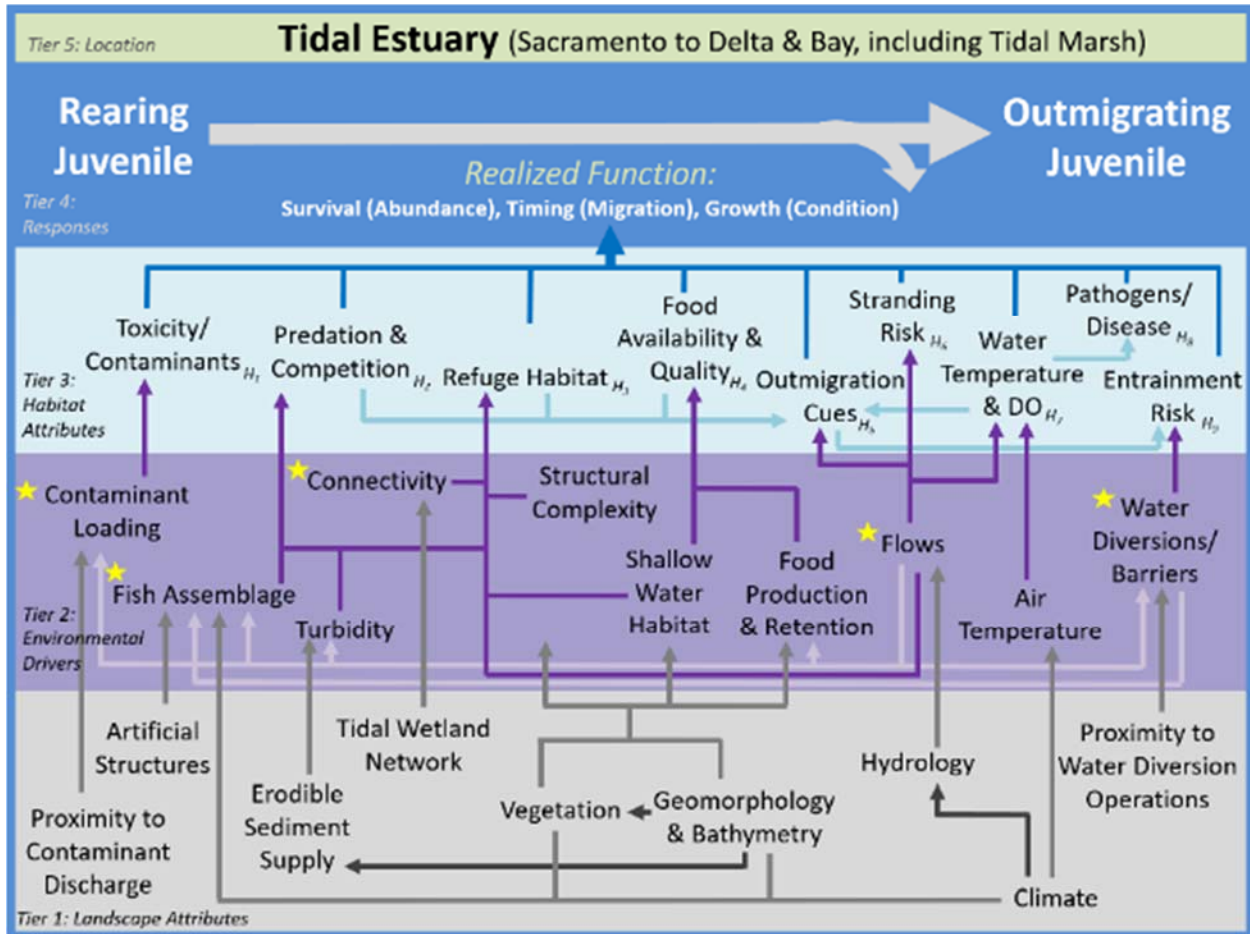


Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 5.6-3. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Middle Sacramento River.

Middle Sacramento River rearing to outmigrating juvenile attributes relevant to the proposed action include: dilution (e.g., toxicity and contaminants), water temperatures (which also affect DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Juvenile rearing and migration in the tidal estuary and bays life stage transition includes tidal Sacramento River downstream of the I Street Bridge in Sacramento City, the Sacramento-San Joaquin Delta, and the Suisun, San Pablo and San Francisco Bays. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-4.



Source: Windell et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes and potential management actions discussed by Windell et al. (2017) are denoted by stars

Figure 5.6-4. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Bay-Delta.

Tidal estuary and bay juvenile rearing and migration attributes relevant the proposed action include outmigration cues and entrainment risk.

The adult migration from the ocean to the upper Sacramento River life stage includes the entire Bay-Delta and Sacramento River system. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-5.

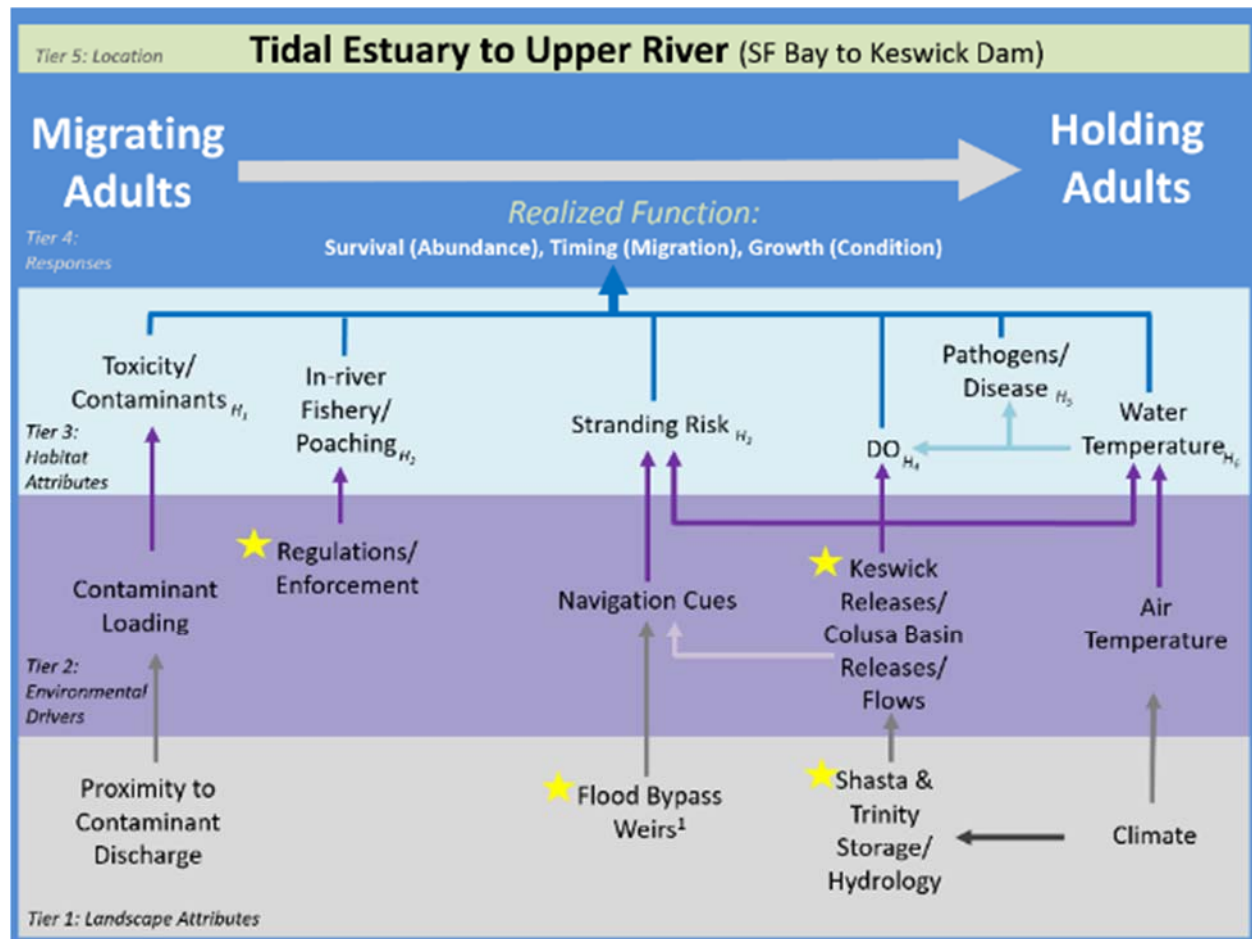


Figure 5.6-5. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Migrating Adults in the Bay-Delta to Holding Adults in the Upper Sacramento River.

Continuing their upstream migration from the Delta, Winter-run Chinook Salmon adults enter the middle Sacramento River and ultimately make their way to the upper River, beginning as early as December, where they hold within 10 to 15 miles of Keswick Dam until they are ready to spawn (Windell et al. 2017). Adult migration attributes relevant to the proposed action include, as indicated by the SAIL conceptual model (Figure 5.6-5), water temperature, DO, and other habitat attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration and holding in the middle and upper Sacramento River. Instream flow from Keswick Dam releases relative to flow from the lower Yolo and Sutter bypasses and agricultural drains may affect navigation cues and straying of Winter-run Chinook Salmon adults into canals and behind weirs, increasing their stranding risk (Figure 5.6-5).

The adult holding to spawning life stage in the upper Sacramento River includes Keswick Dam to the Red Bluff Diversion Dam. It also includes selecting sites for and building spawning redds. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.6-6.

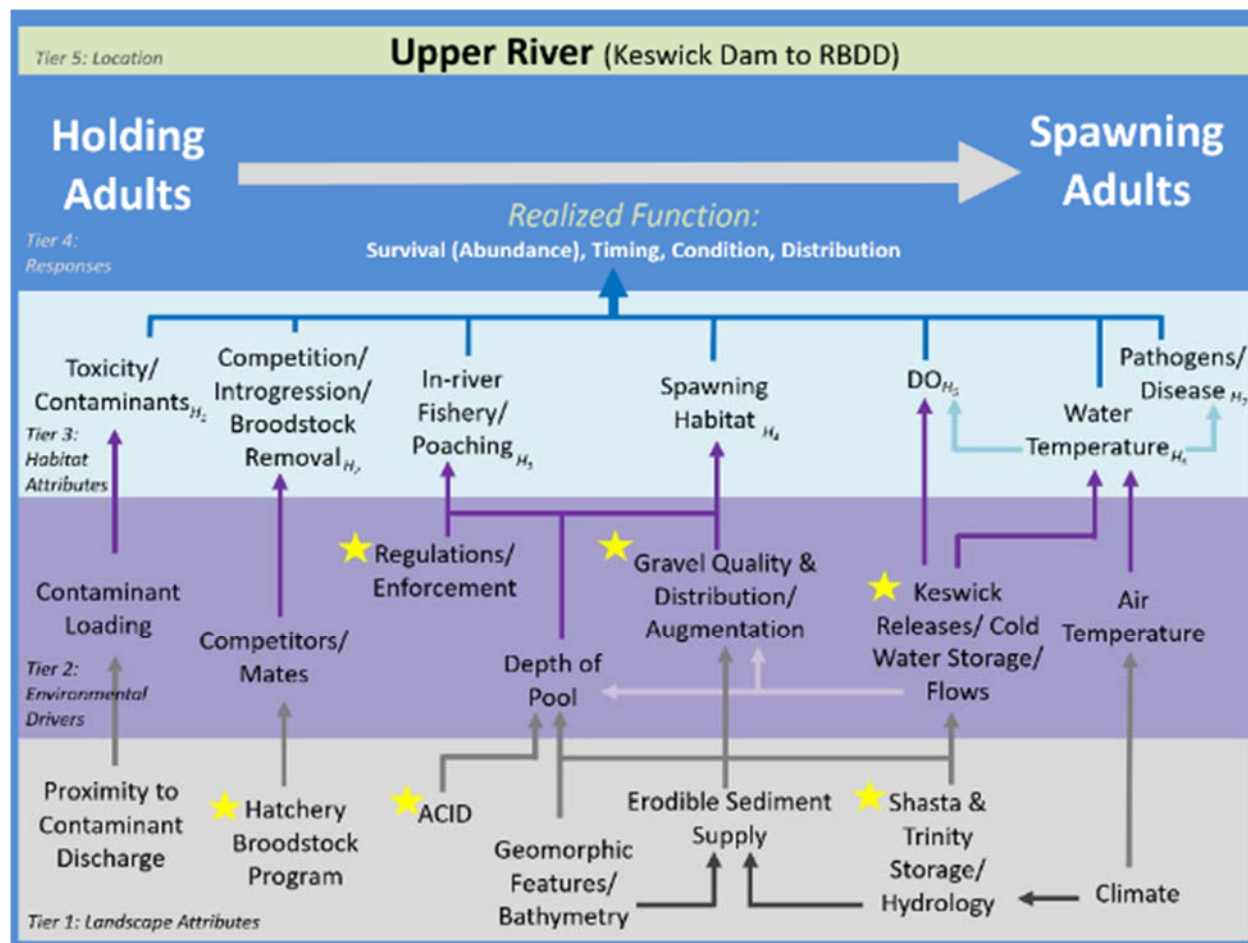


Figure 5.6-6. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon Adults from Holding to Spawning in the Upper Sacramento River.

Adult holding attributes relevant to the proposed action include primarily water temperature and DO.

The SAIL conceptual models describe the attributes affecting different life stage transitions. In the following subsections, attributes from the proposed action affecting Winter-run Chinook Salmon are discussed. These include releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, DO, and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds.

5.6.3 Effects of Operations & Maintenance

Water temperatures in the upper Sacramento River during summer and fall are closely tied to flow because both are determined by operations and storage releases at Shasta and Keswick dams and transfers from the Trinity River. Under WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases, no transfer of water from the Trinity River Basin, and no control of flow or water temperature in the upper Sacramento River. Shasta storage levels would be reduced (Figure 5.6-7) and, assuming stratification developed, the cold water pool would be small and

unmanaged. Further, the shallow reservoir that would remain behind Shasta Dam would absorb significant heat during warm, sunny days.

In the upper Sacramento River, where all Winter-run Chinook Salmon spawning occurs, modeling results showed WOA monthly mean water temperatures (HEC-5Q WOA scenario) during most of May through November spawning and incubation period would be high, ranging from ~46 degrees Fahrenheit in November, to 73 degrees Fahrenheit in July. During the peak spawning and incubation period, June through September, water temperatures would consistently exceed both the 56 degrees Fahrenheit and 53.5 degrees Fahrenheit water temperature thresholds (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D). Such conditions would make survival of incubating eggs and alevins impossible, eliminating the Winter-run Chinook Salmon population from the Sacramento River and reducing the extent of the ESU to a single population in Battle Creek.

Monthly mean water temperatures at Keswick would be high during the July through September period, ranging from ~63 degrees Fahrenheit during September to 72 degrees Fahrenheit during July and August, thereby exceeding the 61 degrees Fahrenheit water temperature thresholds in all years (Figures 5-16 through 5-18 in the HEC5Q Temperatures section of Appendix D). Water temperatures during these months would be even higher at other locations in the upper Sacramento River, ranging as high as 79 degrees Fahrenheit at Red Bluff Diversion Dam during July (Figure 10-16 in the HEC5Q Temperatures section of Appendix D). By October, the mean monthly water temperatures under the WOA scenario would be lower, remaining at or below the 61 degrees Fahrenheit in all years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). The water temperatures would remain below 61 degrees Fahrenheit from November through March (Figures 5-8, 5-10, 5-11, and 5-12 in the HEC5Q Temperatures section of Appendix D), by which time few Winter-run Chinook Salmon juveniles remain in the upper Sacramento River. The warm conditions in the upper Sacramento River during July through September would likely make survival of juvenile Winter-run Chinook Salmon impossible in the Sacramento River. Under the WOA, Winter-run Chinook Salmon could persist as a single population in Battle Creek (Phillis et al. 2018).

The low fall flows under WOA conditions would likely result in reduced conditions in juvenile Winter-run Chinook Salmon rearing habitats in the Sacramento River. During October and November, in years with dry hydrology, the flows would often fall below 3,250 cfs Keswick release for October through March as well as the target of 5,000 cfs at Wilkins Slough (note that the 3,250 cfs minimum flow is not required below the Red Bluff Diversion Dam (SWRCB 1990). As described by Windell et al. (2017), potential negative effects of the low flows include higher water temperatures and lower DO, reduced habitat complexity, less side-channel rearing habitat, less floodplain habitat and less connectivity of floodplains with the river mainstem, less refuge habitat, reduced availability and quality of prey organisms, greater crowding and competition, greater predation risk, greater entrainment risk, greater potential for pathogens and diseases, higher concentrations of toxic contaminants, and reduced emigration cues.

CalSim modeling indicates that from December through March, the first part of the period during which Winter-run Chinook Salmon adults migrate upstream through the middle Sacramento River to holding habitat in the upper River, there are low flows at Wilkins Slough and Keswick that would be low enough to create potential passage problems for immigrating adults. The most severe conditions would be at Wilkins Slough in May, when over 30 percent of years would have flows lower than the 5,000 cfs minimum flow requirement (NCWA 2014). These conditions would create poor passage conditions for adult Winter-run Chinook Salmon migrating upstream, possibly resulting in a reduction in spawning and recruitment of the new year-class.

Under WOA, upper Sacramento River flows modeled by CalSim for the December through August holding period are low in December, except in wet years, high during January through May, except in dry years, low in June, except in wet years, and low in almost every year during July and August (Figures 15-9 through 15-17 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding adult Winter-run Chinook Salmon by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017). The low flows in July and August would likely be stressful to holding adults and reduce suitable areas for redd construction.

From December through April, mean water temperatures under the WOA scenario are consistently below the 61 degrees Fahrenheit threshold for holding adults and mostly below this threshold in May (Figures 5-9 through 5-14 in the HEC5Q Temperatures section of Appendix D). During June through August, however, the water temperatures are almost entirely above the threshold (Figures 5-15 through 5-17 in the HEC5Q Temperatures section of Appendix D). The water temperatures reach as high as 72 degrees Fahrenheit in July and August.

The critical temperature threshold for spawning adults are the same as those discussed previously for incubating eggs and alevins (i.e., 56 degrees Fahrenheit and 53.5 degrees Fahrenheit). These thresholds would be exceeded under the WOA scenario in almost all years from May through August, but would be exceeded only occasionally during December through April (Figures 5-9 through 5-17 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario would be poorly suited for holding or spawning Winter-run Chinook Salmon adults during the summer months.

The COS provides context and analytical support for the potential positive and negative effects of the proposed action. Reservoir operations work with a limited resource to balance the current needs of the fish populations, cold water storage for the following year, and sufficient space for flood control in the winter and spring. During the first part of the juvenile rearing period, July through September, operations are largely dictated by needs of incubating Winter-run Chinook Salmon eggs and larvae. After September, current operations target several requirements, including stable river flows to minimize dewatering of Winter-run Chinook Salmon redds and stranding of juveniles, suitable flow and temperature conditions for Spring-run and Fall-run Chinook Salmon spawning, incubation and rearing, and conserving storage for the next year's cold-water pool. The minimum flow requirement for the upper Sacramento River from October 1 until April 1 is 3,250 cfs from State Water Resources Control Board Water Rights Order 90-5. Delta operation under the COS seeks to support exports while minimizing and/or avoiding entrainment of listed species. Fall X2 conditions for Delta smelt are also considered under the COS (USFWS 2008).

5.6.3.1 *Upper Sacramento River Seasonal Operations including Shasta Cold Water Pool Management*

Under WOA conditions, there would be 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 Winter-run Chinook Salmon spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage (Figure 5.6-7). The similarity to uncontrolled flows is reflected in seasonal flows under the WOA scenario in the Sacramento River at Keswick, with low summer and fall flows and high winter and spring flows (Figures 5-7 through 5-18 in the CalSim II Flows section of Appendix D). Other locations in the Sacramento River show similar seasonal flow patterns (Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D).

Under the proposed action, flows in the upper Sacramento River result from controlled releases from Shasta and Keswick reservoirs, as well as transfers from the Trinity River. These releases and transfers are determined by a suite of laws, regulations, contracts, and agreements to address demands of water users, requirements for water quality, and needs of fish populations throughout the river and the Delta, including Winter-run Chinook Salmon.

The primary difference between proposed action and current operations modeling for the Sacramento River upstream of the Delta is in operations of Shasta and Keswick reservoirs for cold water pool management and the COS requirement for Fall X2.

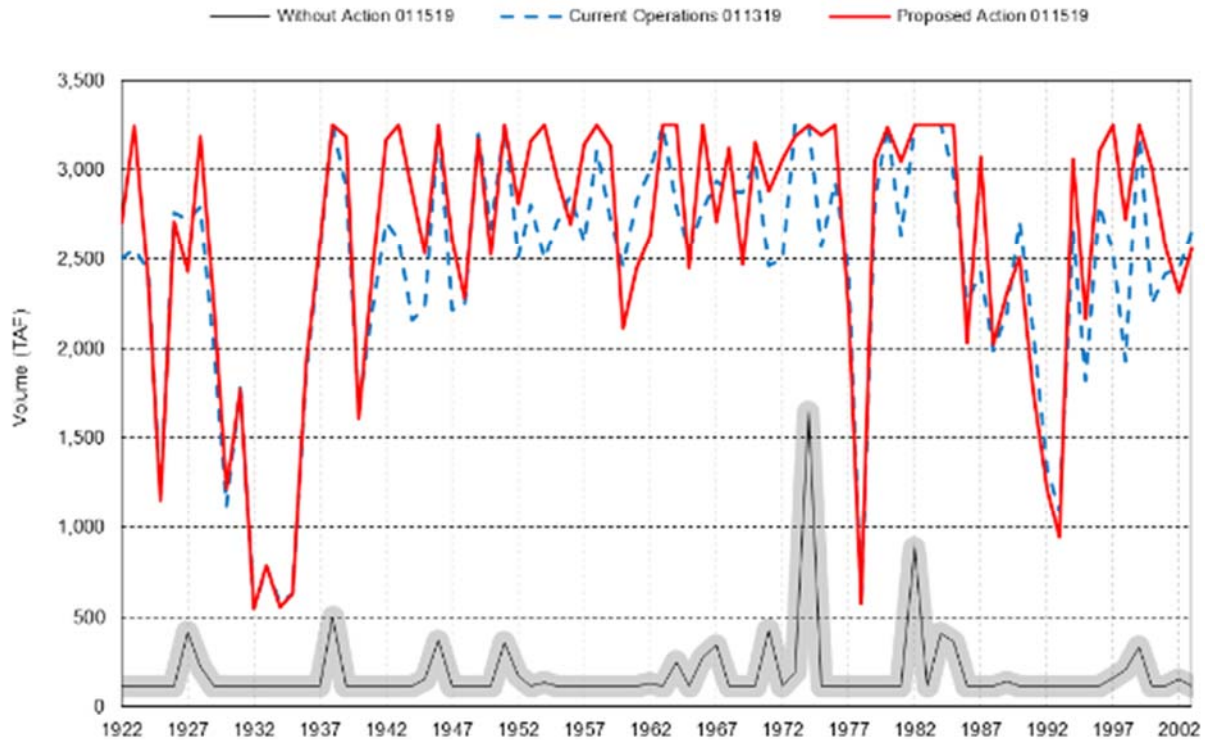


Figure 5.6-7. ShastaStorage. CalSim II Estimates of Mean Shasta Storage, 1923-2002.

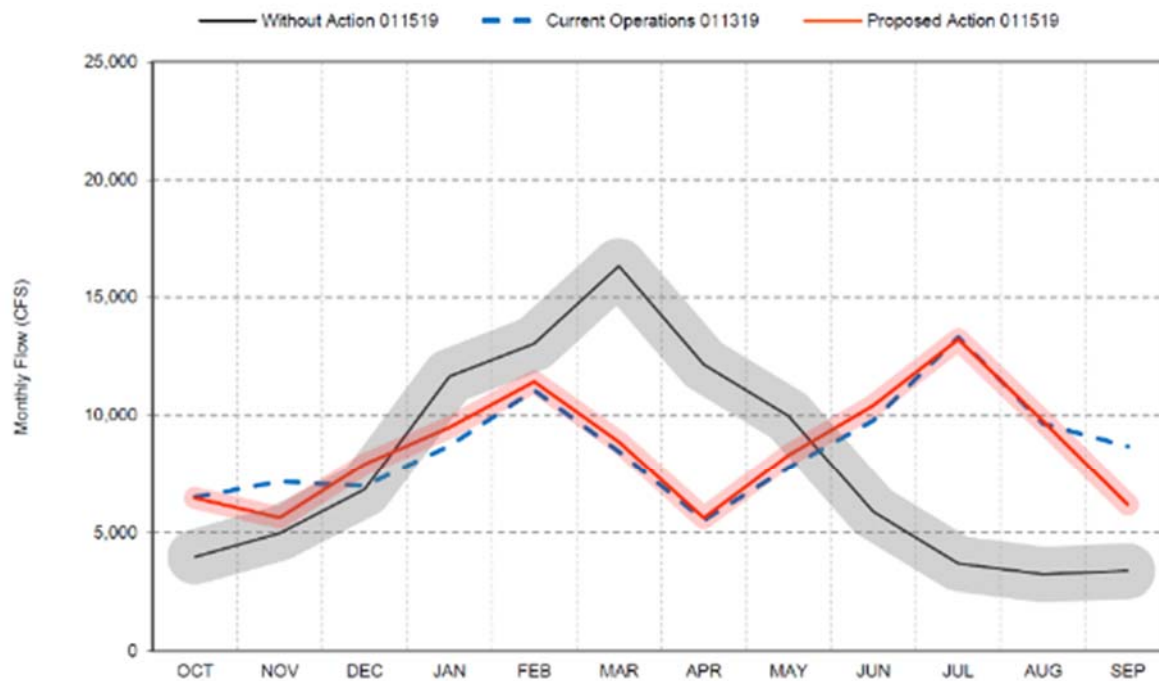


Figure 5.6-8. Calsim II Sacramento River Flow downstream of Keswick Reservoir, Long-term average

The CalSim modeling shows large seasonal changes in the differences in upper Sacramento River flow between the WOA scenario and the proposed action. In July through October, the WOA flows are consistently well below those of the proposed action (Figures 15-16 through 15-18 and 15-7, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). By November there is little difference between the WOA and proposed action scenarios, except in years with the highest flows. In January, the WOA flows are higher than the proposed action at most flow levels (Figure 15-10 in the CalSim II Flows section of Appendix D) and in March the WOA flows are consistently higher than the proposed action flows (Figure 15-12 in the CalSim II Flows section of Appendix D). These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low, and diversions to Shasta Reservoir storage under the proposed action during winter and spring, when uncontrolled flows are high. Diversion to storage is higher in spring than in winter because the flood control pool in the reservoir can be reduced during spring as flood risk declines.

The differences in flows between the WOA scenario and the proposed action and COS scenarios would likely have very large effects on Winter-run Chinook Salmon juveniles and their habitats. The lower summer and fall flows under the WOA scenario would likely result in reduced conditions in juvenile rearing habitats, including less habitat complexity, side channel habitat structure, refuge habitat, and greater disease potential (Windell et al. 2017). As noted previously, the higher WOA flows in winter and spring could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. Benefits include increased floodplain and side-channel habitat, better feeding conditions, reduced competition and predation; decreased water temperatures and increased DO; and enhanced emigration flows. Negative impacts include increased stranding risk (due to greater flow fluctuations), and increased contaminant loading from stormwater runoff. Although conditions may be suboptimal for juvenile

Winter-run Chinook Salmon, the impacts of increased summer and fall flows under the proposed action and COS would be beneficial compared to the WOA. During summer and fall juvenile Winter-run Chinook Salmon are less robust due to young age and are more sensitive to stressful conditions than other times of the year (NMFS 2009). Therefore, juveniles would be less susceptible to reduced winter and spring flows under the proposed action and COS as compared to the WOA.

CalSim modeling indicates that upper Sacramento River flows during the period of juvenile rearing in the upper Sacramento River are generally similar between the proposed action and COS (Figures 15-7 through 15-12 and 15-16 through 15-18, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D), except for higher flows during September under the COS scenario in the upper range of flows (Figure 15-18 in the CalSim II Flows section of Appendix D). The COS flows are also higher than the proposed action flows during November (Figure 15-8 and Table 15-3 in the CalSim II Flows section of Appendix D) where Reclamation proposes to rebuild storage and cold water pool for the subsequent year.

Flow under the COS and proposed action scenario are consistently well above the WOA flow in all months of the primary spawning and incubation period, especially in dry years (Figures 15-15 through 15-18 in the CalSim II Flows section of Appendix D). Therefore, all potential adverse effects of low flows on Winter-run Chinook Salmon spawning and incubation listed above are expected to be much less severe under the proposed action or COS than under the WOA.

The low summer and fall flows under the WOA conditions would likely result in reduced conditions for spawning and incubation of Winter-run Chinook Salmon in the upper Sacramento River (Figures 15-7 through 15-9 and 15-15 through 15-18, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The WOA flows range from 772 cfs in August to about 63,000 cfs in March. During dry years, the flows would often fall below the proposed action flow for October through March of 3,250 cfs.

In the uppermost section of the Sacramento River, where most Winter-run Chinook Salmon spawning occurs, flows the WOA scenario during the May through November spawning and incubation period, are generally low (Figures 15-16 through 15-18 in the CalSim II Flows section of Appendix D). Reduced flows under WOA conditions during the driest summer and fall months would have significant negative effects on rearing habitat of Winter-run Chinook Salmon juveniles. Water temperatures would be too high to successfully reproduce; hence, no juvenile Winter-run Chinook Salmon would be present under WOA.

The higher WOA flows in winter and spring could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse effects including higher stranding risk because of increased use of flood plains combined with greater flow fluctuations, and higher contaminants loading from stormwater runoff.

The USEPA (2003) defines 61 degrees Fahrenheit as the critical seven day average daily maximum (7DADM) water temperature for Chinook Salmon juveniles. While this source is commonly cited and used to identify general temperature thresholds for most species and life-stages in this document, it is based on data from fish in the Pacific Northwest and based on different thermal regimes with smoother average temperatures. In addition to the lack of local relevance, 7DADM has operational challenges as a compliance metric, including the fact that it will create a lag in the data (Figure 5.6-9 below). The 2017 Long-term Operations Biological Opinions (LOBO) Biennial Science Review (Gore, 2018) stated that for datasets that are not centered on the mean, the moving average will create a lag in the data that can bias the average by the previous data point, and that alternate averaging approaches should be considered in

addition to 7DADM, such as a weighted moving average. Gore et al state that, “The proposed 7DADM significantly lags the observed data. However, both a 3-day and 4-day average daily maximum both follow the sharp rise in observed temperature with less lag at the temperature peak.” Reclamation will continue to use this reference as a general characterization of the temperature tolerance of lifestages and species in this document, with the understanding that it is inappropriate to use as a compliance metric and that local temperature tolerance studies would be preferred, but are not available.

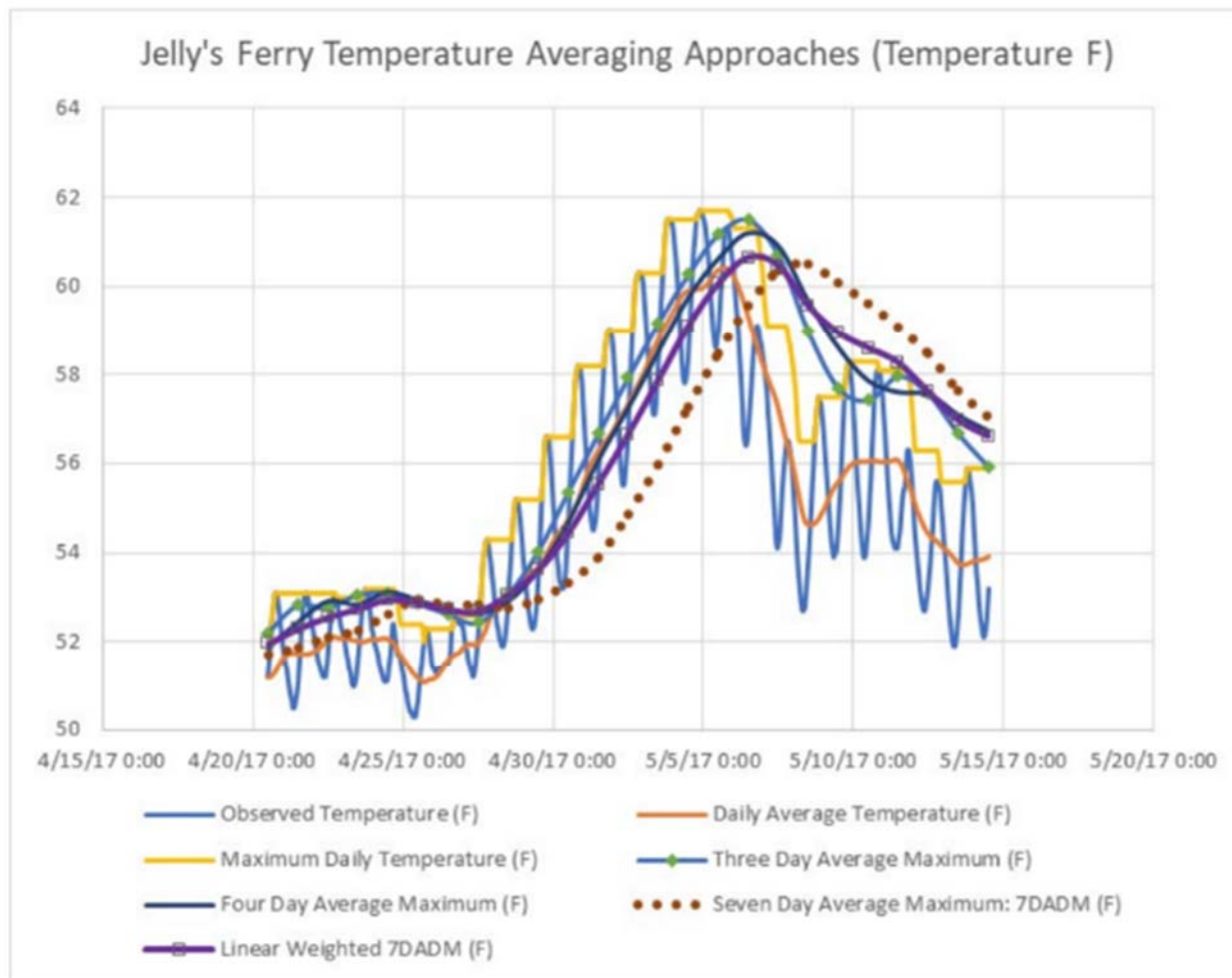


Figure 5.6-9. Comparison of Averaging Approaches that could be used to Specify Temperature at Jelly's Ferry (reproduced from the 2017 LOBO review report, Gore 2018)

The USEPA (2003) defines 64 degrees Fahrenheit as the critical 7DADM water temperature for Chinook Salmon juveniles rearing, based on Pacific Northwest fish and not considering operational limitations of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing, the WOA scenario monthly mean water temperatures would be high during October, ranging up to 73 degrees Fahrenheit and exceeding the 64 degrees Fahrenheit threshold in about 80 percent of years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). The water temperatures would remain well below 64 degrees Fahrenheit from November through March (Figures 5-9 through 5-12 in the HEC5Q Temperatures section of Appendix D), by which time most Winter-run Chinook Salmon juveniles have migrated into the Delta.

5.6.3.1.1 Egg to Fry Emergence

Windell et al. (2017) links egg to fry survival with releases from Keswick and water temperatures. Critical water temperatures thresholds for Winter-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Under the WOA, there is no temperature management. The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under COS and the proposed action in the upper Sacramento River during the May through November spawning and incubation period than would be possible under the WOA. Under the proposed action, the river’s temperatures are controlled by selective withdrawal through the TCD at Shasta Reservoir and by balancing releases between Lewiston (Trinity River) and Shasta reservoirs.

Operation of the Shasta TCD provides for cold water to maintain egg incubation and avoid temperature dependent mortality. The availability of cold water depends upon reservoir stratification and is not known until April; however, the amount of water in storage provides an indicator. Under the WOA scenario, no storage results in little cold water. Under the proposed action improvements in storage improve the ability to manage cold water for Winter-run Chinook Salmon incubation. Figure 5.6-10 shows the modeled temperature management tiers and operational parameters that influence the tiers, based on storage, for the last 19 years of the CalSim period of record. Figure 5.6-11 shows the same figure for the full 1922-2003 CalSim period of record.

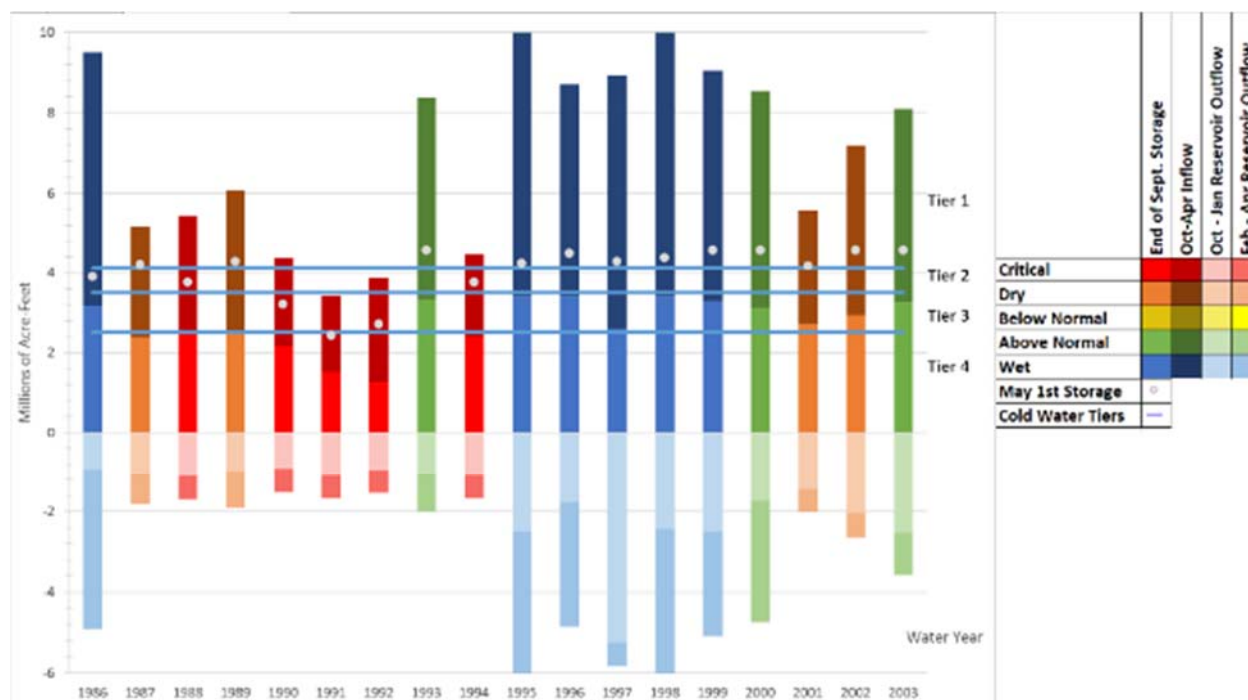


Figure 5.6-10. CalSim Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities (1986-2003 for ease of visualization)

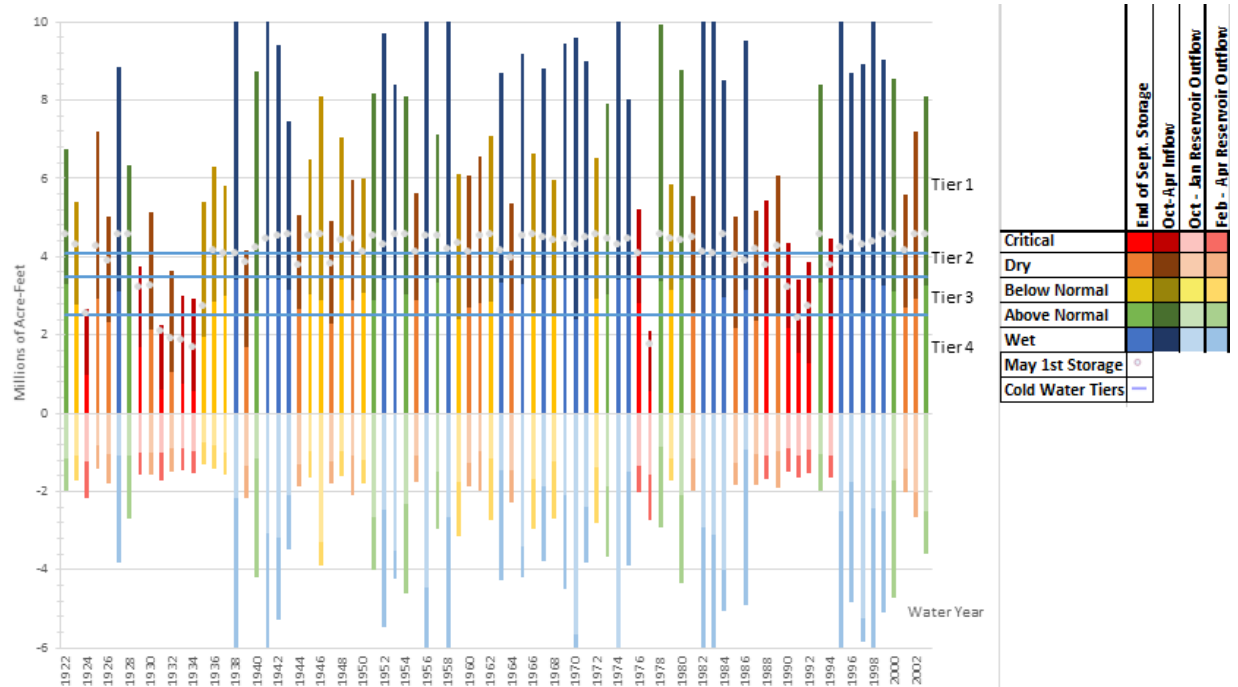


Figure 5.6-11. CalSim Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities (1922-2003)

CalSim modeling over the 1922-2003 period of record indicates Reclamation is in Tier 1 over 69 percent of the time and in Tier 4 less than 8 percent of the time (Tier 2 in 17% of the years, and Tier 3 in 7% of the years). End of September storage has little influence on the subsequent tier as releases for flood management and other purposes (e.g. dewatering) erode the storage. Actions to rebuild storage when storage is known to be low can shift operations into a higher tier, to some degree; however, the cold water resource depends primarily on inflow.

Although it does not include the altered water operations, historical data provides information to infer how operations may change under the proposed action. Figure 5.6-12 shows recent history (since 2001) that is largely not simulated within CalSim.

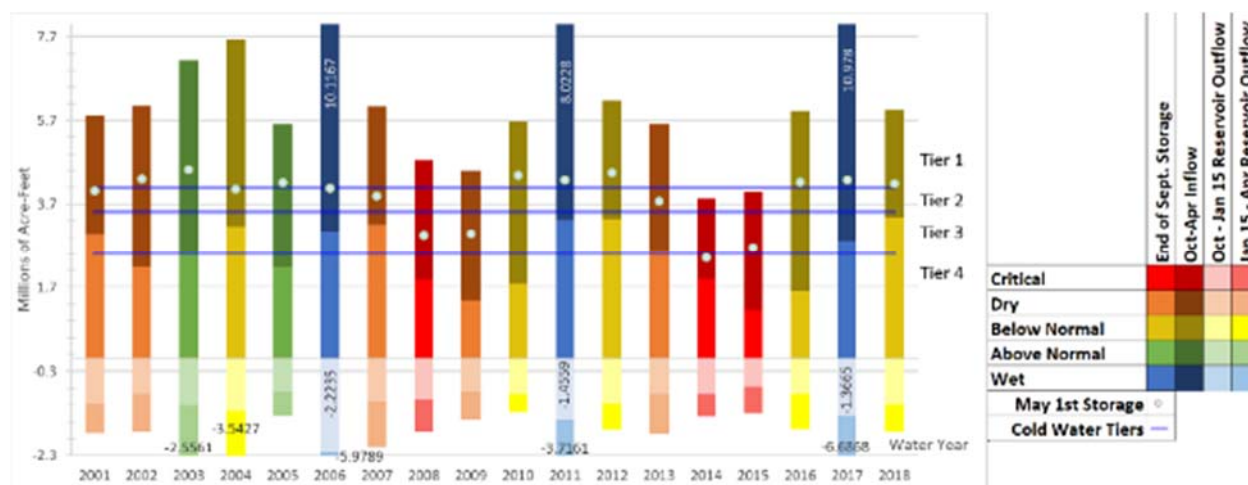


Figure 5.6-12. Historical Prior Storage, Inflow, and Releases for May 1 Cold Water Capabilities

Reviewing the end of September storages shows little ability to modify the tier in the subsequent year. Reviewing the releases (shown as negative on the Y-axis) indicates that lower releases in the fall of 2013 could have improved conditions for 2014.

The main difference in flow and water temperature management between the proposed action and COS during the June through September Winter-run Chinook Salmon spawning and incubation period would be in how the TCD would be operated to preserve sufficient cold water pool and what water temperature thresholds would be used.

Under the proposed action as modeled in the HEC-5Q temperature model, mean monthly water temperatures at Clear Creek during May through November range from roughly 48 degrees Fahrenheit in May to 67 degrees Fahrenheit in September (Figures 5.6-13 through 5.6-20).

The proposed action incorporates new water temperature management measures based on water temperatures that include a water temperature target of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence (CCR). CCR is a surrogate for the downstream-most redd. Some redds occur downstream of clear creek, however the 53.5 F target is below the 56 F threshold and cold water will propagate further downstream. Targeting CCR avoids the need to use additional cold water over areas where few redds occur.

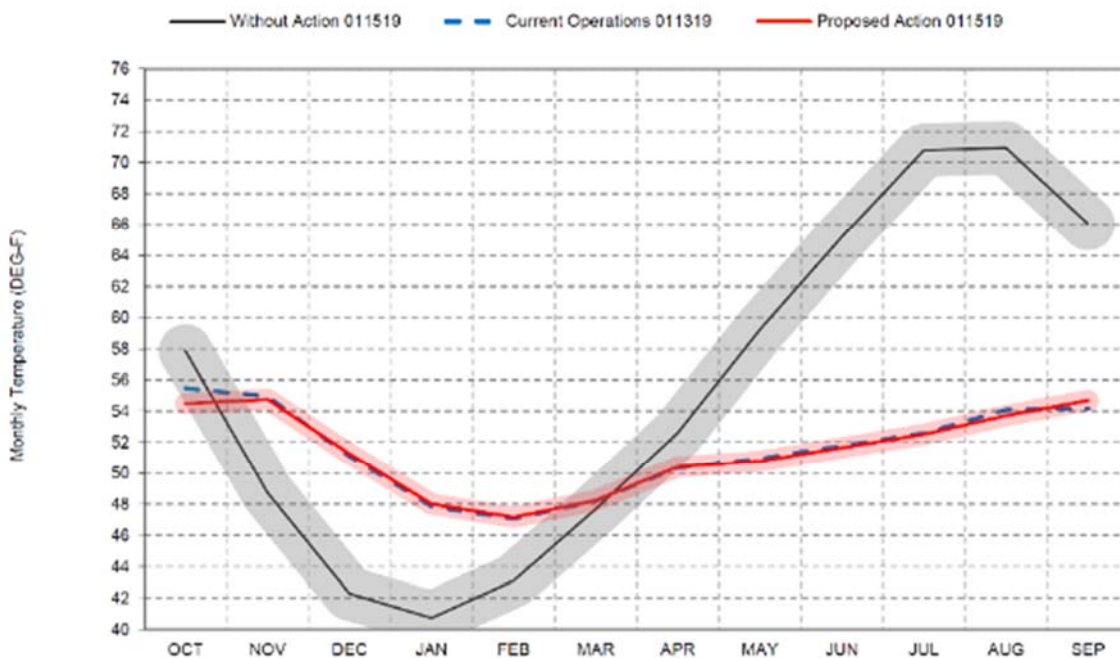


Figure 5.6-13. HEC-5Q Sacramento River Water Temperatures at Clear Creek by Monthly average

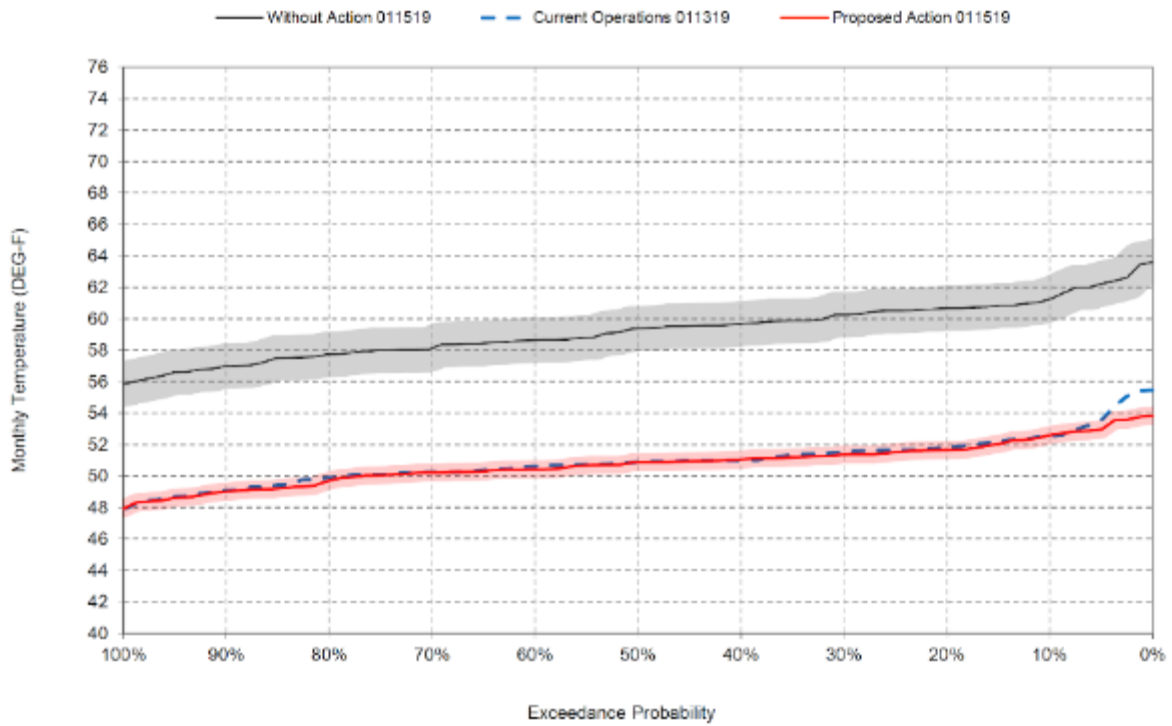


Figure 5.6-14. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, May

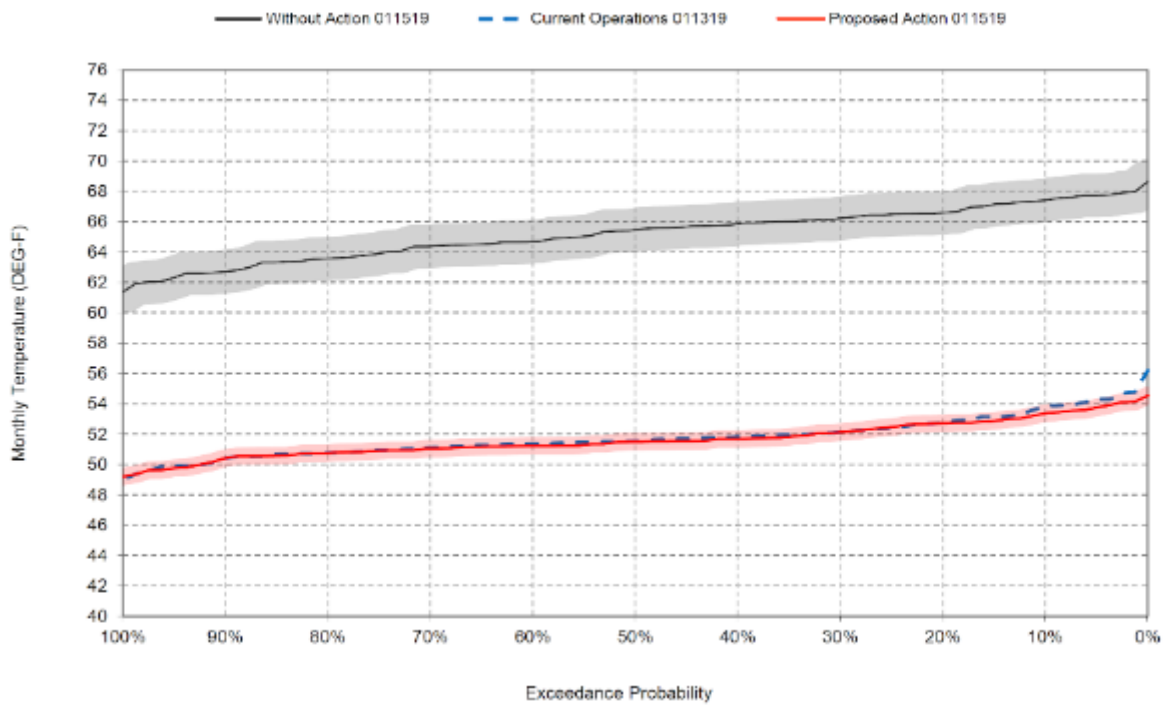


Figure 5.6-15. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, June

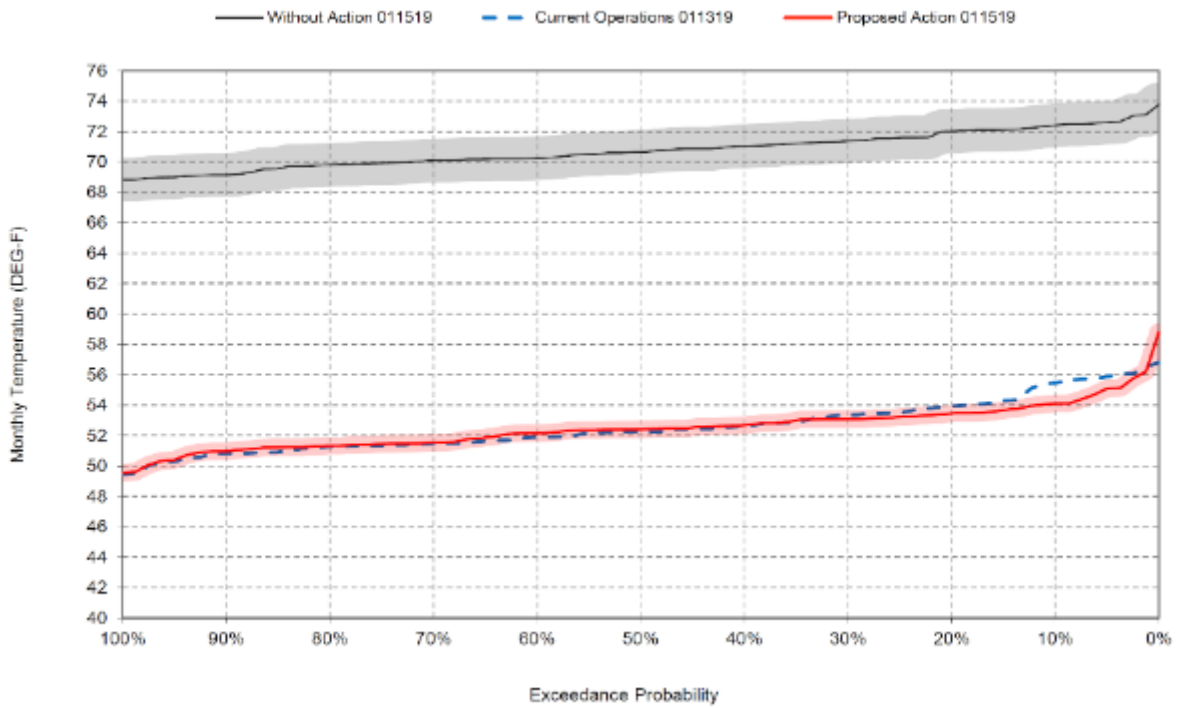


Figure 5.6-16. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, July

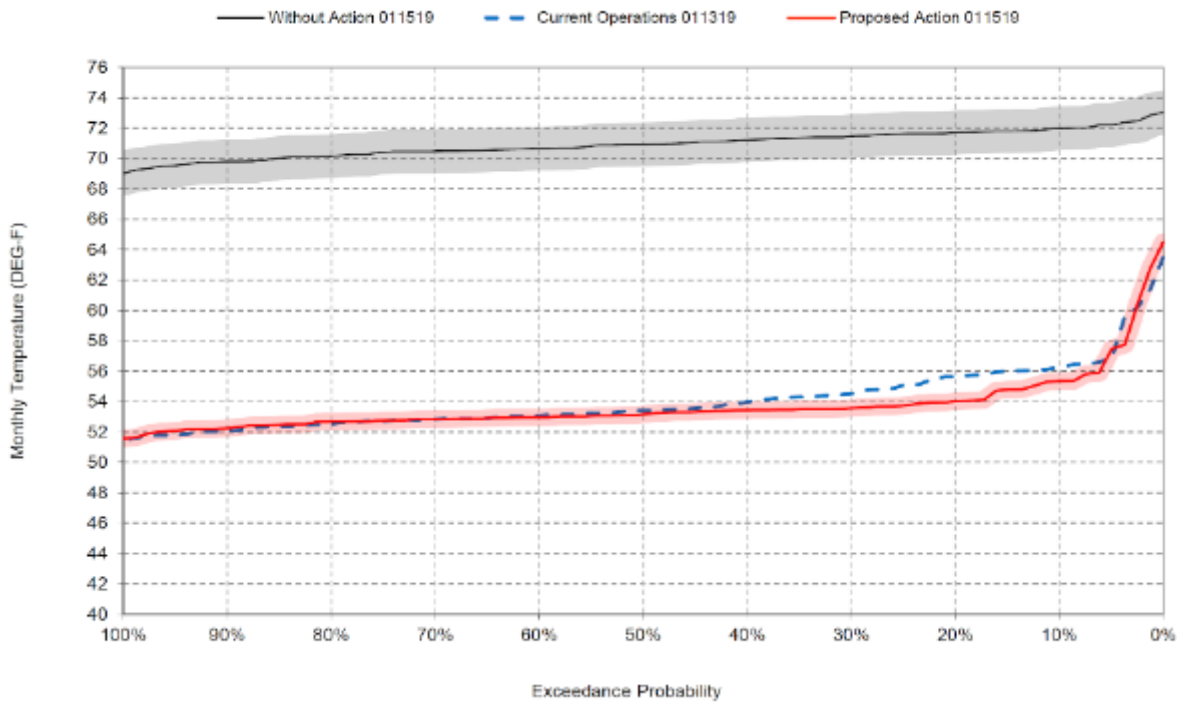


Figure 5.6-17. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, August

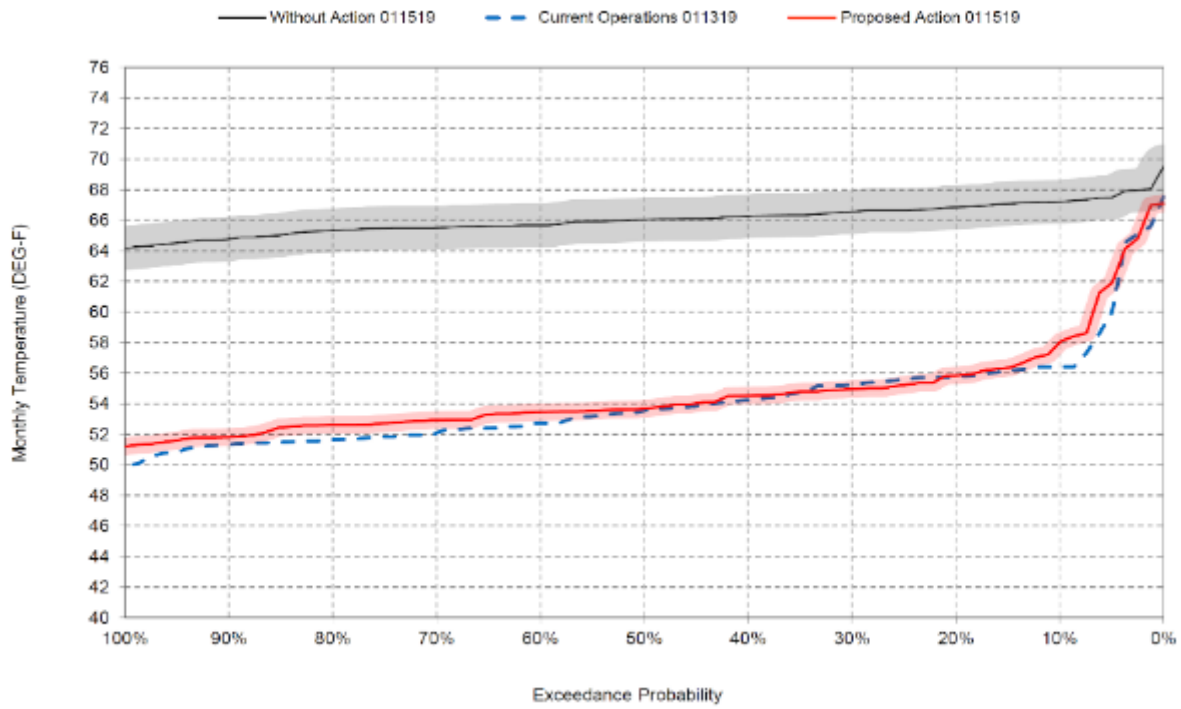


Figure 5.6-18. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, COS and proposed action scenarios, September

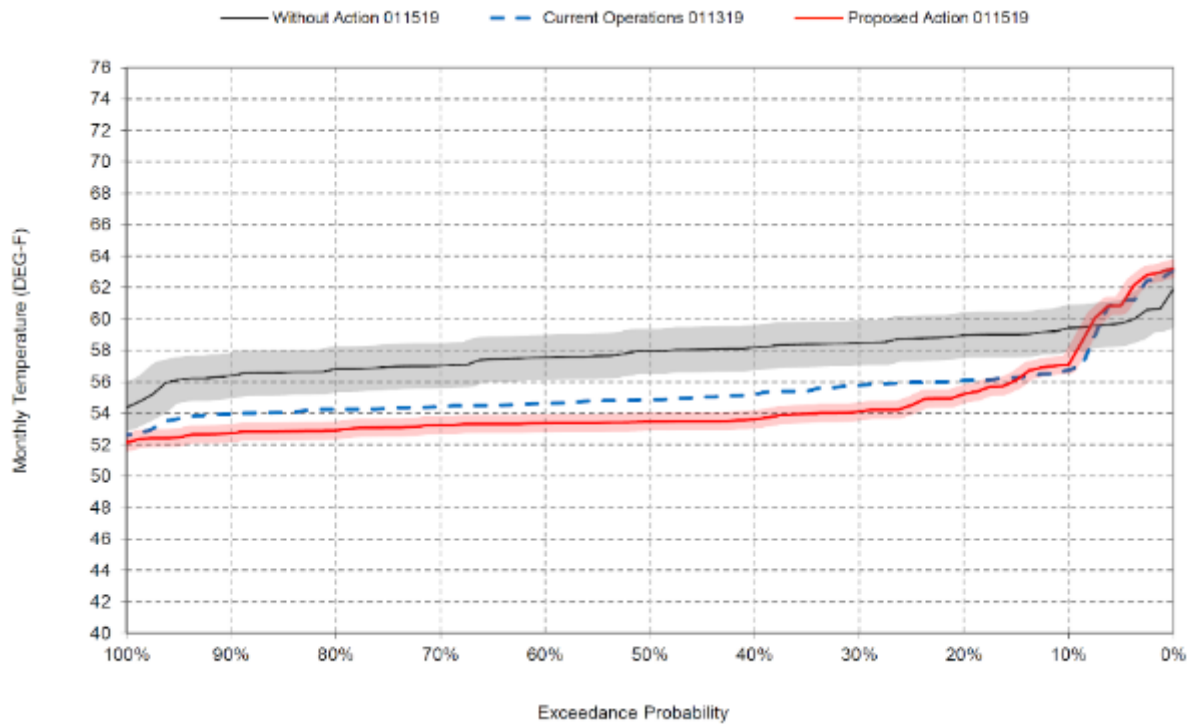


Figure 5.6-19. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, October

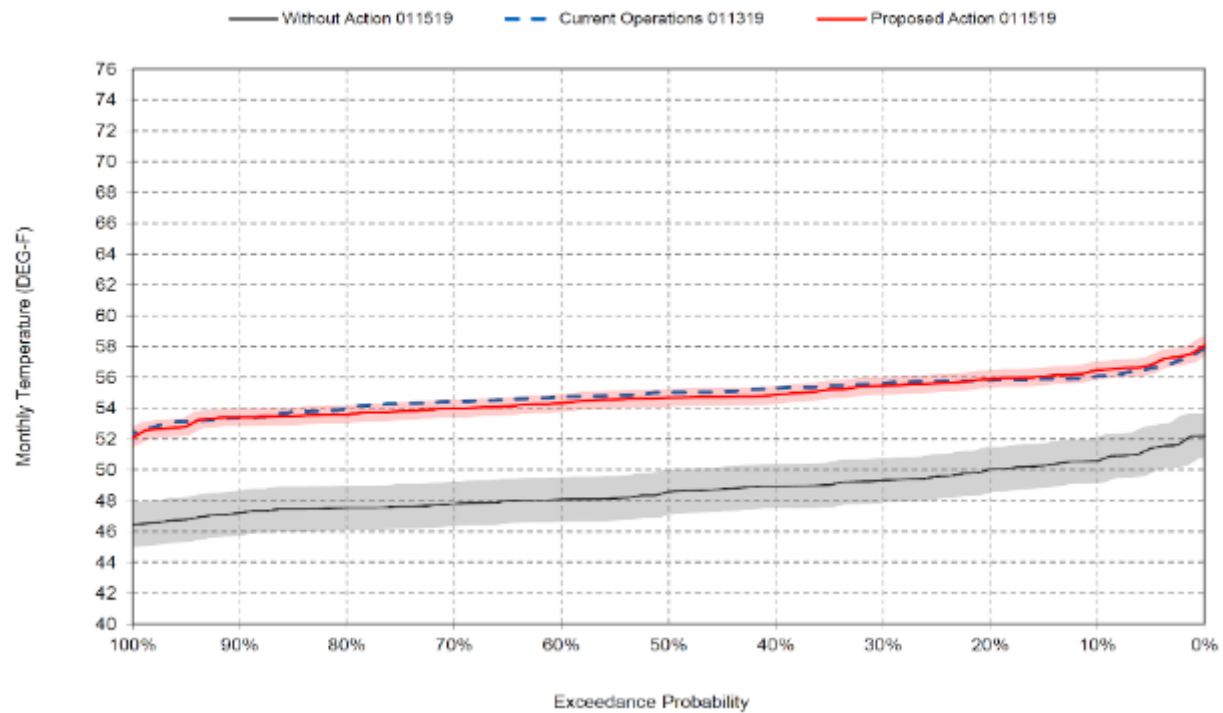


Figure 5.6-20. HEC-5Q Sacramento River Water Temperatures at Clear Creek under the WOA, proposed action, and COS scenarios, November

While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average temperatures near the Keswick Dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam. During the June through September peak spawning and incubation period, the water temperatures at Clear Creek exceed the 53.5 degrees Fahrenheit threshold in at most 25 percent of years (50% for September). During October, when the cold water pool is especially at risk of being depleted, the water temperatures would exceed the 53.5 degrees Fahrenheit threshold in about 40 percent of years. There is little difference in water temperatures among the proposed action and COS scenarios during all months except October (Figures 5.6-13 through 5.6-20). In October, temperature modeling indicates that the proposed action has an improvement over the current operations scenario in 80% of the years, and an improvement over the WOA scenario in 90% of the years, decreasing October temperatures by 1-2 degrees Fahrenheit as compared to COS, and 4-5 degrees as compared to WOA. The proposed action conserves cold water earlier in the year and is able to extend cooler temperatures into October.

Summer water temperatures under the proposed action and COS scenarios are consistently much lower than those under the WOA scenario (Figures 5.6-15 through 5.6-18). These results indicate that the proposed action and COS, relative to the WOA, provide a clear benefit to Winter-run Chinook Salmon eggs and alevins incubating in the upper Sacramento River. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Winter-run Chinook Salmon eggs and alevins relative to current operations.

Martin et al. (2017) developed an egg mortality model for Winter-run Chinook Salmon on the Upper Sacramento River and performed regression on historical data to find a critical incubation temperature for eggs of 53.6 degrees Fahrenheit below which minimal mortality due to temperature occurred. The 2017

LOBO review (Gore, 2018), stated that the Martin et al. (2017) approach represents a powerful predictive model for salmon vulnerability to temperature exposure but that the results of the oxygen diffusion model should be tested under field conditions. The model is sensitive to extremely small changes in flow velocity, and it may be problematic to apply a density dependent model that lacks mechanistic basis or site-specific information. Additionally, new laboratory studies from UC Davis (Del Rio et al. In Press) affirm earlier findings (USFWS 1999) that embryo survival is not appreciably impaired at daily mean water temperatures at or near 56 °F.

Newer models, described in Anderson (2018), are similar but include different assumptions and provide for more targeted water temperature management practices in the upper Sacramento River (Anderson 2018). Both the Martin et al. (2017), and Anderson (2018) models were used to estimate water-temperature related mortality of Winter-run Chinook Salmon eggs to fry under the WOA, proposed action, and COS. Martin et al applies mortality based on the season-long temperature. Anderson applies mortality based on just the temperature of the 5 days preceding hatch. The modeling was based on the HEC 5Q water temperature estimates at Keswick Reservoir under the three scenarios for the range for years (1922 to 2002) used for the CalSim and HEC 5Q modeling. Figure 5.6-21 gives the exceedance curves for the water-temperature related egg to fry mortalities under the WOA, COS, and proposed action scenarios. Separate results are given for the Martin et al. (2017) and Anderson 2018 modeling.

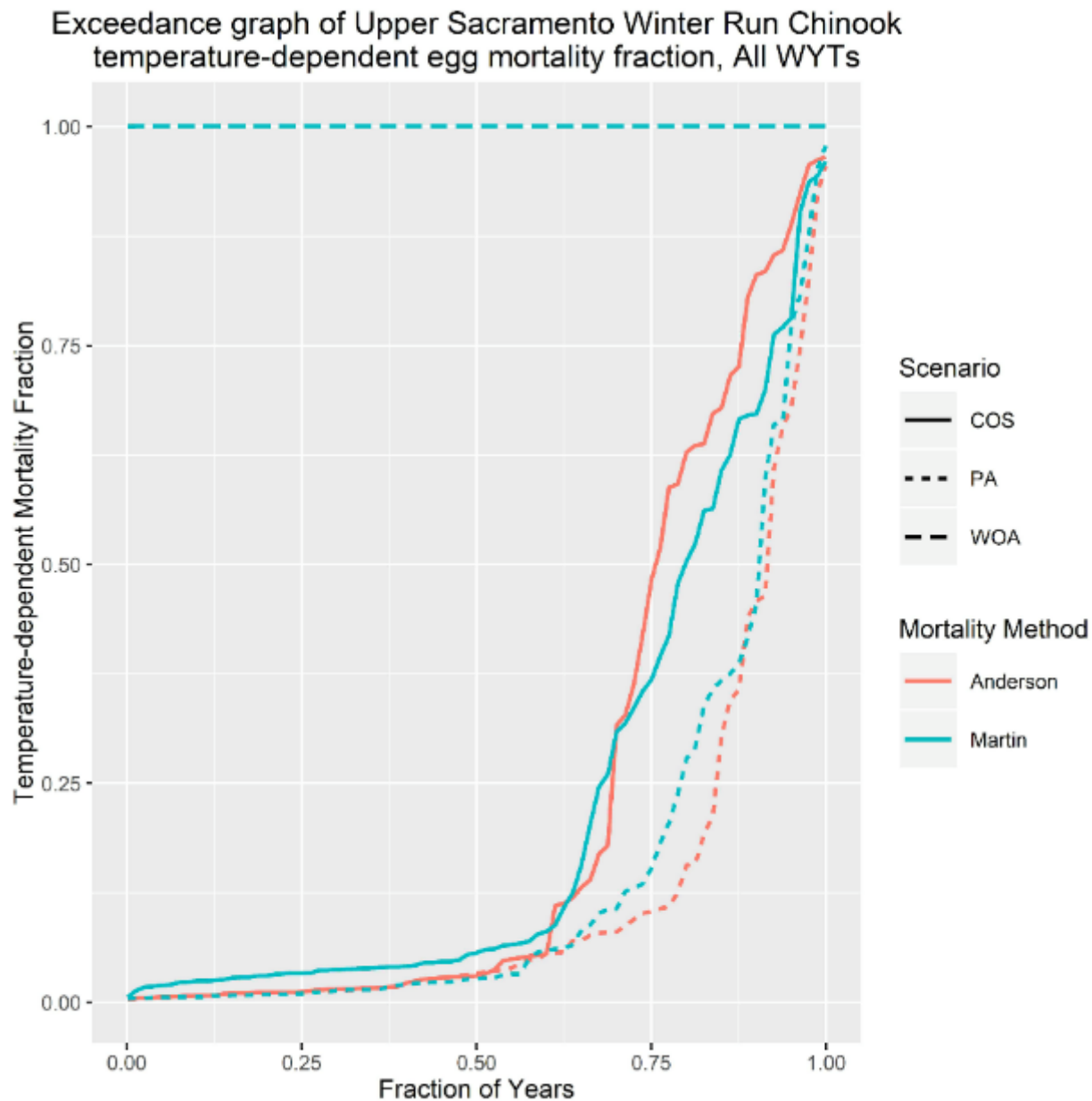


Figure 5.6-21. Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for All Water Year Types

The modeled mortality rate for the WOA scenario is 100 percent for both models used (Figure 5.6-21). This result is the same as that deduced from the HEC 5Q water temperature results presented previously in the water temperature section. Differences between the Martin and Anderson model results are generally small, but tend to show slightly higher mortalities for years with overall lower mortalities (i.e., cooler water temperatures) for the Martin model and slightly higher mortalities for years with overall high mortalities (warmer temperatures) for the Anderson model. For both models, the proposed action mortalities are less than the COS mortalities for the majority of years in all water year types, with some lower performance in some above-normal water-year types.

Figure 5.6-21 combines results for all water year types, including wet years, when there is little temperature-related mortality. This obscures the modeling results for drier years, when egg/alevin mortalities are especially high. In critically dry years, the proposed action continues to outperform current operations, with up to a 40 percent improvement in mortality above current operations in some critically dry years (Figure 5.6-22). As discussed above, the proposed action optimization of water temperatures early in the year leads to significant October improvements in temperatures driving these large improvements in temperature dependent mortality in wetter critically dry years.

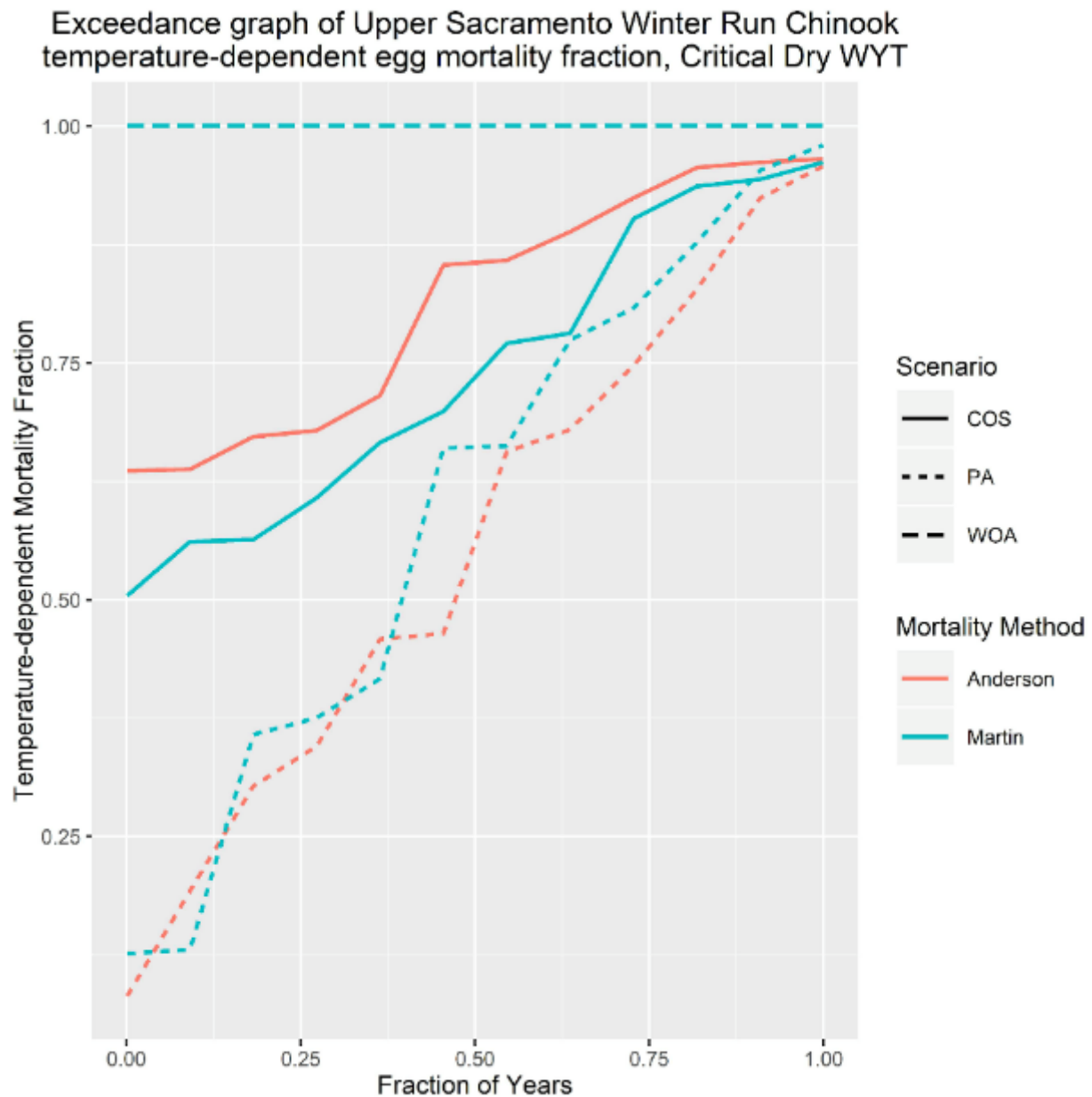


Figure 5.6-22. Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for Critically Dry Water Year Types

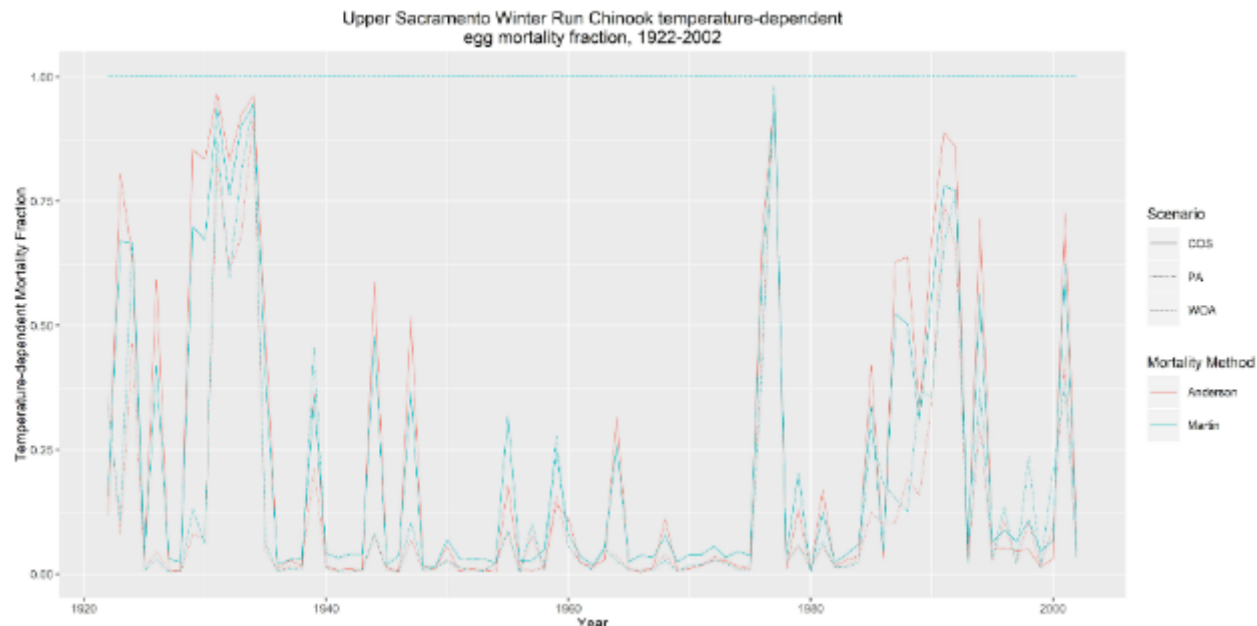


Figure 5.6-23. Estimated Winter-run Chinook Salmon Egg to Fry Average Annual Mortalities (average of Martin and Anderson mortality estimates) and HEC 5Q Estimates of June through September Monthly Average Water Temperatures at Keswick from 1922 to 2002.

The highest estimated mortality rates consistently occur during periods of high water temperatures, such as the droughts of the late 1920 through the mid-1930s, 1976 and 1977, and the late 1980s through the early 1990s (Figure 5.6-23).

The impacts of increased summer and fall flows under the proposed action compared to WOA and COS would be beneficial for egg and alevin survival. Reduced winter and spring flows under the proposed action as compared to the WOA and COS would occur outside of the June—September period of egg and alevin incubation for Winter-run Chinook Salmon.

5.6.3.1.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon juveniles rear throughout the upper Sacramento (Keswick to Red Bluff) from July through March, with a peak rearing period during August through December, and emigrate from the upper River during this period (Table 5.6-1). The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Water temperatures under the proposed action are consistently lower than those under the WOA scenario during July through September, moderately lower in October, similar during March, and above the WOA scenario from November through February (Figure 5.6-23 below). Under the proposed action as modeled in HEC-5Q, monthly mean water temperatures at Keswick exceed the 61 degrees Fahrenheit threshold for rearing juvenile Winter-run Chinook Salmon only in about 5 percent of years in August, September, and

October, and in no years during the other months (see Appendix D, *Modeling*). There is little difference in water temperatures between the proposed action and COS scenarios during the period of Winter-run Chinook Salmon rearing in the upper Sacramento River.

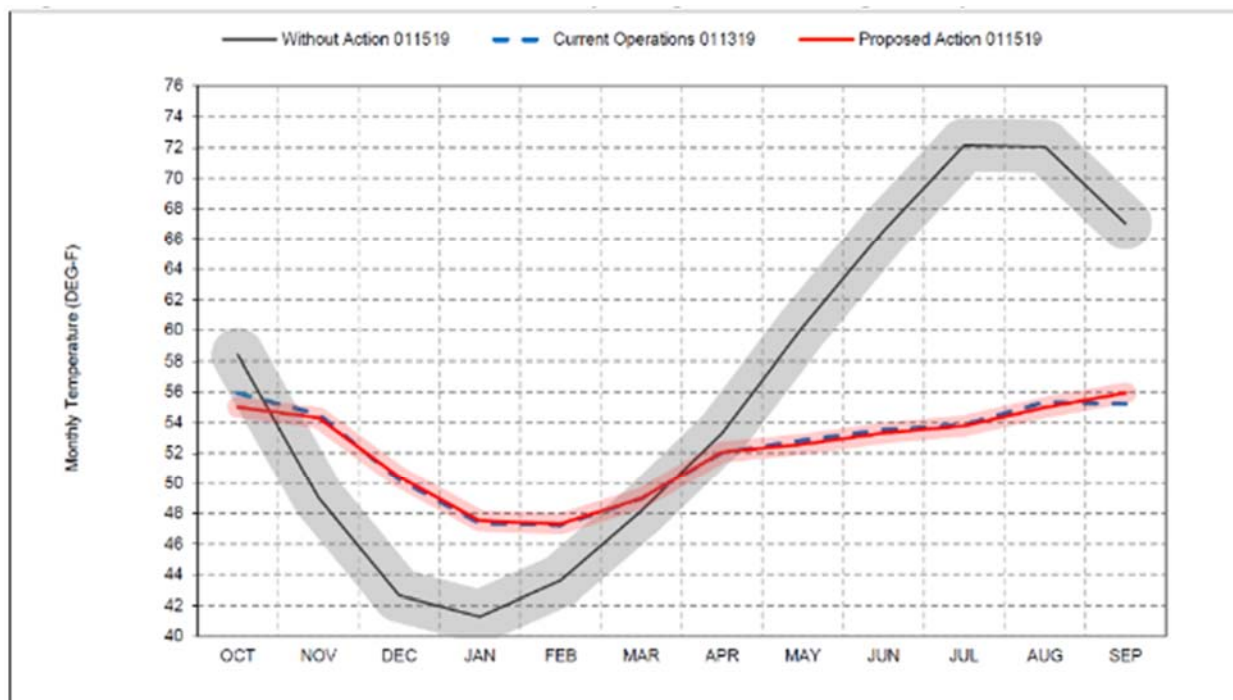


Figure 5.6-24: Sacramento River at Balls Ferry Long-term Average Temperatures

Flows during summer and fall of dry and critically dry years generally have the greatest potential to adversely affect the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats. The proposed action would help protect Winter-run Chinook Salmon from water temperature extremes through the end of October in all but the driest years.

The benefits of the lower summer and fall water temperatures under the proposed action outweigh potential adverse effects of higher winter water temperatures because the summer and fall temperatures are often near critical temperature thresholds and, therefore, more of a limiting factor. Also, the juveniles are at their youngest and therefore most vulnerable during summer and fall. These results indicate that water temperatures under the proposed action provide benefits to rearing juvenile Winter-run Chinook Salmon in the upper Sacramento River relative to the WOA.

Events in recent years have demonstrated that water temperatures in the upper Sacramento River under current operations negatively impact Winter-run Chinook Salmon, perhaps including rearing juveniles. With the proposed improvements in water temperature management under the proposed action, adverse effects on Winter-run Chinook Salmon are expected to lessen.

5.6.3.1.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

Many of the factors that affect rearing and outmigrating Winter-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. As

indicated by the SAIL conceptual model (Figure 5.6-3), flows from the upper Sacramento River and tributaries of the middle Sacramento, combined with other environmental drivers such as floodplain connectivity, food production and retention, and water diversions, affect water temperature, DO, food availability, stranding, outmigration cues and other habitat attributes that influence timing, condition, and survival of rearing juvenile Winter-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017). The main difference between the juveniles in the middle Sacramento River and those in the upper river with respect to these adverse effects is that the juveniles in the middle river would generally be less sensitive to the effects because their greater age and size would result in greater robustness.

Juvenile Winter-run Chinook Salmon spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. The majority of Winter-run-sized juveniles occur in the middle Sacramento River from October through March (Table 5.6-1), with peak occurrence in December and January. The timing of peak migration is typically associated with the earliest occurrence of high flow storm events during the migration season (Windell et al. 2017).

Flows in the middle Sacramento River under the WOA scenario, as was true for the upper Sacramento River, would generally be low during fall and higher in the winter and early spring (Figure 5.6-24 below).

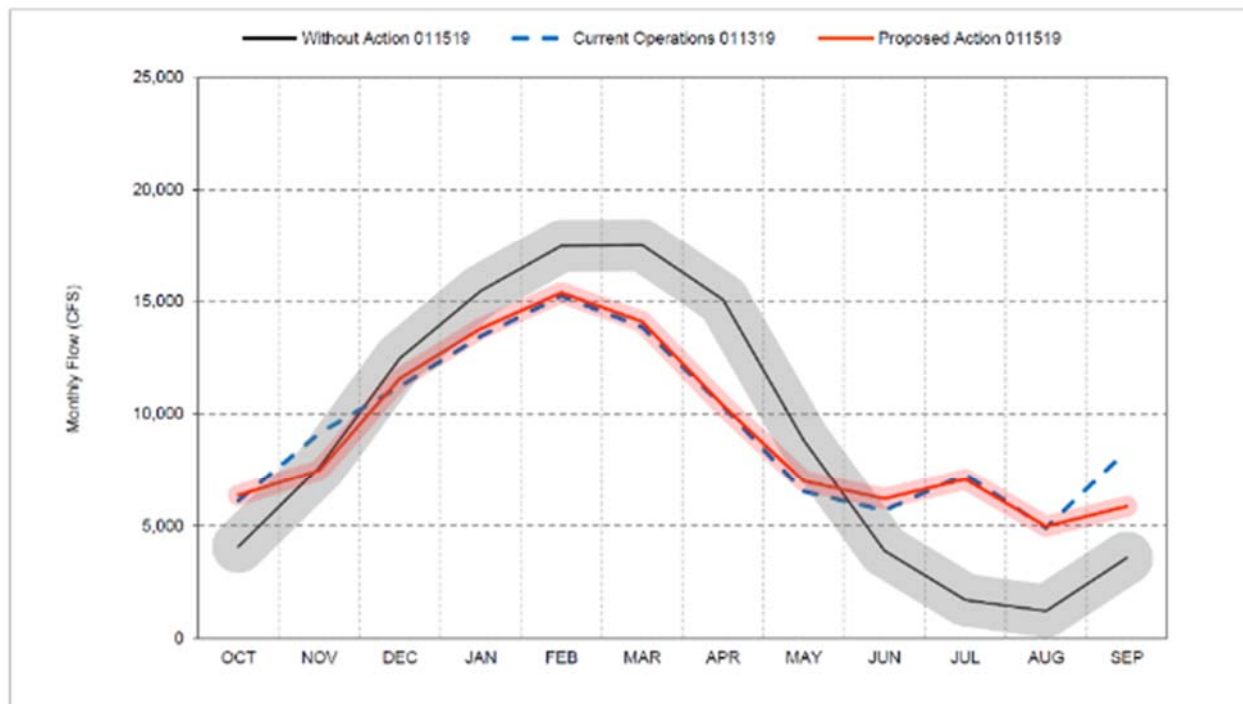


Figure 5.6-25: Sacramento River Flows at Wilkins Slough, Long-Term Average

As was true for the upper Sacramento River, the CalSim modeling results show large seasonal changes in the differences in middle Sacramento River flow between the WOA scenario and the proposed action. In October, the WOA scenario flows are below those of the proposed action except for the wettest years. By November, there is little difference in flow between the WOA and proposed action scenarios, except in the middle-high quarter of flows years, when the WOA flows tend to be moderately higher. In December

through February, the WOA flows are generally similar to or slightly higher than the proposed action for most flow levels and in March the WOA flows are consistently higher than the proposed action flows. These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low, and Shasta Reservoir storage releases under the proposed action during winter and spring, when uncontrolled flows are high. Diversion to storage is higher in spring than in winter because the flood control pool can be reduced during spring as flood risk declines.

The differences in flows between the WOA scenario and the proposed action would likely have large effects on Winter-run Chinook Salmon juveniles and their habitat. The higher summer and fall flows under the proposed action would likely result in improved conditions in juvenile rearing habitats, including more habitat complexity, side channel habitat structure, refuge habitat, and less disease potential. The lower proposed action flows in winter and spring, compared to WOA, could have both positive and negative effects on rearing juvenile Winter-run Chinook Salmon. Potential effects include less floodplain and side-channel habitat; poorer feeding conditions, increased competition and predation; higher water temperatures and lower DO; and reduced emigration flows. Potential benefits include lower stranding risk because of less flow fluctuations and lower contaminants loading from stormwater runoff. Although conditions may still be stressful for juvenile Winter-run Chinook Salmon, the impacts of increased summer and fall flows under the proposed action and COS would be beneficial compared to the WOA. Juveniles are younger and less robust during summer and fall and more sensitive to stressful conditions than other times of the year (NMFS 2009). Therefore, juvenile Winter-run Chinook Salmon would be less susceptible to reduced winter and spring flows under the proposed action as compared to the WOA.

Inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven particularly successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

CalSim modeling indicates that middle Sacramento River flows during October through March are generally similar between proposed action and COS scenario, except during November of above normal and wet years, for which the mean flows under the COS scenario are higher (see Appendix D, *Modeling* and Figure 5.6-24 above). The November reductions in flow under the proposed action scenario for the middle ranges of the exceedance curves (roughly 6,000 cfs to 13,000 cfs) would generally be suitable for rearing Winter-run Chinook Salmon juveniles (USFWS 2005).

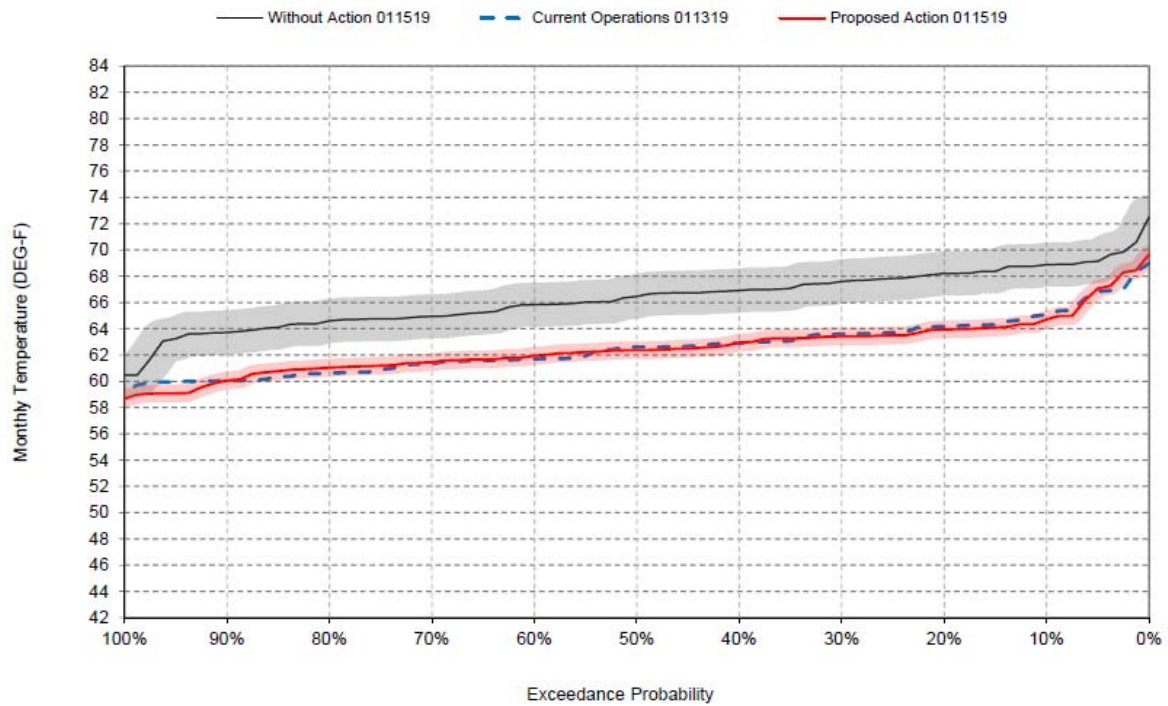


Figure 5.6-26. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, October

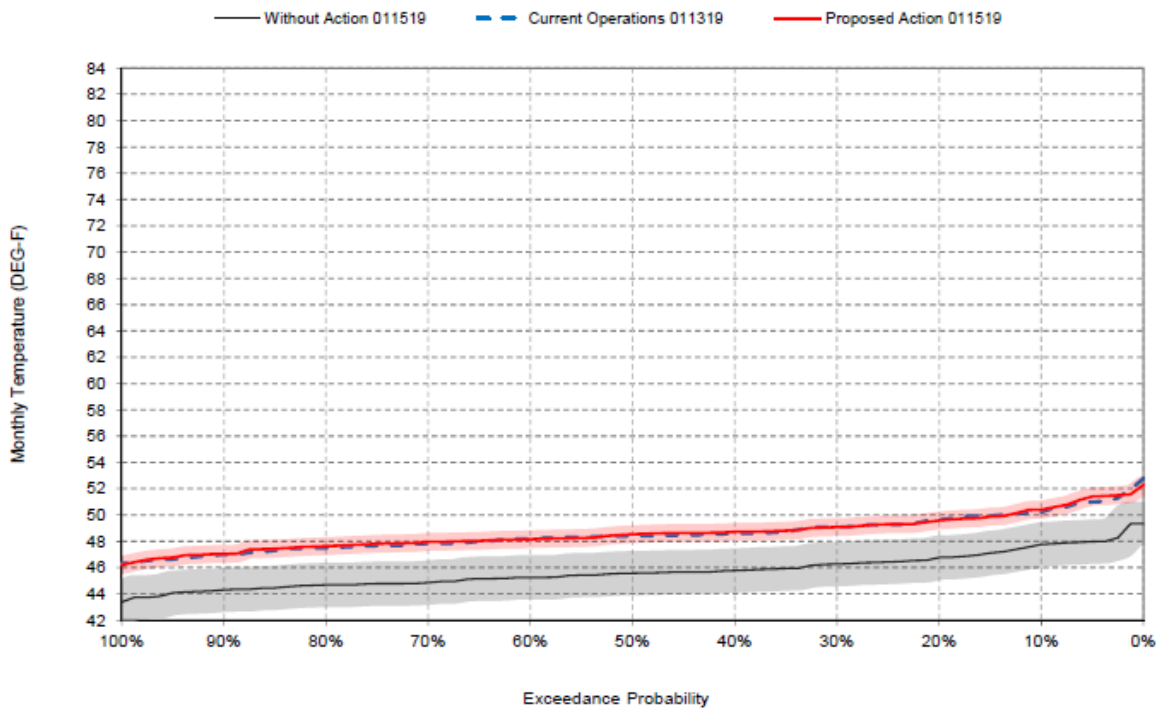


Figure 5.6-27. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, December

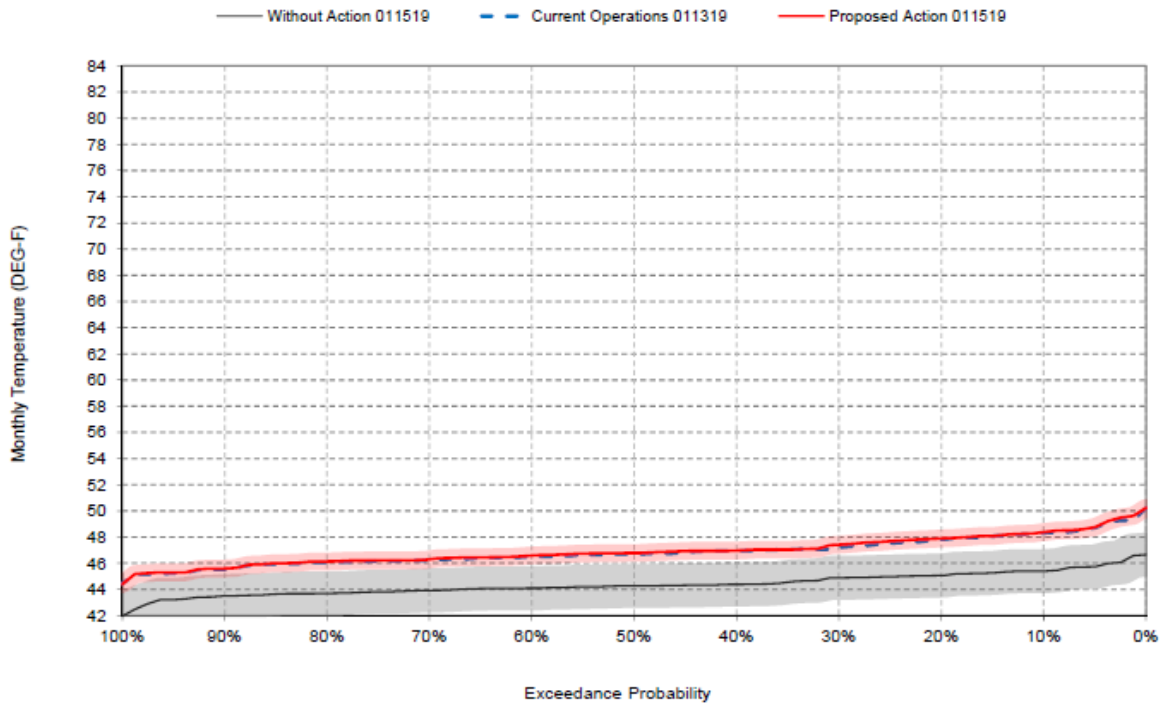


Figure 5.6-28. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, January

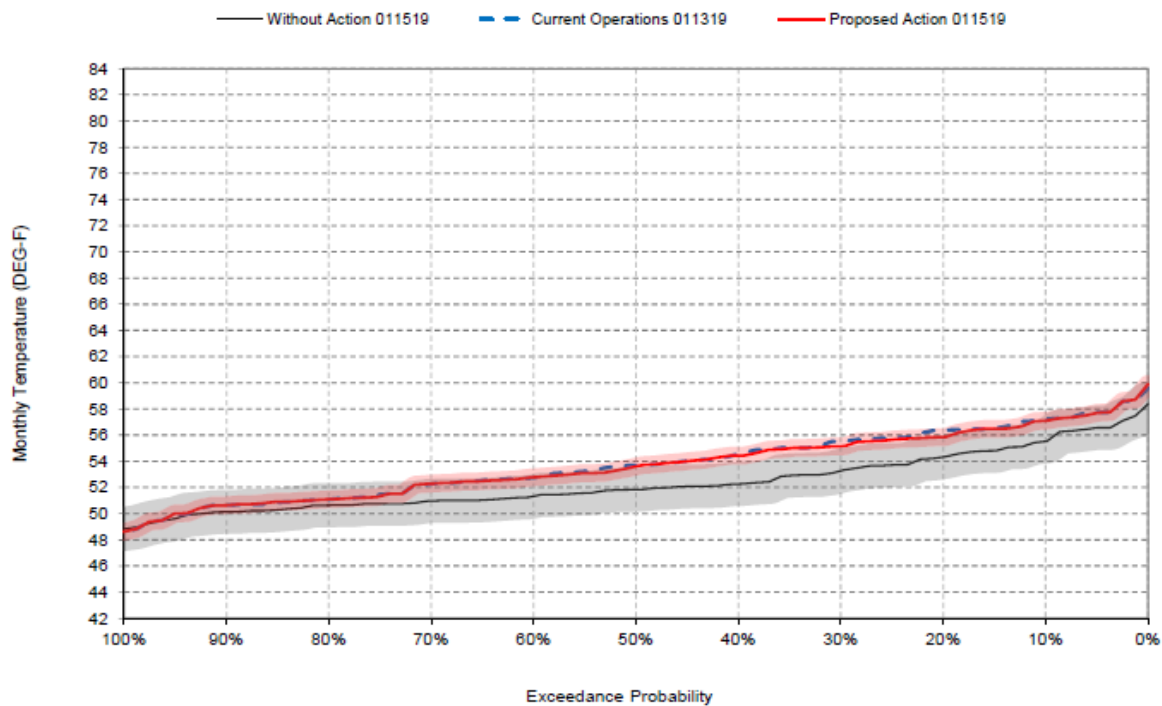


Figure 5.6-29. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, proposed action, and COS scenarios, March

Under the proposed action scenarios, monthly average water temperatures below the Colusa Basin Drain would range from about 59 to 69 degrees Fahrenheit during October, exceeding the 64 degrees Fahrenheit threshold in about a third of the years (Figure 5.6-25). From November through March, water temperatures for both scenarios would remain well below the 64 threshold (e.g., Figures 5.6-27 and 5.6-28).

Water temperatures under the proposed action are moderately lower than those under the WOA scenario during October in most years (Figures 5.6-25), similar during March (Figure 5.6-28), and well above the WOA scenario water temperatures from November through February (e.g. Figure 5.6-26 and 5.6-27). Water temperatures during most of the October through March period under the WOA scenarios and the proposed action are suitable for juvenile Winter-run Chinook Salmon that rear in and emigrate from the middle Sacramento River, therefore, Winter-run Chinook Salmon juveniles are not expected to be impacted by the proposed action.

5.6.3.1.4 Adult Migration from Ocean to Upper Sacramento River

CalSim modeling indicates that WOA flows are generally similar to or moderately higher than proposed action during December through February (see Appendix D, *Modeling*). In March, April and May, however, the WOA flows are considerably higher than the proposed action, except for May flows in critical water years (see Appendix D, *Modeling*). The lower flows at Wilkins Slough under the proposed action during March and April, as well as January and February in drier years, would likely affect adult Winter-run Chinook Salmon migrating in the middle Sacramento River by reducing water quality and increasing stranding, straying, poaching, and disease risks (Windell et al. 2017). Conditions under the proposed action would be better in May of drier years, when flows in ten percent of WOA years are below 1,000 cfs (Figure 5.6-29). In these low WOA years, the proposed action would reduce passage problems for upstream migrating adults.

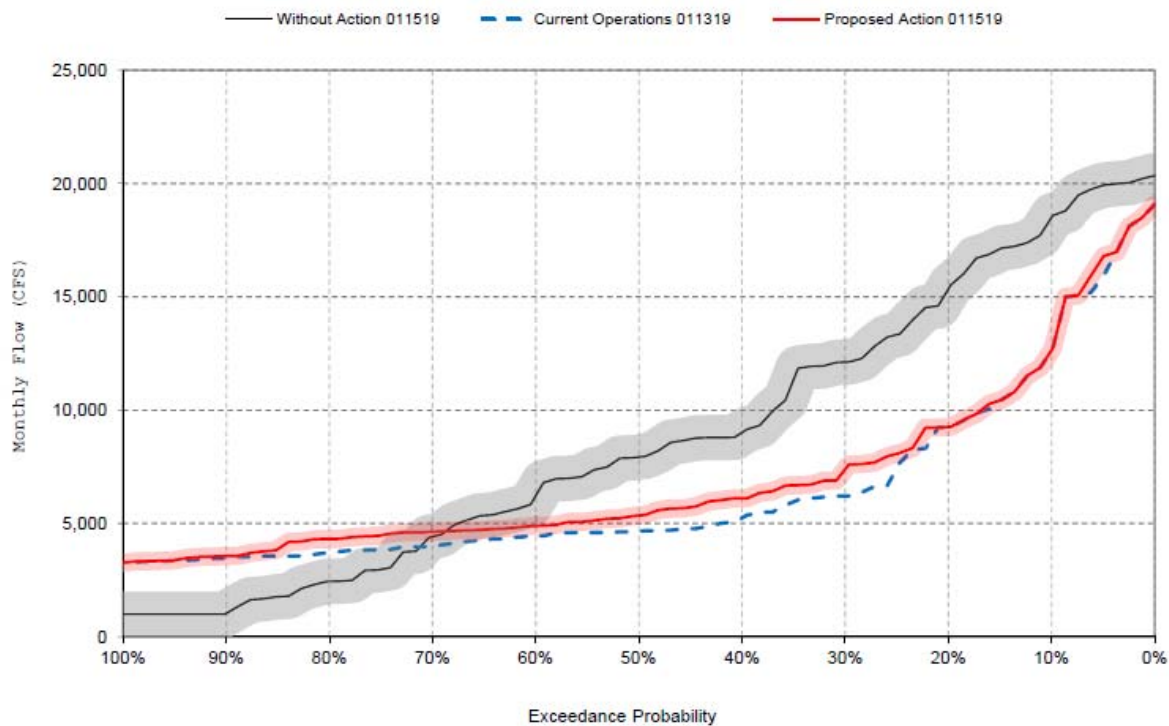


Figure 5.6-30. Modeled Sacramento River Flows at Wilkins Slough, May

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action scenarios are similar to WOA water temperatures during May, except in warmer years, when the WOA water temperatures are higher (Figure 5.6-29). The proposed action water temperatures are generally above the WOA water temperatures from December through April (e.g. Figures 14-9 through 14-13 in the HEC5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick, water temperatures under the proposed action scenarios are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures from December through February (e.g. Figures 5-9 through 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April and May (Figures 5.6-30 and 5.6-31).

Water temperatures during December through April period are suitable for adult Winter-run Chinook Salmon immigrating in the middle Sacramento River or holding in the upper river. In May, however, modeled water temperatures in the middle river below the Colusa Basin Drain exceed the threshold for immigrating adults in a large percentage of years under the WOA scenarios and the proposed action, with a greater percentage of years exceeding the threshold under the WOA scenario. At Keswick, only about four percent of years are expected to exceed the 68 degrees Fahrenheit threshold for holding adults under the WOA scenario, and no years are expected to exceed the threshold under the proposed action and COS scenarios. The anticipated water temperature differences among the scenarios during May are expected to result in greater negative impacts on the immigrating Winter-run Chinook Salmon adults in the middle Sacramento River under the WOA conditions than under the proposed action and COS conditions.

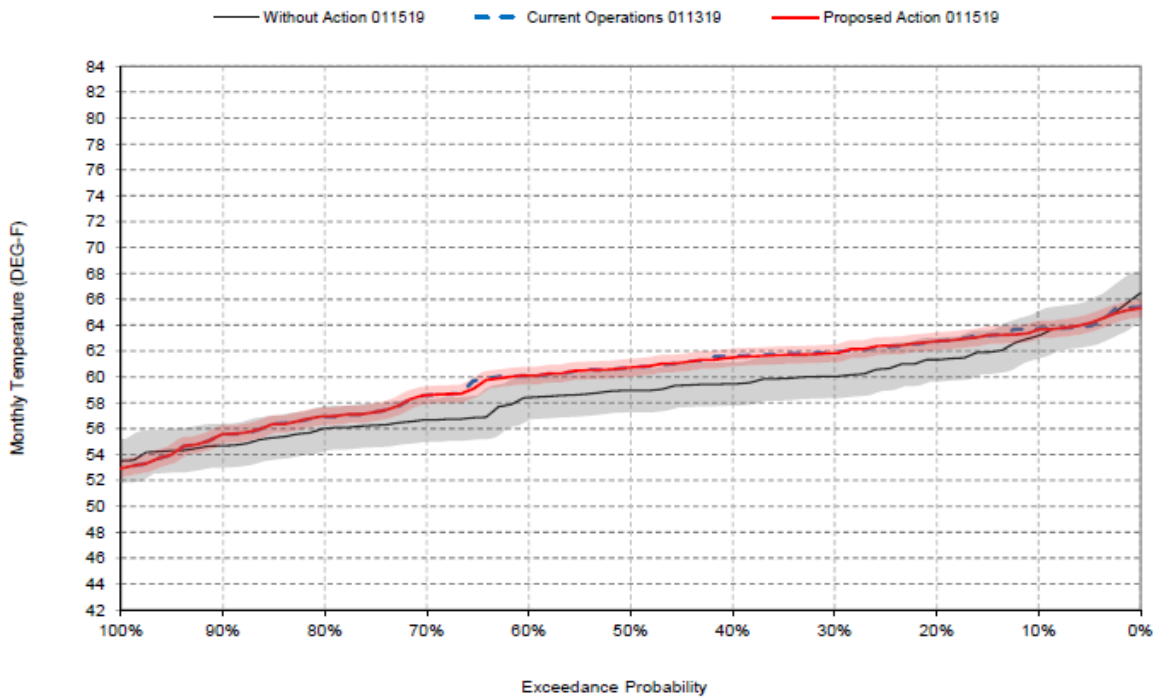


Figure 5.6-31. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, COS and proposed action scenarios, April

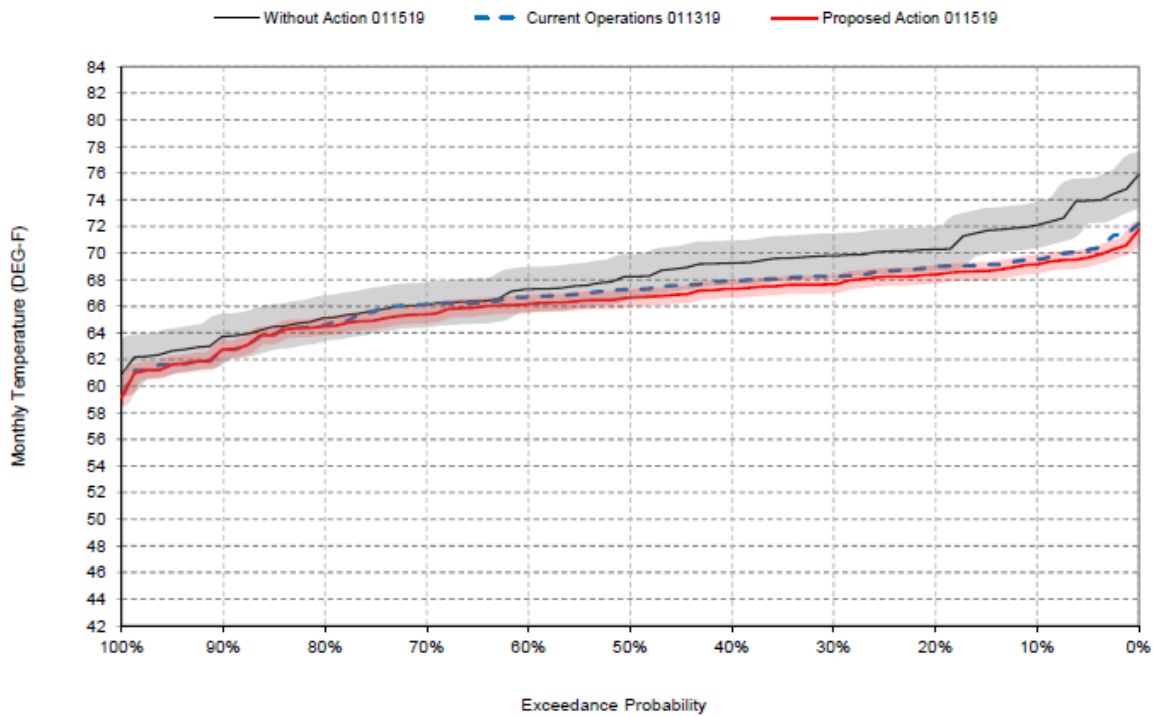


Figure 5.6-32. HEC-5Q Sacramento River Water Temperatures at Knights Landing under the WOA, COS and proposed action scenarios, May

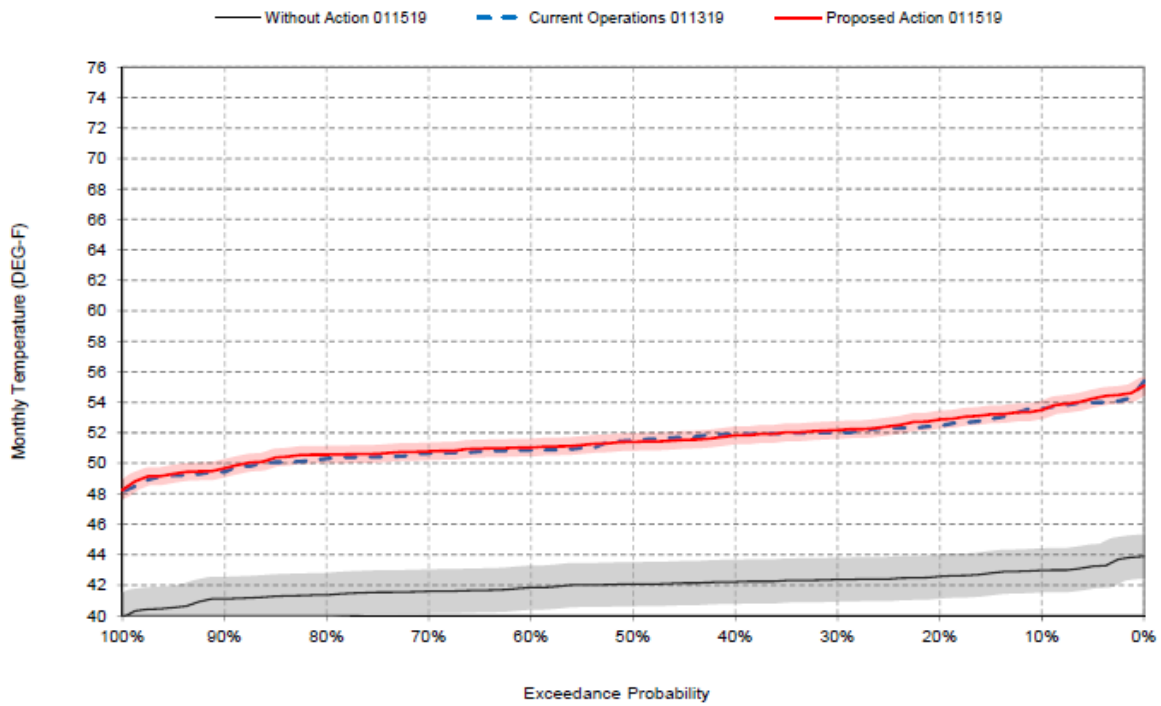


Figure 5.6-33. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, December

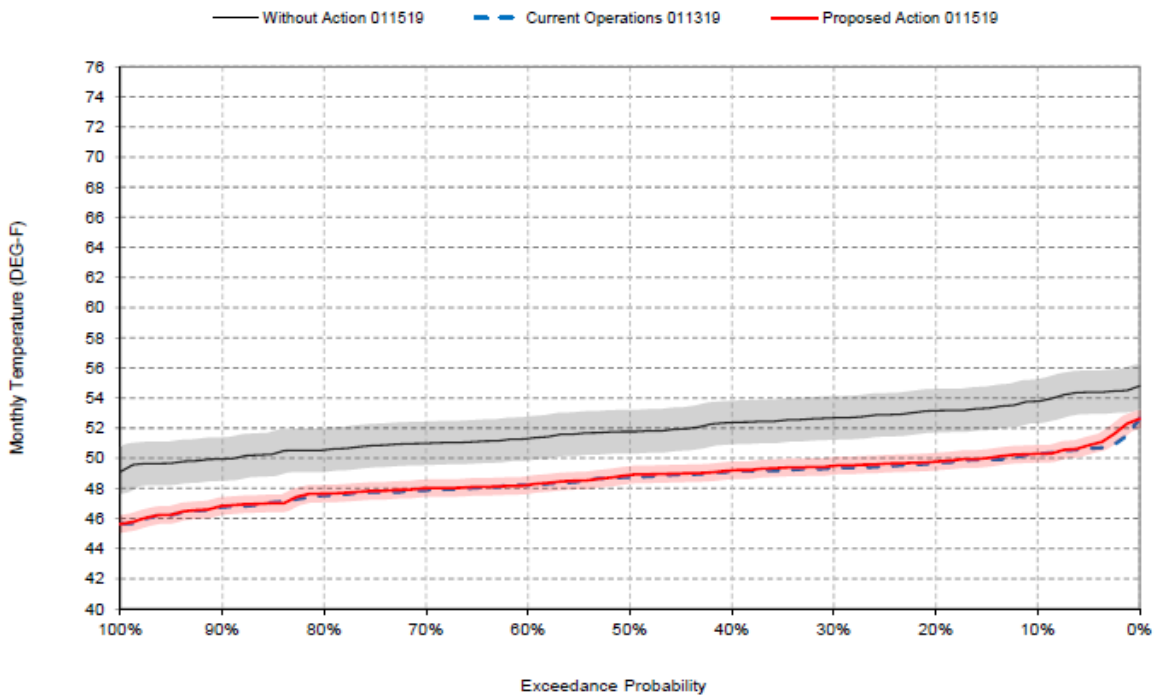


Figure 5.6-34. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, April

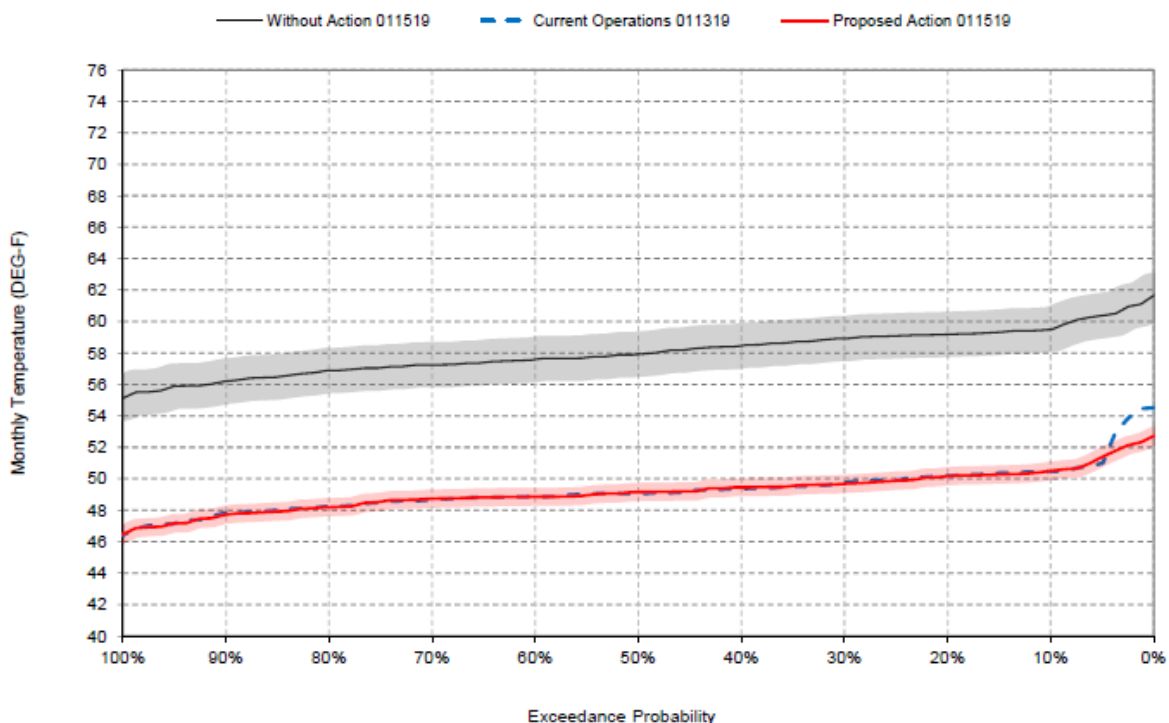


Figure 5.6-35. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, May

There are few differences in water temperatures between the proposed action and COS scenarios during any of the months that adult Winter-run Chinook Salmon migrate upstream in the middle Sacramento River or hold in the upper river (see Appendix D, *Modeling*). Under the proposed action and COS scenarios, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating adults from December through April, but would exceed the threshold in May in about 30 percent of the years (Figure 5.6-31). In the upper Sacramento River at Keswick Dam under the proposed action and COS scenarios, the average water temperatures would be well below the 61 degrees Fahrenheit threshold for holding adults from December through May (Figures 5.6-32-34). The May water temperatures in the middle Sacramento River modeled for many years under both the proposed action and COS scenarios would likely negatively impact Winter-run Chinook Salmon adults migrating at that time in the middle Sacramento River, compared to WOA.

5.6.3.1.5 Adult Holding in the Upper Sacramento River

As indicated by the SAIL conceptual model (Figure 5.6-6), flows from Keswick Dam releases affect water temperature, DO, and other habitat attributes that influence the timing, condition, distribution, and survival of adult Winter-run Chinook Salmon during their holding and spawning in the upper Sacramento River. The period of holding is essentially the same as that for upstream migration in the middle and upper Sacramento River, December through May. Spawning extends this period through June, July and August.

CalSim modeling also indicates that WOA flows are generally similar to or moderately higher than proposed action during December through February (Figures 15-9 through 15-11 in the CalSim II Flows section of Appendix D), are much higher than proposed action during March and April and during May of wetter years (Figures 15-12 through 15-14 in the CalSim II Flows section of Appendix D), and are lower than proposed action flows during June through August (Figures 15-15 through 15-17 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding and spawning adult Winter-run Chinook Salmon by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, lower risk from anglers, and a greater area of river bed with suitable attributes for redds (Windell et al. 2017). The proposed action scenarios would have much higher flows than the WOA scenario during summer, when flow is generally low and so particularly likely to limit Winter-run Chinook Salmon holding and spawning success. Therefore, the proposed action is expected to be more protective of Winter-run Chinook Salmon than the WOA conditions.

Flows during the December through August period would generally be similar between the proposed action and COS scenario (Figure 15-9 through 15-17 in the CalSim II Flows section of Appendix D). The biggest differences among these scenarios would occur in June for the upper 70 percent of flows, when proposed action scenario flows would be greater than COS flows. The differences occur over a range of flows from 8,000 cfs to 16,000 cfs, all of which are suitable for holding and spawning adults (USFWS 2003), therefore, flows are not expected to substantially affect adult Winter-run Chinook Salmon.

As noted above, the period of adult holding and spawning in the upper Sacramento River extends from December through August. In the upper Sacramento River at Keswick, water temperatures under the proposed action are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures from December through February (Figure 5-9 through 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April through August (Figures 5-13 through 5-17 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario exceed the 61 degrees Fahrenheit holding threshold in almost all years during June through August and the 56 and 53.5 degrees Fahrenheit spawning threshold in almost all years during May through August. In contrast, water temperatures under the proposed action do not exceed the 61 degrees Fahrenheit holding threshold in almost all years of every month in the December through August period and do not to exceed the 56 and 53.5 degrees Fahrenheit thresholds in almost all years of all months in the period, except for 15 and 30 percent of years in July and August, respectively. These results indicate that the proposed action, relative to the WOA, provide a clear benefit to adult Winter-run Chinook Salmon individuals holding and spawning in the upper Sacramento River.

There are few differences in water temperatures among the proposed action and COS scenarios during any of the months that adult Winter-run Chinook Salmon hold and spawn in the upper Sacramento River (e.g., Figures 5-9 through 5-17 in the HEC5Q Temperatures section of Appendix D). At Keswick Dam, under the proposed action and COS, the mean water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults for all months from December through August, except for the warmest one percent of years in August (Figure 5-17 in the HEC5Q Temperatures section of Appendix D). The 56 degrees Fahrenheit thresholds for spawning adults would be exceeded under the proposed action and COS scenarios only during August in about five percent of years, and the 53.5 degrees Fahrenheit would be exceeded in May through August, including the warmest years, two percent of years in May and June, the warmest 15 percent of years in July, and the warmest 30 percent of years in August. In view of the improved water temperature management operations, including less releases for Delta outflow and more cold water storage, the proposed action is expected to benefit the Winter-run Chinook Salmon adults relative to the COS.

5.6.3.2 *Spring Pulse Flows*

5.6.3.2.1 Egg to Fry Emergence

Spring pulse flows could reduce cold water pool available for Winter-run Chinook Salmon eggs. Therefore, Reclamation only proposes pulse flows if projected May 1 Shasta storage is greater than 4 MAF, and storage is unlikely to drop such that Shasta summer temperature management would drop into lower tiers.

5.6.3.2.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

Spring pulse flows could help trigger outmigration of Winter-run Chinook Salmon juveniles. See the Spring-run Chinook Salmon section for a discussion of benefits of spring pulses for outmigrating juveniles.

5.6.3.2.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the upper Sacramento River.

5.6.3.2.4 Adult Migration from Ocean to Upper Sacramento River

Spring pulses would have potentially beneficial effects for Winter-run Chinook Salmon adults who are migrating up the Sacramento River in the late spring. The spring pulses could cool temperatures and allow for better passage.

5.6.3.2.5 Adult Holding in the Upper Sacramento River

Spring pulses would have no effect on adult holding, other than those discussed for other lifestages above.

5.6.3.3 *Fall and Winter Refill and Redd Maintenance*

5.6.3.3.1 Egg to Fry Emergence

The proposed action would allow for higher fall flows than WOA, leading to less dewatering of the last few emerging Winter-run Chinook Salmon redds. The proposed action would also reduce overall instances of temperature dependent mortality compared to the COS, but may result in dewatering limited redds in certain years in order to protect the next year's cold water resource.

5.6.3.3.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon rearing and outmigrating juveniles would experience higher fall flows than under WOA, leading to more food, rearing habitat, and cover.

5.6.3.3.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

Winter-run Chinook Salmon rearing and outmigrating juveniles would experience higher fall flows than under WOA, leading to more food, rearing habitat, and cover.

5.6.3.3.4 Adult Migration from Ocean to Upper Sacramento River

Fall and winter refill and redd maintenance would have no effect to this lifestage as it does not overlap with the time period of this action.

5.6.3.3.5 Adult Holding in the Upper Sacramento River

See adult migration from ocean to upper Sacramento River.

5.6.3.4 *Delta Seasonal Operations*

Under WOA conditions, the Delta Cross channel would be closed and no CVP or SWP diversion would occur. The proposed action stores water in the fall, winter, and spring for release and conveyance through the Delta in the summer and fall.

5.6.3.4.1 Rearing to Outmigrating Juveniles in Bay-Delta

Rearing Winter-run Chinook Salmon are present in the Delta between October and May. Key habitat attributes relevant to seasonal operations in the Delta include outmigration cues and entrainment risk.

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, and 2) “far-field” mortality resulting from altered hydrodynamics. Near-field or entrainment effects of proposed seasonal operations can be assessed by examining patterns of proportional population entrainment available from decades of coded wire tag studies (e.g. Zeug and Cavallo 2014). A foundation for assessing far-field effects has been provided by work of the Collaborative Adaptive Management Team’s (CAMT) Salmonid Scoping Team (SST). The SST completed a thorough review of this subject and defined a driver-linkage-outcome (DLO) framework for specifying how water project operations (the “driver”) can influence juvenile salmonid behavior (the “linkage”) and potentially cause changes in survival or routing (the “outcome”). The SST concluded altered “Channel Velocity” and altered “Flow Direction” were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta. Figure 5.6-35 provides a simplified conceptual model of the DLO defined by the CAMT SST.

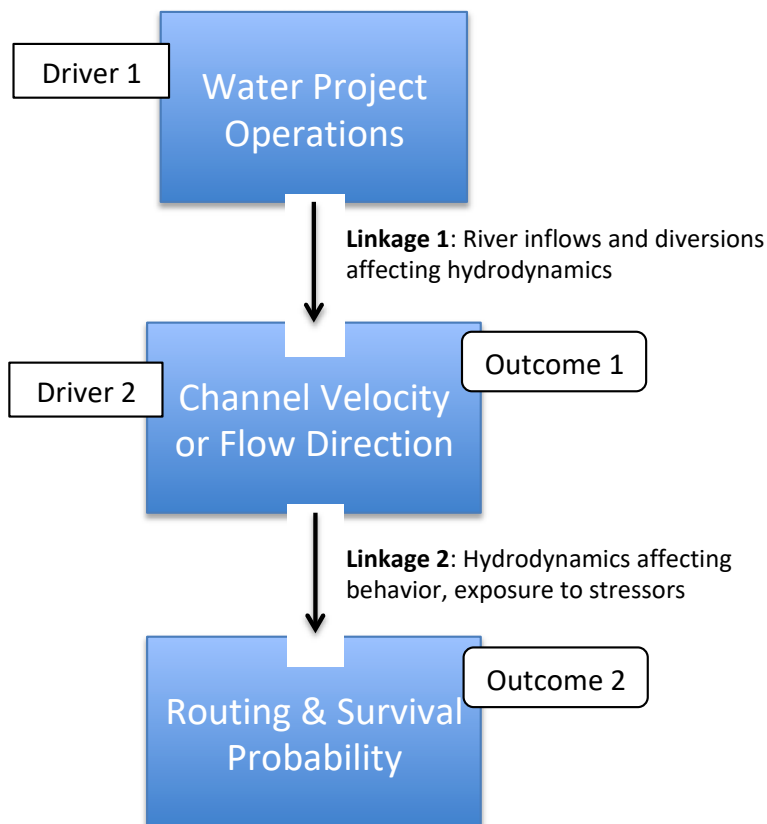


Figure 5.6-36. Conceptual Model for Far-field Effects of Water Project Operations on Juvenile Salmonids in the Delta. This CM is a Simplified Version of the Information Provided by the CAMT SST.

In order to assess the potential for water project operations to influence survival and routing, Reclamation and DWR analyzed Delta hydrodynamic conditions by creating maps from DSM2 Hydro modeling. The maps are based on a comparative metric, proportion overlap (more below), to capture channel-level hydrodynamic details as a single number for color-scale mapping of Delta channels.

The objective of the comparative metric is to summarize the water velocity time series for each channel and scenario such the channel-level comparison is captured in a single number. For the proportion overlap metric, kernel density estimates are calculated on each time series. The kernel density estimates represent a non-parametric smoothing of the empirical distribution of time series values. The proportion overlap of two kernel density estimates is calculated with the following steps: 1) calculate the total area under the curve (AUC_t) as the sum of the AUC for each density estimate, 2) calculate the AUC of the overlapping portions (AUC_o) of the two density distributions being compared, and 3) calculate the overlapping proportion of the density distributions as AUC_o/AUC_t . Proportion overlap is naturally bound by zero and one; a value of zero indicates no overlap and a value of one indicates complete overlap. Lower values of proportion overlap identify channels demonstrating larger differences in a scenario comparison.

The proportion overlap metric is best applied over relatively short time periods because seasonal and annual variation in water velocity can overwhelm differences between scenarios. Thus, Reclamation calculated proportion overlap for every DSM2 channel for two seasons (Dec-Feb, Mar-May) in each water year (1922-2003). DSM2 output was excluded from water year 1921 to allow for an extensive burn-

in period. The proportion overlap was calculated based on hourly DSM2 output. Because each season was roughly 90 days, each comparison involved roughly 4,300 DSM2 values (2 scenarios * 24 hours * 90 days) for each channel.

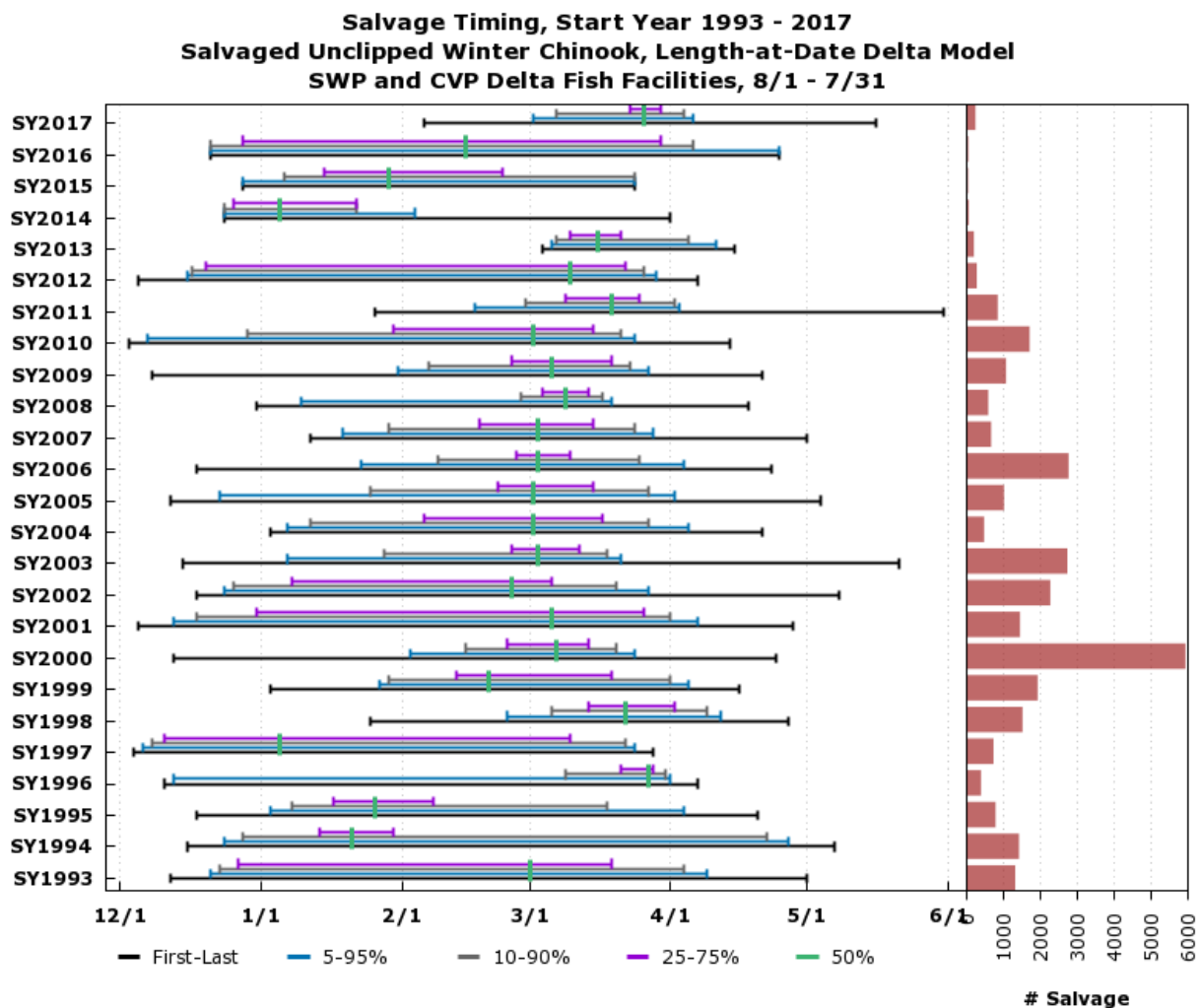
Because the proportion overlap was calculated for each channel in each water year, the proportion overlap values were summarized prior to mapping (i.e., not feasible to map proportion overlap for every comparison in every water year). To summarize, the minimum and median proportion overlap for each channel for each water year type for each comparison was found. The minimum values represent the maximum expected effect. The median values represent the average expected effect. Note that the year with the minimum (or median) proportion overlap for one channel might not be the same year as for another channel.

5.6.3.4.1.1 Entrainment

As there are no exports under WOA, there is no entrainment risk under WOA. In the December through May period, the average total export rate, under the proposed action, is slightly higher difference compared to COS. Therefore, slightly higher entrainment is expected as compared to COS.

Zeug and Cavallo (2014) analyzed more than 1,000 release groups representing more than 28 million coded wire tagged juvenile fish including winter, late fall and fall run Chinook Salmon. This data represents large release groups of tagged smolts where the number of fish representing each release group lost to entrainment at the export facilities has been estimated. Cavallo (2016) provided a supplemental assessment of Winter-run Chinook Salmon entrainment risk (building upon Zeug and Cavallo 2014) that showed total CVP and SWP exports described entrainment risk better than OMR or other flow metrics. Entrainment loss results as reported below represents the proportion of coded wire tagged Winter-run Chinook Salmon released upstream of the Delta which were entrained at South Delta export facilities. This proportion accounts for and includes expansion for sampling effort at the salvage facilities and also prescreen mortality. With total exports of $\leq 6,500$ cfs, entrainment loss rates for Winter-run Chinook Salmon range between 0 and 1.5 percent (mean 0.1%) (Zeug and Cavallo, 2014). With total exports greater than 6,500 cfs, entrainment losses range between 0 and 4 percent (mean 0.25%) (Zeug and Cavallo, 2014). For December through February, the proposed action has an average total export rate similar to COS (7,988 and 7,622 cfs respectively; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*), and will therefore have similar entrainment risk. In the March through June period, total exports for the proposed action increase entrainment risk relative to COS (5,873 vs. 4,174 cfs, respectively; Figure H-2 – Appendix H, *Bay-Delta Aquatics Effects Figures*), but entrainment losses should average 0.1 percent and not exceed 1.5 percent. While entrainment risk will increase under the proposed action as compared to WOA or COS, the proposed action includes restrictions to OMR (-3,500 cfs and -2,500 cfs) when cumulative salvage of any species reaches 50 percent of the salvage threshold. CalSim modeling incorporates an assumption for this cumulative salvage restriction.

According to SacPAS (Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*), between 0 and 6000 unclipped Winter-run Chinook salmon are currently salvaged at CVP and SWP fish facilities each year, and between 0 and 8000 clipped Winter-run Chinook salmon from the Livingston Stone Fish Hatchery. Salvage estimates are made by counting fish for 30 minutes every 2 hours, and multiplying by 4 to obtain the estimate for the number of fish that are entrained into Tracy Pumping Plant or eaten by predators in the canal or fish facility. Entrainment results in harassment and often mortality for juvenile Chinook salmon. Fish that are counted are salvaged and trucked back to the Delta where they are released and may complete their lifecycle.



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Figure 5.6-37: Juvenile Winter-run Chinook Salmon salvage at Jones and Banks Pumping Plants

5.6.3.4.1.2 Routing

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2. Juvenile Winter-run Chinook Salmon are present in the Sacramento River at Sherwood Harbor upstream of the first distributary junctions between November and March with peak abundance in February and March (Table 5.6-1).

Comparing the proposed action to WOA in the December to February period revealed low velocity overlap in Dry, Above Normal and Wet years with higher velocities in the WOA scenario (Figure H-4 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were more similar in Critical and Below Normal years; however, velocities were still higher in the WOA scenario. This pattern indicates routing into the interior Delta would be higher under the proposed action than under WOA (Perry et al. 2015). In the March to May period comparison of the proposed action revealed similar patterns of velocity overlap indicating routing into the interior Delta would be higher under the proposed action during March to May. Comparing the proposed action with WOA in March to May revealed low overlap in Sacramento River

main stem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA scenario, indicating routing into the interior Delta under the proposed action would be higher than WOA.

Abundance of juvenile Winter-run Chinook Salmon at Chipps Island peaks in March and April but fish are collected between December and May (Table 5.61). During this time period, Winter-run Chinook Salmon originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can potentially be exposed to hydrodynamic effects associated with the CVP and SWP that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. The December to February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin rivers between the proposed action and WOA (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*).). Similar results were obtained when comparing the proposed action to WOA in the March to May period (Figures H-9 and H-10– Appendix H, *Bay-Delta Aquatics Effects Figures*).).

In the December to February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was more than 50 percent in Critical, Dry, Below Normal and Above Normal Years (Figure H-3 – Appendix H, *Bay-Delta Aquatics Effects Figures*). In Wet years, velocity overlap in this reach was ≤ 50 percent. Velocities were higher under proposed action in all water year types in December through February indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015 described for the December-February period (Figure H-11 – Appendix H, *Bay-Delta Aquatics Effects Figures*).).

Overall, the proposed action results in lower flows in the Delta in the spring than under WOA, during the outmigrating juvenile time period. Survival probabilities are non-linear; however, the lower discharge at Freeport in the spring under the proposed action results in greater probability of routing into the interior Delta, which has the lowest survival probability regardless of flow.

5.6.3.4.1.3 Through-Delta Survival

Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases.

To examine potential effects of the proposed action, changes in velocity distributions were examined for the Sacramento River at Walnut Grove and Steamboat Slough which are both in this “transitional” region. During the December to February period at Walnut Grove, there are higher velocities under WOA than the proposed action Figure H-12– Appendix H, *Bay-Delta Aquatics Effects Figures*. When the proposed action was compared to WOA, overlap was moderate to high with values between 45.0 and 76.6 percent (Figure H-14– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14– Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March through May period at Walnut Grove, when the proposed action was compared to WOA, velocity overlap was variable among water year types from a low of 18.7 percent in Wet years to 63.5 percent in Critical years (Figure H-16– Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocity overlap was lower when proposed action was compared to WOA at Steamboat Slough in the March through May period (Figure H-18– Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (23.2%) and highest in Critical years (74.9%). In all water year types, velocities were greater under the WOA relative to the proposed action.

Overall, the proposed action results in lower flows in the Delta in the spring than under WOA, during the outmigrating juvenile time period. Survival probabilities are non-linear; however, the lower discharge at Freeport in the spring under the proposed action results in lower survival in the transition reaches. Lower flows also lead to greater probability of routing into the interior Delta, which has the lowest survival probability regardless of flow.

5.6.3.5 *Delta Cross Channel Operations*

5.6.3.5.1 Rearing to Outmigrating Juveniles in Bay-Delta

Under WOA conditions, the DCC would remain closed and Winter-run would not be entrained into the central and south Delta through the DCC. Under the proposed action, the DCC may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes. The peak migration of juvenile Winter-run Chinook Salmon in the Sacramento River at Sherwood Harbor, which is near the DCC, occurs from February through March (Table 5.6-1). Therefore, the DCC is closed for the majority of the juvenile Winter-run Chinook Salmon migration period in the Sacramento River and as such the proportion of juvenile Winter-run Chinook Salmon exposed to an open DCC would be negligible. Juvenile Chinook Salmon entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010; Perry et al. 2018).

5.6.3.6 *Agricultural Barriers*

Juvenile Winter-run Chinook Salmon are not expected to co-occur in space or time with the agricultural barriers indicating no potential impacts.

5.6.3.7 *Contra Costa Water District Rock Slough Intake*

CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The subject of this consultation is the actual diversion of water through the Rock Slough Intake, covered under the 2009 biological opinion on the long-term coordinated operations of the CVP and SWP. However, since the 2009 biological opinion, the Rock Slough Fish Screen has been built, and entrainment of salmonids resulting from diverting water the into Rock Slough intake has been fully avoided. Adverse effects of fish screen operation are covered under the 2017 biological opinion.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for Winter-run Chinook Salmon (NMFS 2017), approximately 18 miles from the Sacramento River via the shortest route. Designated critical habitat for Winter-run Chinook Salmon does not occur within Rock Slough, but is present further to the north in the Delta (NMFS 2017; NMFS 2014). Salmonids are expected to avoid the area of the Rock Slough Intake during certain times of the year based on historical water temperatures.

Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of Winter-run Chinook Salmon presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD's operations. From 1994 through 1999, CDFW conducted fish monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over

this 6-year period, CDFW captured a total of 13 juvenile Winter-run Chinook Salmon from January through May (CDFG 2002; NMFS 2017). From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected no juvenile or adult Winter-run Chinook Salmon at the Rock Slough Headworks (Reclamation 2016; NMFS 2017).

Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018, 47 salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a), but none of the captured fish were identified as Winter-run Chinook Salmon (NMFS 2017).

NMFS issued a biological opinion in 2017 (NMFS 2017) that considered improvements to the RSFS facility including the hydraulic rake cleaning system, operations and maintenance (O&M) of the RSFS and associated appurtenances, and administrative actions such as the transfer of O&M activities from Reclamation to CCWD. NMFS determined that the O&M of RSFS may result in the incidental take of juvenile Winter-run Chinook Salmon and provided an incidental take limit based upon the number of listed fish collected in the pre and post-construction RSFS monitoring (NMFS 2017). The incidental take provided in NMFS 2017 is five juvenile Winter-run Chinook Salmon per year.

5.6.3.7.1 Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile Winter-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmon can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates. One indicator of reverse flows is the net flow in Old and Middle Rivers (OMR). Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect OMR, and any effect that diversions at Rock Slough Intake would have in the Old and Middle River corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants.

However, diversions at the Rock Slough Intake could affect flows in the San Joaquin River at Jersey Point, which is approximately 14 river miles from the Rock Slough Intake (via the shortest route through Franks Tract). Mean velocity in a river channel can be calculated by dividing the flow rate by the cross-sectional area of the channel. The maximum effect of Rock Slough diversions on the channel velocity would be the maximum diversion rate (350 cfs) divided by the minimum cross-sectional area of the channel. This calculation assumes that all water diverted at Rock Slough comes from the San Joaquin River at Jersey Point, which is a conservative assumption (i.e., overestimates the effect on velocity). The cross-sectional area of the San Joaquin River at Jersey Point is approximately 60,500 square feet (sf), but varies depending on the tidal stage from approximately 56,000 sf (at low tide and low San Joaquin River flow) to 68,000 sf (at high tide and high San Joaquin River flow) as shown in Figure 5.6-36.

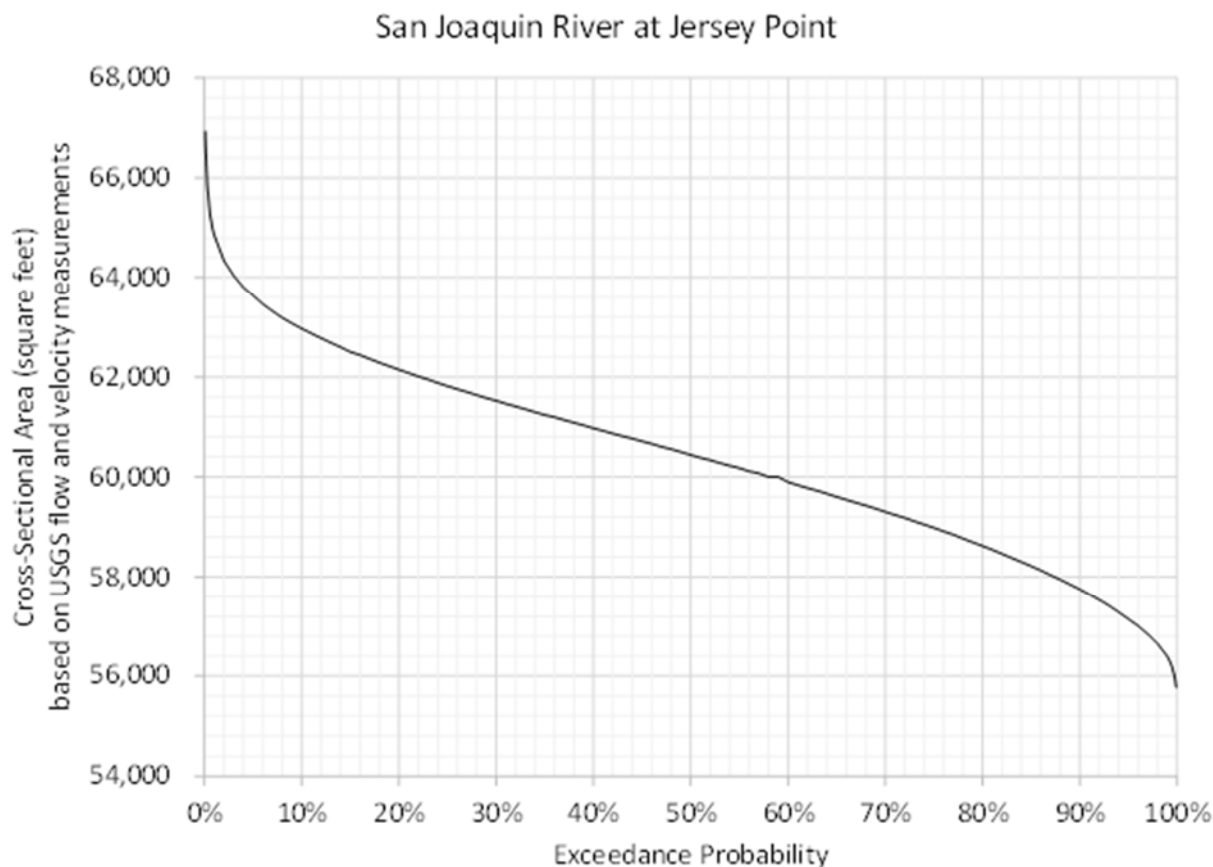


Figure 5.6-38. Cross-sectional area of the San Joaquin River at Jersey Point (Station: 11337190) Calculated from USGS Measurements of Flow and Velocity every 15 Minutes for Water Years 2014 through 2018.

The maximum effect of water diversions at Rock Slough Intake on velocity in the San Joaquin River at Jersey Point is calculated as 350 cfs divided by 56,000 square feet; resulting in 0.00625 feet per second (ft/sec). For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from Rock Slough diversions. Furthermore, the actual effect is likely to be much lower than 0.00625 ft/sec because the water diverted at the Rock Slough Intake does not all come from the San Joaquin River west of Jersey Point.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, the combined effect of all three intakes is examined. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile Winter-run Chinook Salmon and are not likely to affect the movement of juvenile salmonids.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. To examine the effect on neutrally buoyant particles, the distance that a particle would travel due to the maximum permitted Rock Slough diversions over the course of a day is calculated. A change in velocity of 0.00625 ft/sec could move a neutrally buoyant particle approximately 540 ft over the course of the day (0.00625 ft/sec * 86,400 sec/day). For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is not significant in comparison to the tidal excursion and mixing at this location.

5.6.3.7.2 Adults

Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult Winter-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake and have never been observed in 24 years of fish monitoring (1994-2018). However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). As illustrated in NMFS (2017) (Figure 10), water diversions at the Rock Slough Intake reduce the ebb tidal flows through the RSFS. Thus, the diversion of water at the Rock Slough Intake, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal. Furthermore, it is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs. Although the likelihood that adult Winter-run Chinook Salmon will be present near the Rock Slough Intake is low, a small number of fish could stray into Rock Slough, or be attracted by the flows exiting the Contra Costa Canal on ebb tides.

5.6.3.8 *North Bay Aqueduct*

The proposed action includes the North Bay Aqueduct (NBA) intake in the North Delta and operation of the Barker Slough Pumping Plant. Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data is available at <https://www.wildlife.ca.gov/Regions/3>). There should be no discernable effect to the Winter-run Chinook salmon due to the operations of the Barker Slough Pumping Facility. This is due to the infrequent presence of Winter-run Chinook salmon in the monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Facility fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screen.

5.6.3.9 Water Transfers

Under the WOA scenario, there is no pumping from the Delta and therefore no water transfers through Jones or Banks Pumping Plants. Under the proposed action, Reclamation is extending the water transfer window until November, from the current July through September window. This extension could result in increased flows entering the Delta and increased pumping at Jones and Banks Pumping Plants.

Egg, alevin, and fry lifestages of Winter-run Chinook Salmon do not occur in the Delta, and therefore would not be impacted by this action. Winter-run Chinook Salmon juveniles enter the Delta starting in December, and therefore would be unlikely to be exposed to increased pumping of water transfers through November. Adults returning from the ocean could possibly be in the Delta in July; however, they are strong swimmers, large fish that can avoid predators, and are unlikely to have impacts associated with direct entrainment of the pumping plants.

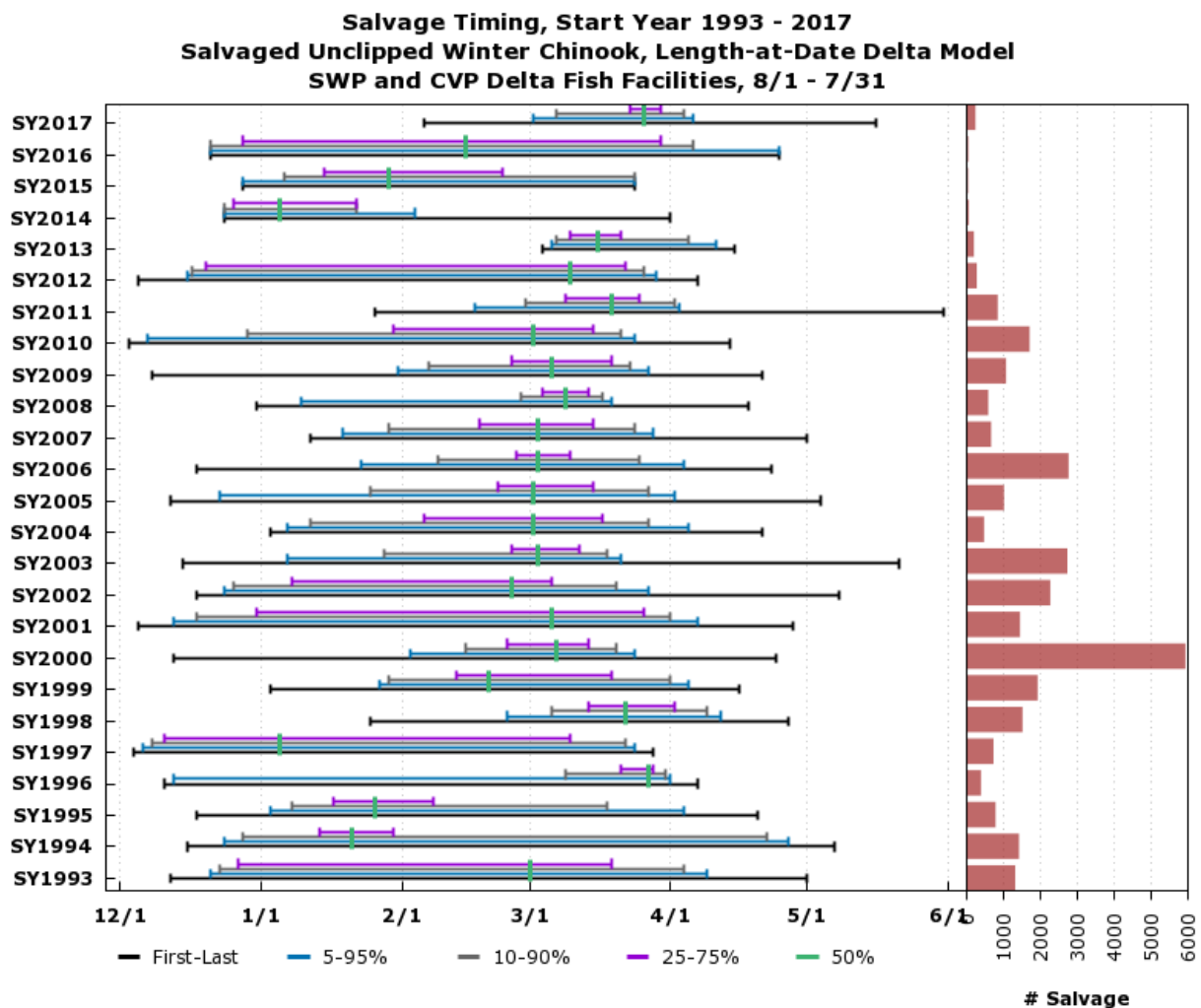
5.6.3.10 Clifton Court Aquatic Weed Removal

5.6.3.10.1 Rearing to Outmigrating Juveniles in Bay-Delta

Few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program. Juvenile Winter-run Chinook Salmon are present in the Delta between December and May with a peak in March and April (Table 5.6-1). The application of aquatic herbicide to the waters of CCF will occur during the summer months of July and August. Thus, the probability of exposing Winter-run Chinook Salmon to the herbicide is very low. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70 degrees Fahrenheit by mid-June. Mechanical harvesting would occur on an as-needed basis and, therefore, Winter-run Chinook Salmon could be exposed to this action, if entrained into the CCF.

5.6.3.11 OMR Management

The proposed action also includes management of Old and Middle River reverse flows (OMR) to minimize risk of entrainment to fish species, including restricting OMR flows to -5000 cfs when between 5 and 95 percent of any salmonid species are in the Delta, or January 1 to June 30, whichever window is smaller. Delta seasonal operations above describe entrainment in more detail. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. Figure 5.6-37 shows historical salvage under the COS. Salvage under the proposed action is anticipated to be similar or less.



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Figure 5.6-39. Salvage of Winter-run Chinook Salmon from 2009 - 2018.

5.6.3.12 Operation of a Shasta Dam Raise

Under the proposed action, Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report. Operation under scenario CP4A for CVP only would include an 18.5 foot raise, an increase in storage by approximately 634 TAF, and a dedicated cold water storage of 191 TAF that acts as a thermal cap to chill the rest of the stored water. Reclamation proposes to address cold water management using a tiered strategy. With increased storage and dedicated cold water storage under a raised Shasta Dam, Reclamation would likely be able to meet Tiers 1 and 2 more often. Therefore, with a raised Shasta Dam Reclamation would be more likely to operate a daily average temperature of 53.5 °F at CCR and minimize temperature dependent mortality of salmonids.

CalSim modeling indicates that upper Sacramento River flows during the period of juvenile rearing in the upper Sacramento River are generally similar between CP4A and the proposed action, especially compared to the differences between the proposed action and WOA. This section provides general information on trends to help inform how flows under a raised Shasta Dam scenario (CP4A) may differ from the CalSim modeling results for the proposed action presented in the upper Sacramento Seasonal Operations section.

The CP4A scenario looks at raising Shasta Dam 18.5 feet for CVP use. This scenario was modeled in CalSim and compared to the Full Obligation scenario that has the same assumptions as CP4A except for a raised Shasta Dam. Because the Full Obligation scenario does not exactly align with the assumptions of the proposed action, COS, or WOA, additional calculations were necessary. Through looking at the difference between CP4A and Full Obligation compared to the COS, and the COS compared to the proposed action, Reclamation was able to approximate the differences between the CP4A and proposed action model runs. An “adjusted CP4A” was developed and is referenced in this section to more closely estimate the differences between a raised Shasta Dam and the proposed action as modeled.

The numbers are approximate, and these comparisons done to determine general trends attributable to a raised Shasta Dam of 18.5 feet for CVP only. The figures below show CP4A as modeled in CalSim and do not represent the adjusted CP4A used for comparisons. The trends are generally similar between CP4A as modeled and the adjusted CP4A calculated.

For the purposes of these analyses the proposed action modeling results (without a raised Shasta Dam) are compared to the adjusted CP4A (with a raised Shasta Dam). To clarify, the proposed action does include operation of a raised Shasta Dam and the comparison is to estimate differences in modeling.

For minimum monthly average flows below Keswick, the adjusted CP4A results were similar (5% or less difference) to the proposed action model results, except for June, September and October. Adjusted CP4A results indicated increased minimum flow of about 6 percent in October and 5 percent in September compared to the proposed action model results. Adjusted CP4A also indicated a decrease of about 5 percent in June.

Due to minimum releases of 3,250 cfs under CP4A, Full Obligation, COS and proposed action, minimum averages in December-April are the same (3,250 cfs). The remainder of the year (May-November) releases are generally similar (5% or less difference) under these scenarios. For example, there is a decrease of 5 percent in June between the adjusted CP4A (6,067 cfs) and the proposed action model results (6,369 cfs), i.e., the modeled Shasta Dam raise for CVP resulted in an average of 302 cfs lower minimum flows over the month of June. By contrast, WOA average minimum flows in June were 2,649 cfs. Under the proposed action, including a raised Shasta Dam, average minimum flows would largely be similar to COS (6,372 cfs) and significantly higher than WOA.

The minimum flows in the modeled results under a raised Shasta Dam for CVP operation (CP4A) are generally similar to the Full Obligation results, the COS, and the proposed action (PA) as shown in Figure 5.6-38. These scenarios differ more from the WOA than they do from each other. Therefore, the proposed action with a Shasta Dam raise for minimum monthly flows would be similar to the proposed action without a raised Shasta Dam. Given these similar flows and the greater differences between the proposed action and the minimum flows under the WOA, the operation of a raised Shasta Dam would not impact the minimum flows in the upper Sacramento River below Keswick Dam.

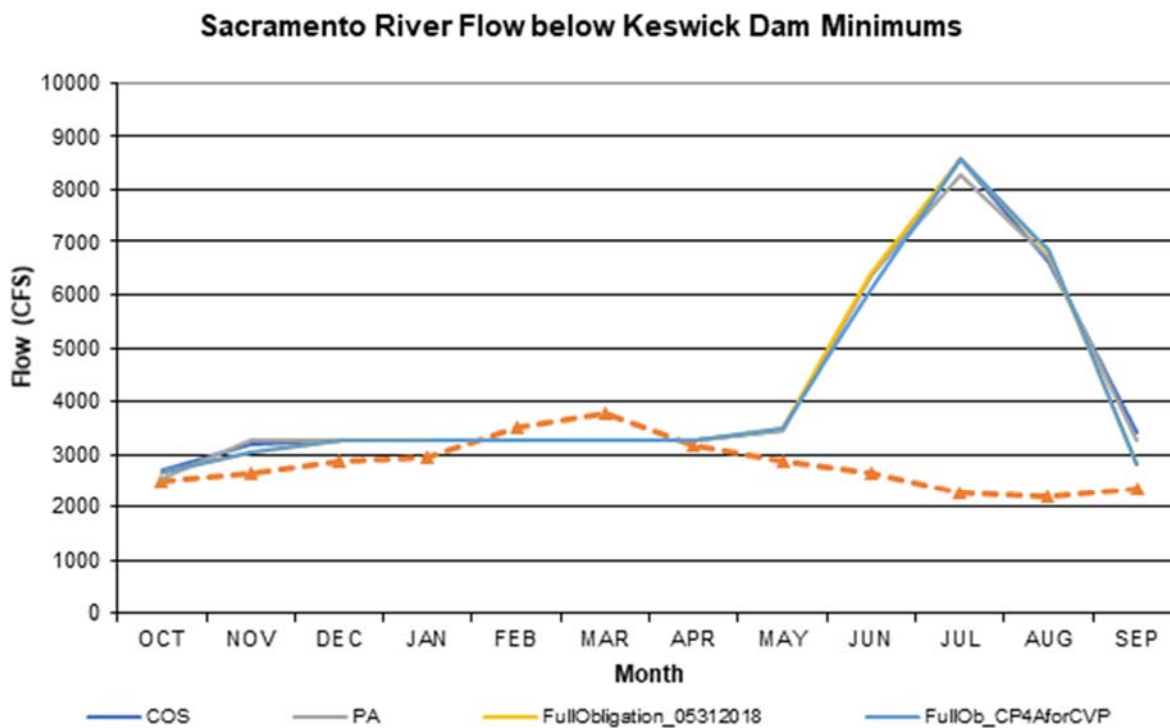


Figure 5.6-40. CalSim II Sacramento River Flows below Keswick Dam all scenarios

The maximum average monthly flows under adjusted CP4A were similar (5% or less difference) to the proposed action model results in December-August. The maximum flows generally increase in September (by 40%) and October (by 24%) and decrease in November (by 23%) with a raised Shasta Dam (adjusted CP4A) compared to the proposed action model results.

Adjusted CP4A average maximum flows in September are 17,081 cfs. Under proposed action modeling results, maximum flows in September are 12,195 cfs. By contrast, WOA average maximum flows in September are 4,627 cfs. The greatest variation between adjusted CP4A and the proposed action model results occurs in September (40%). The largest decrease (23%) between the proposed action and adjusted CP4A is in November.

The maximum flows in the modeled results under a raised Shasta Dam for CVP operation (CP4A) do vary in certain months compared to the Full Obligation, the COS, and the PA as shown in Figure 5.6-39. These scenarios differ more from the WOA than they do from each other. The WOA represents higher flows in the spring (February-May) and generally lower flows late-summer/fall (July-November).

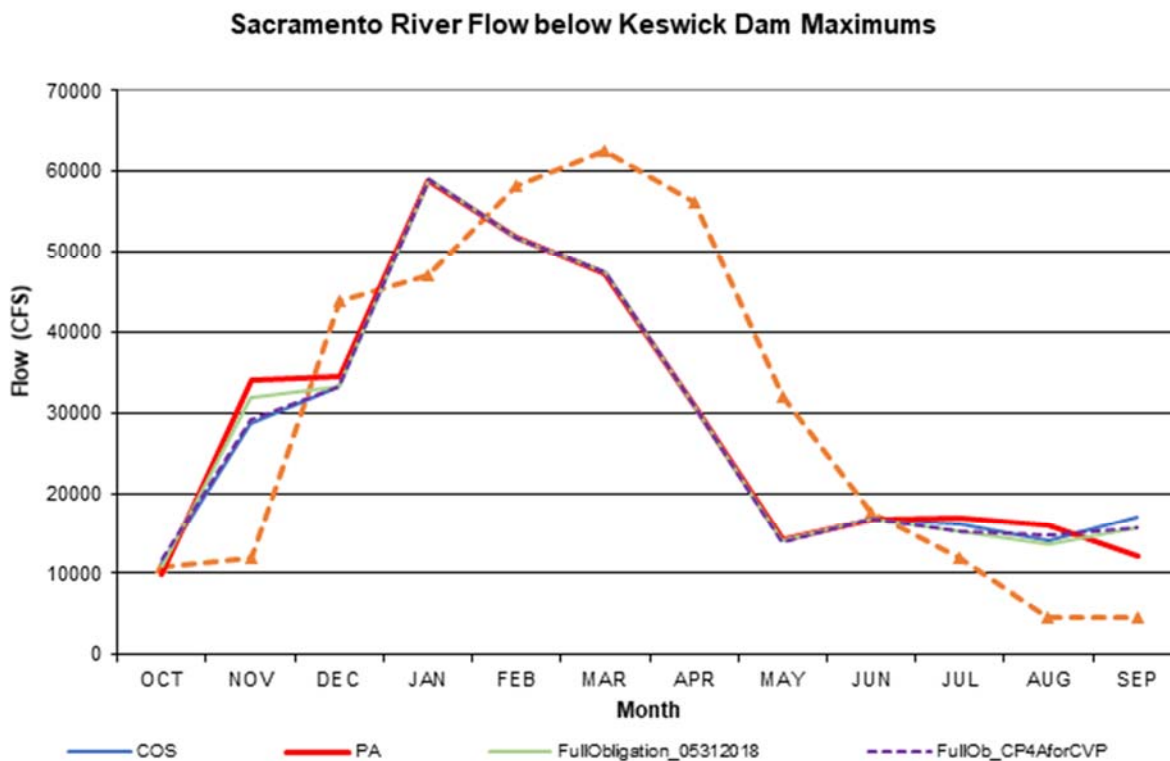


Figure 5.6-41. CalSim II Sacramento River Flows below Keswick Dam all scenarios

The average monthly flows under adjusted CP4A were similar (5% or less difference) to the proposed action in June-August. The average flows generally increase in September (by 44%) and November (by 30%) and decrease in December-May (by at most 19%) with a raised Shasta Dam (adjusted CP4A) compared to the proposed action model results.

The adjusted CP4A average monthly flows in September was 8,904 cfs. Under the proposed action model results these flows are 6,186 cfs. By contrast, WOA average flows in September are 3,370 cfs. The difference between the adjusted CP4A and the proposed action (44%) was 2,718 cfs.

The average flows in the modeled results under a raised Shasta Dam for CVP operation (CP4A) do vary in certain months compared to the Full Obligation, the COS, and the PA as shown in Figure 5.6-40. These scenarios differ more from the WOA than they do from each other.

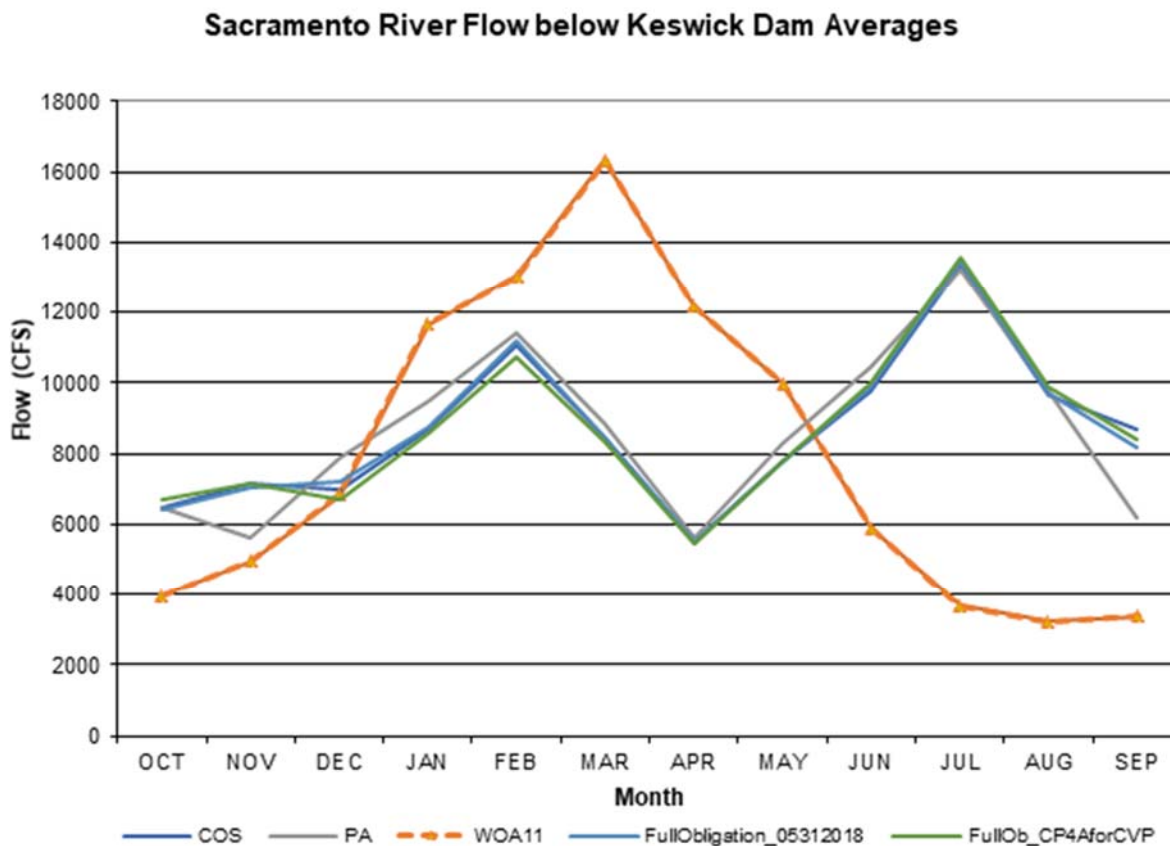


Figure 5.6-42: CalSim II Sacramento River Flows below Keswick Dam all scenarios

5.6.3.12.1 Egg/Alevin Mortality

The effects of increased summer and fall flows under the proposed action, including the operation of a raised Shasta Dam, compared to WOA would be beneficial for egg and alevin survival. Reduced winter and spring flows under the proposed action and COS as compared to the WOA would occur outside of the June to September period of egg and alevin incubation for Winter-run Chinook Salmon.

The minimum flows under the proposed action compared to the WOA vary the greatest in June-August. The largest decrease in minimum flows estimated (adjusted CP4A compared to the proposed action) as a result of a raised Shasta Dam occurs in June (5%). This is followed by a 4% increase in July under a raised Shasta Dam.

The effect of a raised Shasta Dam operating for CVP only on the proposed action may be uncertain, however all scenarios provide greater minimum flows compared to the WOA between June-August (Figure 5.6-38), the most important period for spawning and incubation of Winter-run Chinook Salmon. Average monthly flows are similar between June-August with and without a raised Shasta Dam. Overall adjusted CP4A and the proposed action represent similar flows and the differences are minimal compared to the differences between the proposed action and the minimum flows under the WOA.

Flows are increased from October to November and therefore do not present a risk of redd de-watering compared to the proposed action without a raised Shasta Dam. Additionally, these flows occur when the proposed action provides beneficial effects to Winter-run Chinook Salmon compared to WOA and the adjusted CP4A continues these benefits.

With the proposed improvements in water temperature management, including more cold water storage under a raised Shasta Dam, the proposed action is expected to benefit Winter-run Chinook Salmon compared to the WOA and COS.

5.6.3.12.2 Egg to Fry Emergence

Adjusted CP4A and proposed action modeled results provide greater minimum flows compared to the WOA between June-August (Figure 5.6-38), important for emergence of Winter-run Chinook Salmon.

Average monthly flows are similar between June to August with and without a raised Shasta Dam. The maximum flows under the adjusted CP4A compared to the proposed action are lowest in November (by 23%), which could provide less benefits to Winter-run Chinook Salmon egg to fry emergence towards the end of the incubation season. However, in adjusted CP4A average flows are increased from October to November which could provide a benefit not seen in the proposed action without a raised Shasta Dam (Figure 5.6-40). Additionally, these flows occur when the proposed action provides beneficial effects to Winter-run Chinook Salmon compared to WOA and the adjusted CP4A continues these benefits.

The impacts of increased summer and fall flows under the proposed action, including the operation of a raised Shasta Dam, compared to WOA would be beneficial for egg to fry emergence, and similar to egg and alevin survival.

With the proposed improvements in water temperature management, including more cold water storage under a raised Shasta Dam, the proposed action is expected to benefit Winter-run Chinook Salmon compared to the WOA and COS.

5.6.3.12.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

Flows during summer and fall of dry and critically dry years generally have the greatest potential to adversely affect the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats.

With the proposed improvements in water temperature management, including more cold water storage under a raised Shasta Dam, the proposed action is expected to better provide suitable flow and water temperature conditions in rearing habitats. This would be a benefit to juvenile rearing and outmigrating Winter-run Chinook Salmon compared the proposed action without a raised Shasta Dam, and compared to the WOA and COS.

5.6.3.12.4 Rearing to Outmigrating Juveniles in Middle Sacramento River

Many of the factors that affect rearing and outmigrating Winter-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. The main difference between the juveniles in the middle Sacramento River and those in the upper river with respect to these adverse effects is that the juveniles in the middle river would generally be less sensitive to the effects because their greater age and size would result in greater robustness.

Increased cold water storage under a raised Shasta Dam may better provide suitable flow and water temperature conditions in rearing habitats than under the proposed action without a raised Shasta Dam, WOA, or COS. However, water temperatures during most of the October through March period under the WOA scenarios and the proposed action and COS scenarios are suitable for juvenile Winter-run Chinook Salmon that rear in and emigrate from the middle Sacramento River; therefore, Winter-run Chinook Salmon juveniles are not expected to be impacted by the proposed action, with or without a raised Shasta Dam.

5.6.3.12.5 Adult Migration from Ocean to Upper Sacramento River

Generally, over the winter period average flows decrease and maximum flows are the same with a raised Shasta Dam (adjusted CP4A) compared to the proposed action model. Therefore, Winter-run Chinook Salmon adult migration from ocean to the upper Sacramento River is not expected to be impacted by the proposed action, with or without a raised Shasta Dam.

5.6.3.12.6 Adult Holding in the Upper Sacramento River

The adjusted CP4A minimum average for June was about 303 cfs lower than the proposed action model results. However, both the adjusted CP4A and the proposed action modeled results are more than double the WOA average minimum flows in June (2,649 cfs). Minimum average flows in December-April are the same with and without a raised Shasta Dam.

Under the adjusted CP4A minimum flows would be lower in June than proposed action model results, however, they would still be significantly higher (more than double) than under WOA. The average flows generally decrease in December-May (by at most 19%) with a raised Shasta Dam (adjusted CP4A) compared to the proposed action modeling results.

Adjusted CP4A results indicated increased minimum flows below Keswick of about 5 percent in September and 6 percent in October compared to the proposed action model results. Increased cold water storage under a raised Shasta Dam would provide the ability to provide better water quality for holding adults in September and October compared to the proposed action modeling results without a raised Shasta Dam.

5.6.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis looks at the construction related effects of the measures and the benefits to the population once completed. Conservation measures would not occur under WOA.

5.6.4.1 *Rice Decomposition Smoothing*

5.6.4.1.1 Egg/Alevin Mortality

Reclamation's proposed action to work with the SRSC to smooth rice decomposition water demands would allow for higher fall flows than WOA, leading to less dewatering of the last few emerging Winter-run Chinook Salmon redds.

Under the proposed action, lower releases compared to the COS in late October and early November would result in late spawning Winter-run Chinook Salmon less likely to spawn in shallow areas that would be subject to dewatering during winter base flows.

5.6.4.1.2 Egg to Fry Emergence

See egg / alevin mortality above.

5.6.4.1.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon rearing and outmigrating juveniles would experience higher fall flows than under WOA, leading to more food, rearing habitat, and cover.

5.6.4.1.4 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the Upper Sacramento River.

5.6.4.1.5 Adult Migration from Ocean to Upper Sacramento River

Fall rice decomposition flows would have no effect to this lifestage as this lifestage does not overlap with the time period of this action.

5.6.4.1.6 Adult Holding in the Upper Sacramento River

See adult migration from ocean to upper Sacramento River.

5.6.4.2 *Spring Management of Spawning Locations*

5.6.4.2.1 Egg/Alevin Mortality

Hendrix (2017) performed statistical analysis indicating that there is a correlation between warmer spring temperatures and later spawning Winter-run Chinook Salmon. This could result in an extended Shasta cold water pool management season beyond October 31. To offset this potential but uncertain effect, Reclamation will work with NMFS to experiment with spring temperatures and study the effects on spawning locations of Winter-run Chinook Salmon redds.

5.6.4.2.2 Egg to Fry Emergence

See egg / alevin mortality.

5.6.4.2.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

A spawning location study will have no effect on juvenile Winter-run Chinook Salmon.

5.6.4.2.4 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the Upper Sacramento River.

5.6.4.2.5 Adult Migration from Ocean to Upper Sacramento River

A spawning location study will have no effect on adult migration of Winter-run Chinook Salmon as they do not co-occur in time or space.

5.6.4.2.6 Adult Holding in the Upper Sacramento River

A spawning location study could result in beneficial or negative impacts to adult holding. Colder spring temperatures might allow for earlier spawning, and then emergence before temperatures have warmed in the late / summer and fall, leading to a successful life history strategy. Or, colder spring temperatures might result in Shasta Reservoir running out of cold water pool by the time of emergence, leading to mortality of Winter-run Chinook Salmon eggs or alevin.

5.6.4.3 Battle Creek Restoration

Under the Proposed Action, Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. NMFS and USFWS Biological Opinions were issued in 2005 on this project, and that consultation discusses effects of Battle Creek restoration.

5.6.4.4 Lower Intakes near Wilkins Slough

5.6.4.4.1 Egg/Alevin Mortality

Egg and fry of Winter-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based Winter-run Chinook Salmon adults spawning from May through August with peak spawning during June and July (Table 5.6-1). Most spawning occurs within 10 miles of Keswick Dam (Windell et al. 2017) and spawning does not occur in Wilkins Slough. In addition, the construction of the diversion and screens would occur during an in-water work window (June 1 and October 1) so effects of construction on Winter-run Chinook Salmon eggs and fry would not occur. Replacement of the fish screens would allow for lower releases from Shasta in drought years and better preserve the cold water pool.

5.6.4.4.2 Egg to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Winter-run Chinook Salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. The egg and fry lifestage of Winter-run Chinook Salmon, as well as the population, would benefit from this action.

5.6.4.4.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

The installation of fish screens near Wilkins Slough would be beneficial to rearing and emigrating Winter-run Chinook Salmon in the Middle Sacramento River. As described earlier in rearing to outmigrating juveniles in the Upper Sacramento River. The rearing and emigrating Winter-run Chinook Salmon individuals in the middle Sacramento River, as well as the population, would benefit from this action.

Outmigrating juvenile Winter-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based Winter-run Chinook

Salmon juveniles emigrating from October through February with peak emigration occurring from December through January (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on emigrating Winter-run Chinook Salmon is not expected.

If rearing Winter-run Chinook Salmon are present during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition to noise associated with construction of the cofferdam. Additionally, fish rescue operations may need be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize those effects.

Construction of lowering intakes at Wilkins Slough would not have effects on rearing and emigrating Winter-run Chinook Salmon in the middle Sacramento River.

5.6.4.4.4 Rearing to Outmigrating Juveniles in Bay-Delta

Rearing to outmigrating juvenile Winter-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based Winter-run Chinook Salmon juveniles emigrating from October through February with peak emigration occurring from December through January (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on rearing and emigrating Winter-run Chinook Salmon in the Bay-Delta is not expected.

5.6.4.4.5 Adult Migration from Ocean to Upper Sacramento River

The installation of fish screens near Wilkins Slough would be beneficial to immigrating adult Winter-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. Individual immigrating adult Winter-run Chinook Salmon, as well as the population, would benefit from this action.

Immigrating adult Winter-run Chinook Salmon would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based on adult Winter-run Chinook Salmon immigrating through the Delta into the Sacramento River Basin between December through April (Table 5.6-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1) so effects of construction on immigrating Winter-run Chinook Salmon in the Bay-Delta is not expected.

5.6.4.4.6 Adult Holding in the Upper Sacramento River

Wilkins Slough does not contain the necessary cool water habitat for holding Winter-run Chinook Salmon. Therefore, construction of a new diversion and fish screens near Wilkins Slough would not affect holding Winter-run Chinook Salmon.

5.6.4.5 Shasta Temperature Control Device Improvements

5.6.4.5.1 Egg/Alevin Mortality

Improvements to the Shasta TCD would reduce leakage of warm water into the structure that increase of the temperature of the cold water that is released to maintain suitable temperatures for Winter-run

Chinook Salmon that spawn in the upper Sacramento River (from Keswick Dam to the Red Bluff Diversion Dam) from May through August, with peak spawning during June and July (Table 5.6-1). Fry emergence occurs up to two months after eggs are spawned, so effects of water temperature and flow in the upper Sacramento River on Winter-run Chinook Salmon fry and alevins potentially occur from May through October, but occur primarily during June through September. The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable spawning, incubating, and rearing temperatures throughout the season in all but the driest years.

5.6.4.5.2 Egg to Fry Emergence

See egg/ alevin mortality above.

5.6.4.5.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

Improvements to the Shasta TCD would reduce leakage of warm water into the structure that increase of the temperature of the cold water that is released to maintain suitable temperatures for Winter-run Chinook Salmon that spawn in the Sacramento mainstem. The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable rearing temperatures within the middle reaches of the Sacramento River in all but the driest years.

5.6.4.5.4 Rearing to Outmigrating Juveniles in Bay-Delta

Temperature effects of Shasta TCD improvements are unlikely to reach the Delta. No effects are anticipated on this lifestage.

5.6.4.5.5 Adult Migration from Ocean to Upper Sacramento River

The improved flow management associated with the Shasta TCD improvements under the proposed action would be expected to provide some benefit to adult Winter-run Chinook Salmon adults relative to the COS and WOA.

5.6.4.5.6 Adult Holding in the Upper Sacramento River

See egg / alevin mortality above.

5.6.4.6 *Sacramento River Spawning and Rearing Habitat*

5.6.4.6.1 Egg/Alevin Mortality

Reclamation proposes to create additional spawning habitat by injecting 40-55 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. This additional spawning habitat would help meet the spawning habitat needs on the Sacramento River, shown below. At least an additional 100 acres of spawning habitat is needed to support the target Winter-run Chinook Salmon doubling goal population of 110,000 returning adults. Additional gravel would lead to improved hyporheic flow to move dissolved oxygen to redds, and reduced density-dependent spawning effects (unlikely due to current low population size).

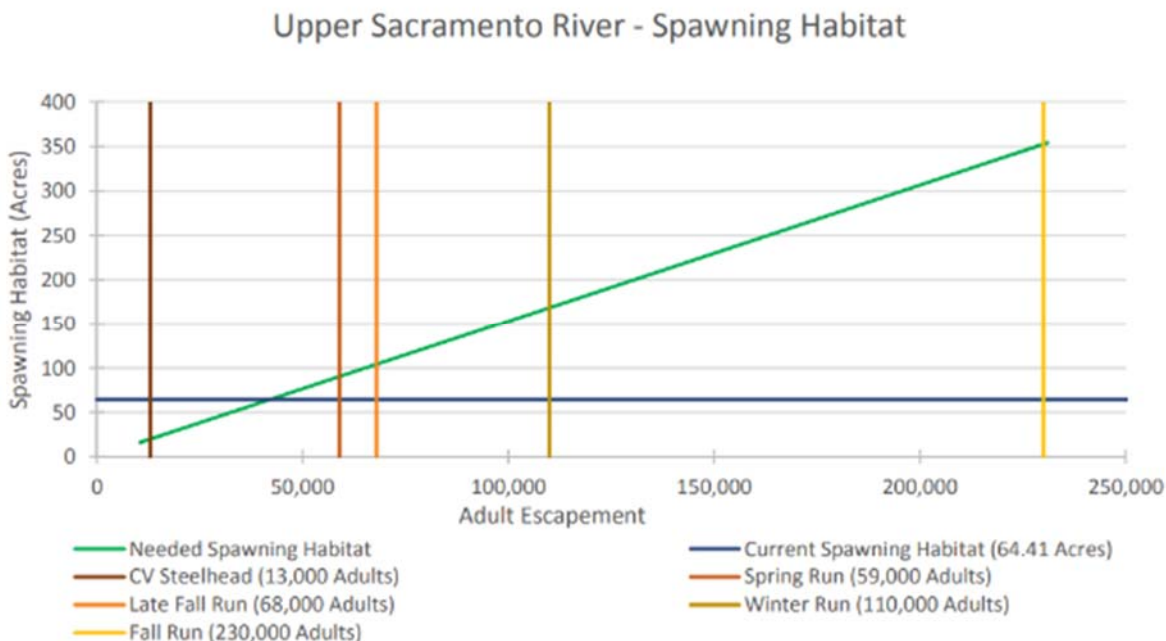


Figure 5.6-43: Spawning Habitat versus Adult Escapement

Construction of spawning and rearing habitat could affect Winter-run Chinook Salmon eggs in the river. Based on the proposed in-water work windows for the upper Sacramento River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Winter-run Chinook Salmon adults, eggs, and alevins would be subject to potential adverse effects from proposed spawning (e.g., gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure of the Winter-run Chinook Salmon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.6.4.6.2 Egg to Fry Emergence

See egg mortality above.

5.6.4.6.3 Rearing to Outmigrating Juveniles in Upper Sacramento River

Reclamation and the SRSC propose to create 40-60 acres of side channel habitat at no fewer than 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. Creation of this

additional 40-60 acres of rearing habitat would help increase the quantity and quality of Winter-run Chinook Salmon juvenile rearing habitat in the Upper Sacramento River. Reclamation estimates that this additional 50 acres of rearing habitat could support the progeny of 5,600 returning adult salmonids based on the relationship shown in the plot below.

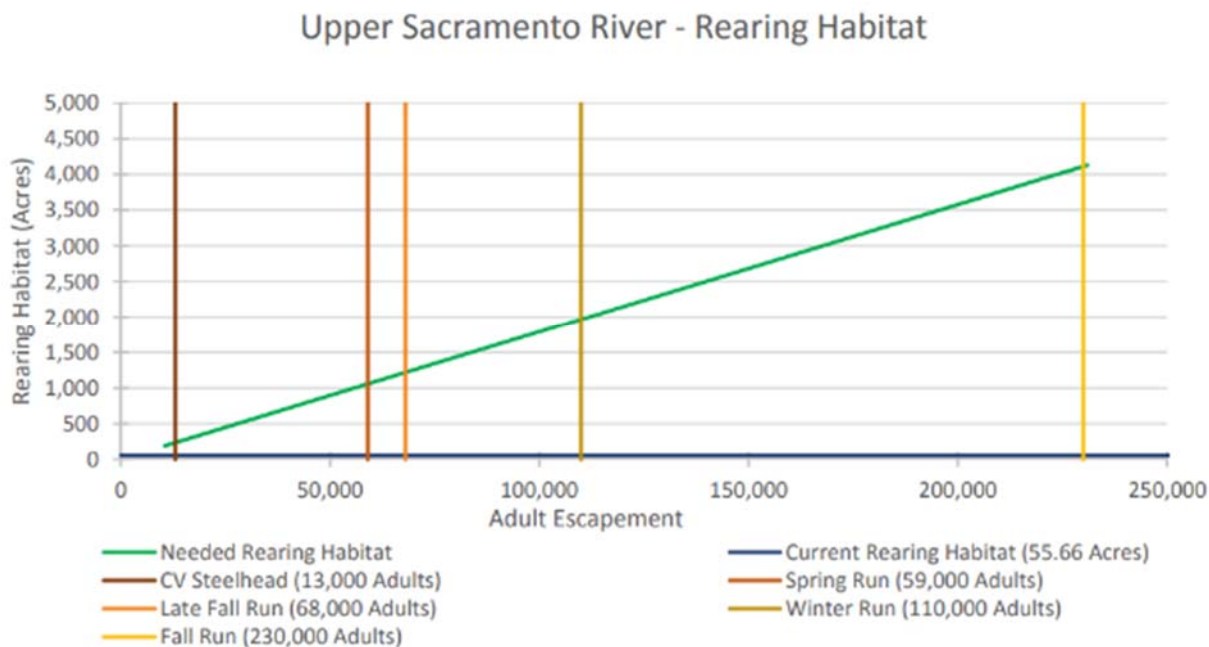


Figure 5.6-44: Rearing habitat versus Adult Escapement

Construction of spawning and rearing habitat could lead to some impacts to early rearing fry in the upper Sacramento River. See egg mortality above for a discussion of effects and minimization measures.

5.6.4.6.4 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the Upper Sacramento River above.

5.6.4.6.5 Adult Migration from Ocean to Upper Sacramento River

Winter-run Chinook Salmon adults would not be exposed to benefits or construction impacts of spawning and rearing habitat as they are not co-located in time or space.

5.6.4.6.6 Adult Holding in the Upper Sacramento River

Additional spawning habitat could also benefit adults holding upstream. See egg mortality above.

5.6.4.7 *Small Screen Program*

5.6.4.7.1 Egg to Fry Emergence

No egg-to-emergence Winter-run Chinook Salmon would be exposed to fish screens since this life stage occurs within the redds and would not be exposed to fish screens. Therefore, there would be no effects from the operation of fish screens for this life stage.

Sacramento River Winter-run Chinook Salmon in the egg-to-emergence life stage may be exposed to the effects of construction of screens on water diversion intakes since this life stage occurs during the typical timing of in-water construction (July 15–October 15). Embryo and alevin development in the redd occurs in the spring through mid-October, following the mid-April to mid-August spawning period (peaking in June), lasting 10 to 14 weeks, (Vogel and Marine 1991) with fry emerge from the gravel occurring from late July to early August and continuing through October (Fisher 1994). Since spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities (Fisher 1994), there is the potential for redds to occur in the work areas or in the direct vicinity of the construction sites. However, these work areas are localized and the number of redds is expected to be low. Potential effects include the disturbance of redds and temporary, localized fine sediment disturbance and deposition in spawning and embryo incubation areas directly adjacent construction sites. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*.

5.6.4.7.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

The operation of fish screens on water diversions would beneficially affect juvenile Winter-run Chinook Salmon in the upper Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Few juvenile Winter-run Chinook Salmon in the upper Sacramento are expected to be exposed to the effects of construction of screens on water diversion intakes. Since Winter-run Chinook Salmon exhibit both ocean-type and stream-type life histories, juveniles are present near year-round (Table 5.6-1) and will likely be present during the timing of in-water construction (July 15 – October 15), the work area for these projects is small, limiting exposure to construction. Potential short-term adverse effects may include temporary degradation of water quality, including increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (i.e., increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general AMMS identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.6.4.7.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

The operation of fish screens on water diversions would beneficially affect juvenile Winter-run Chinook Salmon in the middle Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be

minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Few juvenile Winter-run Chinook Salmon rearing and outmigrating in the middle Sacramento River are expected to be exposed to the effects of construction of screens on water diversion intakes. Since Winter-run Chinook Salmon exhibit both ocean-type and stream-type life histories, juveniles are present near year-round and use this reach for rearing and migration (NMFS 2014) and will likely be present during the timing of in-water construction (July 15 – October 15), the work area for these projects is small, limiting exposure to construction.

Potential short-term adverse effects may include temporary degradation of water quality, including increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (i.e., increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.6.4.7.4 Rearing to Outmigrating Juveniles in Bay-Delta

There may be some overlap Winter-run Chinook Salmon with the main late spring-fall irrigation period for small diversions. Diversion screening could reduce entrainment of late migrating individuals. It is important to note that only a small proportion of the population would be exposed.

Few if any juvenile Winter-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes. Juvenile Winter-run Chinook Salmon primarily migrate from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.6.4.7.5 Adult Migration

The operation of fish screens on water diversions would beneficially affect migrating adult Winter-run Chinook Salmon by reducing the entrainment of fish into unscreened or poorly screened diversions.

Few if any adult Winter-run Chinook Salmon are anticipated be exposed to the effects of construction of screens on water diversion intakes. The adult immigration occurs from December through July, the majority pass RBDD from January through May (peaking in mid-March) (NMFS 2009; NMFS 2014), which is largely of the timing of in-water construction (July 15 – October 15). AMMs would reduce any risk.

5.6.4.7.6 Adult Holding

The operation of fish screens on water diversions would beneficially affect adult Winter-run Chinook Salmon holding in the upper Sacramento River by reducing the entrainment of fish into unscreened or poorly screened diversions.

Adult Winter-run Chinook Salmon in may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (August–October), the May through August spawning period for (NMFS 2014). AMMs would reduce any risk.

5.6.4.8 *Conservation Hatchery (Winter-run Chinook Salmon)*

Expansion of Livingston-Stone National Fish Hatchery would allow increased operation to sustain Winter-run Chinook Salmon, particularly during drought years. The purpose would be to provide artificial rearing and spawning habitat when in-river environmental conditions (low flow and high temperatures) are not suitable for egg-fry life stages. Expanded hatchery production may address most SAIL CM components. Effects of increased hatchery production will depend on complex interactions between hatchery and natural-origin fish and their environment. It will be important to couple other conservation measures together with increased production to ensure that it addresses losses of natural production. For example, if in-river conditions are not conducive to migration downriver, fish produced at the hatchery may need to be trucked to a point with higher downstream survival. Livingston-Stone National Fish Hatchery operates an “integrated” hatchery program with the intention of minimizing genetic divergence between hatchery and natural components of the population by exchanging spawners between them (Paquet et al. 2011). A natural consequence of expanding numbers of hatchery fish is an increase of hatchery origin fish on in-river spawning grounds. This coupled with low survival of natural-origin fish may influence the genetic management criteria to include hatchery-origin spawners and variable numbers of males and females under drought conditions.

5.6.4.9 *Adult Rescue (Yolo and Sutter Bypasses)*

Existing facilities such as the updated Fremont Weir ladder and Wallace Weir fish rescue facility have improved fish passage in the Yolo Bypass and between the bypass and the river, however, there is still the potential for stranding in isolated pools when hydrologic connectivity is not possible within the Yolo Bypass. Under certain circumstances with the proposed action, adult fish rescue may still be necessary at Fremont Weir.

Under the proposed action, the Yolo Bypass Salmonid Habitat Restoration and Fish Passage project provides additional adult fish passage at different locations and additional times compared to WOA and COS. Under the WOA, these facilities would exist but would not be operated for fish passage and rescue. Additionally, under the proposed action Reclamation would undertake, fund, and/or assist in adult fish rescue operations as needed at Fremont, Wallace, and Tisdale Weirs, which would not occur under the WOA. The proposed action and COS would provide more passage and rescue and more opportunities for adult spawning Winter-run Chinook Salmon compared to the WOA.

5.6.4.9.1 Egg to Fry Emergence

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Winter-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the the number of Winter-run Chinook Salmon eggs and emerging fry in the Sacramento River from increased spawner abundance.

5.6.4.9.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

Juvenile Winter-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Winter-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses.

Individual juvenile Winter-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Winter-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Winter-run Chinook Salmon returning to spawning grounds.

As such, it is concluded that there will be no impacts from from adult rescue activities in the proposed action on this life stage of Winter-run Chinook Salmon (no rescue of adult Winter-run Chinook Salmon).

5.6.4.9.3 Rearing to Outmigrating Juveniles in Bay-Delta

Adult fish rescue in the Yolo Bypass and Sutter Bypasses does not affect environmental conditions such as juvenile rearing and migration in the tidal estuary and bays that influence the timing, condition and survival of juvenile Winter-run Chinook Salmon in the middle Sacramento River. This action would not have impacts to this life stage, aside from beneficial indirect effects of increased potential spawners.

5.6.4.9.4 Adult Migration from Ocean to Upper Sacramento River

Exposure of this life stage to adult rescue effects would be restricted only to those adult Winter-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Winter-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses.

Individual adult Winter-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of affected individuals after release. The risk from these potential effects would be

minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Adult Winter-run Chinook Salmon that are rescued may be exposed to detrimental effects; however, individuals would have greater opportunities for spawning success compared to WOA.

As such, it is concluded that the overall population-level effects would be beneficial on this life stage of Winter-run Chinook Salmon from adult rescue activities relative to WOA (no rescue of stranded adult Winter-run Chinook Salmon in Yolo and Sutter bypasses).

5.6.4.10 Juvenile Trap and Haul (Winter-run Chinook Salmon)

5.6.4.10.1 Rearing to Outmigrating Juveniles in Upper Sacramento River

The number of juvenile Winter-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.6-1). Individual juvenile Winter-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release.

Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Winter-run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Winter-run Chinook Salmon. Juvenile Winter-run Chinook Salmon would benefit from juvenile trap and haul activities relative to WOA (no trapping and hauling of juvenile Winter-run Chinook Salmon during drought years).

5.6.4.10.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

If temporary juvenile collection weirs are placed in Middle Sacramento River, potential effects associated with juvenile trap and haul on this life stage would be same as those described above for the rearing to outmigrating juveniles in the upper Sacramento River life stage.

5.6.4.10.3 Rearing to Outmigrating Juveniles in Bay-Delta

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile Winter-run Chinook Salmon trapped in the upper and middle Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta. Wild juveniles that migrate in-river to the Bay-Delta (either before December 1 or that avoid capture by the temporary juvenile collection weirs after December 1) would not be affected by juvenile trap and haul activities. Potential effects associated with juvenile trap and haul on this life stage would be same as those described above in for the rearing to outmigrating juveniles in the upper Sacramento River life stage.

5.6.4.10.4 Adult Migration

Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries or that are otherwise delayed from reaching adult holding areas in the Upper Sacramento River would not be expected to spawn successfully because of the lack of suitable habitat in tributaries. Negative effects on this life stage of adult Winter-run Chinook Salmon from juvenile trap and haul activities would be small compared to WOA (no trapping and hauling of juvenile Winter-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

5.6.4.11 American River Spawning and Rearing Habitat

Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar - North, El Manto, Sacramento Bar - South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction.

5.6.4.11.1 Egg to Fry Emergence

American River Spawning and Rearing Habitat would not co-occur in time or space with egg / alevin mortality of Winter-run Chinook Salmon; therefore, there is no effect to this lifestage.

5.6.4.11.2 Rearing to Outmigrating Juveniles in Upper Sacramento River

See egg to fry emergence above.

5.6.4.11.3 Rearing to Outmigrating Juveniles in Middle Sacramento River

Juvenile Winter-run Chinook Salmon in the middle Sacramento River may use the lower American River as non-natal rearing habitat during late fall and winter. The habitat improvements in the American River would increase quality and quantity of rearing habitat available to juvenile Winter-run Chinook Salmon and be a net benefit to the population. The additional rearing habitat is not expected negatively impact juveniles. Winter-run Chinook Salmon naturally emigrate once they reach a threshold size in the spring, before temperature in the lower Sacramento River and Delta warm to inhospitable levels, indicating there should not be danger of attracting and holding juveniles in American River habitat too far into the warmer time of year.

Spawning and rearing habitat project construction occurs in the American River from July to October, outside the time when Winter-run Chinook Salmon juveniles would be present so there would be no impact on the species from construction activities.

5.6.4.11.4 Adult Migration from Ocean to Upper Sacramento River

See egg / alevin mortality above.

5.6.4.11.5 Adult Holding in the Upper Sacramento River

See egg / alevin mortality above.

5.6.4.12 Clifton Court Predator Management

Clifton Court predator management efforts could reduce predation on listed fishes following entrainment into CCF, reducing pre-screen loss.

5.6.4.13 Sacramento Deepwater Ship Channel

This action would hydrologically connect the Sacramento River with the Sacramento Deepwater Ship Channel (SDWSC) via the Stone Lock facility from mid-spring to late fall. Juvenile Winter-run Chinook Salmon may be exposed to the Sacramento Deepwater Ship Channel (SDWSC) component of the proposed action. This action would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018) to provide foodweb benefits to Delta Smelt. Juvenile Winter-run Chinook Salmon abundance downstream of Stone Lock at Sherwood Harbor is highest in February and March, declines in April, and is moderate in November (Table 5.6-1). Juvenile Winter-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be routed into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, if survival rates are similar, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit associated with the proposed action.

A hydrologically connected SDWSC could potentially attract adult Winter-run Chinook Salmon. If the connection is maintained there would likely not be impacts to adults. However, if the connection is not maintained there could be migratory delays and stranding.

5.6.4.14 North Delta Food Subsidies / Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on Winter-run Chinook salmon, who are in the Delta between December and May for juveniles, and December to July for adults.

5.6.4.15 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on Winter-run Chinook salmon, who are in the Delta between December and May for juveniles, and December to July for adults.

5.6.4.16 Tidal Habitat Restoration (8,000 acres)

5.6.4.16.1 Rearing to Outmigrating Juveniles in Bay-Delta

Although migration through the Delta represents a short period, a large proportion of juvenile Winter-run Chinook Salmon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. Tidal habitat restoration is expected to benefit juvenile Winter-run Chinook Salmon in several aspects represented by the Winter-run Chinook Salmon conceptual model, (Figure 5.6-4) including increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta. Reclamation and DWR will consult on future tidal habitat restoration with USFWS and NMFS on potential effects to fish from construction-related effects.

5.6.4.17 *Predator Hot Spot Removal*

5.6.4.17.1 Rearing to Outmigrating Juveniles in Upper Sacramento River

Winter-run Chinook Salmon juveniles could be exposed to the effects of construction at predator hot spot removal locations in the Sacramento River, as the in-water work window is in the summer / fall when Winter-run Chinook Salmon juveniles are generally in the upper river. AMMs will be used to avoid and minimize impacts from construction including crushing, impingement, mortality, noise, and harassment.

5.6.4.17.2 Rearing to Outmigrating Juveniles in Middle Sacramento River

See rearing to outmigrating juveniles in the upper Sacramento River.

5.6.4.17.3 Rearing to Outmigrating Juveniles in Bay-Delta

Predator hot spot removal is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Winter-run Chinook Salmon. Although the proposed action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Winter-run Chinook Salmon. All 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. 2017, Sabal et al. 2017). Winter-run Chinook Salmon juveniles in the Bay-Delta are unlikely to be exposed to the effects of construction at predator hot spot removal locations in the Sacramento River, as the in-water work window is in the summer / fall when Winter-run Chinook Salmon juveniles are generally in the upper river.

5.6.4.18 *Delta Cross Channel Gate Improvements*

The DCC is an older structure which requires manual operation and increased use could result in locks braking in either open or closed positions. Migrating Winter-run Chinook salmon would benefit from faster operations that prevent straying into the central Delta and catastrophic failure of the facility. Few Winter-run Chinook Salmon are expected to be exposed to improvements to the Delta Cross Channel. Seasonal closure periods would still be in place to protect migrating salmonids. Potential diurnal operation during closure periods could increase exposure of Winter-run Chinook Salmon juveniles to entrainment into the interior Delta. Improved biological and physical monitoring associated with improvements would likely minimize potentially increased routing into the interior Delta and subsequent entrainment. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.6.4.19 *Tracy Fish Facility Improvements*

A small proportion of juvenile Winter-run Chinook Salmon are expected to be exposed to the Tracy Fish Facility (Zeug and Cavallo 2014). However, for fish that arrive at the facility, the proposed improvements are likely to increase survival through the facility. Winter-run Chinook Salmon adults would not be expected to be exposed to the effects of construction of the carbon dioxide injection device proposed for the Tracy Fish Facility, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1).

Few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to construction of the carbon dioxide injection device proposed for the Tracy Fish Facility Improvements based on lack of observed salvage during the August–October in-water work window (Figures F.2.7, F.2.8, and F.2.9 in

Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). However, a few early migrants could occur during the in-water work window based on occurrence in the north Delta (Figures WR_Seines and WR_Sherwood in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*).

To the extent that the construction affects the ability of juvenile Winter-run Chinook Salmon to be efficiently salvaged (as part of the entrainment risk habitat attribute in the SAIL conceptual model; Figure 5.6-44), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, the application of AMMs, and the small scale of the in-water construction.

5.6.4.20 Skinner Fish Facility Improvements

Skinner Fish Facility improvements from predator control efforts to reduce predation on listed fishes following entrainment into CCF could reduce pre-screen loss of juvenile Chinook Salmon entrained into CCF. It is important to note that only small proportions of Winter-run Chinook Salmon are lost at the SWP (Zeug and Cavallo 2014).

5.6.4.21 Delta Fishes Conservation Hatchery

The operation of the Delta Fish Species Conservation Hatchery would not provide benefits to any life stage of Winter-run Chinook Salmon. Potential negative effects of the Delta Fish Species Conservation Hatchery include inadvertent propagation and spread of invasive or nuisance species, which could affect juvenile Winter-run Chinook Salmon through changes in food web structure, for example, in the case of invasive quagga and zebra mussels (Fera et al. 2017). 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 treatment 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 would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities in the Bay-Delta, few if any juvenile Winter-run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1). There may be some exposure of early migrants to in-water and shoreline construction of the hatchery intake and outfall, as illustrated by timing of occurrence in Sacramento seines and trawls (Figures F.2.4 and F.2.5 in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). The relatively few 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 AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, the application of AMMs, and the small scale of the in-water construction.

Winter-run Chinook Salmon adults would not be expected to be exposed to the effects of construction of construction of the Delta Fish Species Conservation Hatchery based on the timing of in-water

construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.6-1).

5.6.5 Effects of Monitoring

A number of monitoring activities described in Appendix C - Real Time Water Operations Charter, in section Routine Operations and Maintenance on CVP Activities would have the potential to capture Winter-run Chinook Salmon. Not all the existing IEP monitoring programs that target pelagic fish identify Chinook Salmon race. Of the programs that target and identify Winter-run Chinook Salmon, collective catches are less than 1% of the winter-run JPE (Table 5.6-2). Because such a small percentage of the total JPE is captured in the monitoring programs, the effects of the monitoring programs are not likely to have effects to the Winter-run population. These monitoring programs are important for understanding entry and residence time of Winter-run Chinook Salmon into the Delta and San Francisco Estuary

Table 5.6-2. Monitoring Programs – Winter-run Chinook Salmon

| Species | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|--------------------------------------------------------|---------|---------|---------|----------|----------|---------|---------|---------|---------|--------|----------|------|------|------|------|------|------|------|
| Chippis Island Trawl | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 136 | 225 | 112 | 125 | 319 | 115 | 42 | 73 | 69 | 64 | 47 | 63 | 76 | 31 | 53 | 304 | 89 | |
| Sacramento Trawl | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 57 | 130 | 74 | 118 | 105 | 55 | 33 | 20 | 17 | 11 | 103 | 0 | 86 | 10 | 9 | 111 | 43 | |
| DJFMP Beach Seine Survey | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 123 | 498 | 299 | 650 | 373 | 125 | 51 | 56 | 182 | 50 | 292 | 74 | 136 | 30 | 80 | 38 | 330 | 24 |
| CDFW Mossdale Trawl | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 8 | 0 | 4 | 1 | 7 | 21 | 5 | 5 | 13 | 11 | 70 | 2 | 2 | 0 | 0 | 18 | 8 | |
| EDSM KDTR Trawls | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | na | na | na | na | na | na | na | Na | na | na | na | na | na | na | 0 | 30 | na | |
| CDFW Bay Study Trawls | | | | | | | | | | | | | | | | | | |
| Chinook Salmon | 273 | 117 | 327 | 115 | 143 | 115 | 17 | 130 | 157 | 215 | 74 | 134 | 71 | 65 | 62 | 236 | na | |
| CDFW SKT Study | | | | | | | | | | | | | | | | | | |
| Chinook Salmon | 35 | 1624 | 1364 | 348 | 822 | 896 | 603 | 187 | 300 | 244 | 219 | 492 | 632 | 432 | 347 | 565 | 124 | |
| Totals | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 324 | 853 | 489 | 894 | 804 | 316 | 131 | 154 | 281 | 136 | 512 | 139 | 300 | 71 | 142 | 471 | 470 | |
| RBDD Rotary Trap or Juvenile Production Estimate (JPE) | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon JPE | 6964626 | 6181925 | 2786832 | 12109474 | 11818006 | 1864521 | 1952614 | 3728444 | 1049385 | 512192 | 16874039 | | | | | | | |
| Percent of Total | | | | | | | | | | | | | | | | | | |
| Winter-run Chinook Salmon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | |

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5.7 Chinook Salmon, Sacramento River Winter-run ESU Critical Habitat

5.7.1 PBF1 - Access to Spawning Areas in the Upper Sacramento River

In the Sacramento River Basin, ancestral spawning areas for Winter-run Chinook Salmon are unreachable due to impassable barriers at Keswick and Shasta dams. Keswick and Shasta dams do not operate in the WOA scenario, but the dams would remain in place and continue to prevent Winter-run Chinook Salmon adults from accessing upstream spawning areas. Adult Winter-run Chinook Salmon access to their current spawning areas in the upper Sacramento River near Keswick Dam is affected by flow and temperature-related conditions in the middle and upper Sacramento River. Winter-run Chinook Salmon currently spawn between Keswick and Red Bluff Diversion dams, with most spawning within ten miles of Keswick Dam (Windell 2017). Low flow may interfere with upstream passage of adults and increases risk of straying and poaching. High water temperature makes habitat physiologically unsuitable for the adults, potentially excluding them entirely.

Under the proposed action, modeled flow in the middle Sacramento River during the December through May period of Winter-run Chinook Salmon adult immigration is similar to or slightly greater than COS, indicating no adverse flow-related effect of the proposed action on access to spawning areas relative to the COS. However, the proposed action flow is much lower than the WOA flow during many years, but the proposed action flow in these years is generally high enough ($> \sim 5,000$ cfs) not to affect access of the adults to spawning areas. In the driest years, however, the proposed action flow is higher than the WOA flow. During May in the driest 25 percent of years, the modeled WOA flows are low enough to potentially obstruct upstream passage of adults, which is not the case under the proposed action. Therefore, modeling results indicate that the proposed action would have no adverse flow-related effect on access to spawning areas in the Winter-run Chinook Salmon critical habitat relative to the COS or WOA.

Adult Winter-run Chinook salmon are present in the Bay/Delta from December through July, with a peak occurrence in December and April. The adults use olfactory cues to find their way through the Delta to the Sacramento River upstream of the Delta, so higher Sacramento River flow may reduce straying to other rivers (Marston et al. 2012; NMFS 2016 *Submitted Ch5 EA Draft BA*). Flow in the Sacramento River at Rio Vista and Freeport during the period of adult migration through the Delta, December through July, is lower to much lower under the proposed action relative to the WOA in most years (e.g., Figures 32-9 through 32-16 in the CalSim II Flows section of Appendix D), but in dry years with low river flow, when the risk of straying is increased, flow is much higher under the proposed action than the WOA, especially for April through July. On balance, the effect of the proposed action on Winter-run upstream migration is uncertain.

Modeled water temperatures under all three scenarios would be favorable in the middle and upper Sacramento River for immigrating adult Winter-run Chinook Salmon during all of the immigration period, except during May for WOA temperatures in about 50 percent of years, and COS and proposed action temperatures in about 35 percent of years. These results indicate that the proposed action would have no adverse water temperature-related effect on access to spawning areas in Winter-run Chinook Salmon critical habitat relative to the COS or WOA.

5.7.2 PBF2 - Availability of Clean Gravel for Spawning Substrate

The proposed action includes adaptive management projects to improve spawning habitat for Chinook Salmon in the upper Sacramento River, and these projects would likely enhance availability of clean gravel for Winter-run Chinook Salmon spawning substrate. Availability of clean gravel is affected by changes in flow. Transport of clean gravel downstream to areas currently used for spawning by Winter-run Chinook Salmon is blocked by Keswick and Shasta dams. While the WOA includes no operation of Keswick and Shasta dams, the dams would remain in place and continue to prevent transport of clean gravel from upstream sources.

Currently, the availability of clean gravel is a function of: 1) upstream supply from tributaries and gravel augmentation projects, and 2) flows, especially pulse flows, that are high enough for periodic flushing of fine sediment, but not so high as to transport the gravel downstream of the spawning area. The proposed action would not affect the amount of upstream gravel supply or natural pulse flows. However, flow during summer, when Winter-run Chinook Salmon spawn and egg/alevin incubation period, would be much higher under the proposed action than under WOA, and potentially would be high enough in some years to flush fine sediments from spawning substrates. Modeled flow during the winter months is higher under the WOA scenario and is likely high enough in some years to flush sediments from spawning substrate. Pulse flows are not included in the CALSIM modeling used to compare flow of the three project scenarios. However, because flow in the upper river under the WOA scenario is less regulated than that under the proposed action and COS scenarios, it is likely that natural pulse flows would be larger and more frequent under the WOA scenario.

The greater frequency of pulse flows would potentially result in more frequent and effective flushing of sediments from the spawning gravel. However, if WOA pulse flows were very large, they could result in downstream transport of gravel from the spawning area, without recruiting gravel from upstream due to blockage by Shasta and Keswick dams. Overall, the effect of the proposed action on the availability of clean gravel for spawning substrate in Winter-run Chinook Salmon critical habitat relative to WOA is uncertain.

5.7.3 PBF3 - Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

As discussed previously, there would be insignificant differences in flows between the proposed action and COS throughout the Sacramento River upstream of the Delta during most of the Winter-run Chinook Salmon spawning, rearing, and emigration periods; however, there would be large and significant differences in flows between the proposed action and WOA.

The months included in Winter-run Chinook Salmon spawning, incubation, rearing and emigration periods are May through March. During these months, proposed action and COS flows are similar, except for greater proposed action flow in June and lower proposed action flow in September and November. The effects of these flow differences are uncertain, with some attributes of habitat benefited and some attributes negatively affected by the higher flows.

The large differences in flow between the proposed action and WOA are expected to have substantial effects. Flows under the proposed action are much higher than WOA flows during the June through October period of spawning and egg/alevin incubation, which is expected to substantially benefit most PBFs of Winter-run Chinook Salmon spawning habitat. In contrast, proposed action flows are lower than WOA flow during most years of the winter months, which is expected to reduce downstream transport and environmental cues of emigrating juvenile Winter-run Chinook Salmon.

5.7.4 PBF4 - Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development

As discussed previously, water temperatures would not significantly differ between COS and proposed action in spawning and rearing reaches in the upper Sacramento River during Winter-run Chinook Salmon spawning and rearing periods; however, there would be large and highly significant differences in water temperatures between WOA and proposed action, especially during the late spring, summer and early fall period of Winter-run Chinook Salmon spawning and egg/alevin incubation.

Water temperatures under the proposed action during May through September would range from roughly 10 to 20 degrees Fahrenheit lower than WOA water temperatures, with WOA water temperatures exceeding critical temperature thresholds for Winter-run Chinook Salmon eggs and alevins during May through September of almost every year, but proposed action water temperature remaining below the thresholds during those months in most years. Water temperature and DO based modeling analyses show 100 percent Winter-run Chinook Salmon egg and alevin mortality under WOA water temperature and DO conditions, as compared to less than 50 percent mortality in 75 percent of years under proposed action conditions. During late fall through early spring, the proposed action water temperatures are generally higher than the WOA temperatures, but the water temperatures under both scenarios are consistently below the critical temperature thresholds for Winter-run Chinook Salmon fry. Overall, the results indicate that proposed action has no effect relative to COS on PBF4, but would have major benefits relative to the WOA.

5.7.5 PBF5 - Habitat Areas and Adequate Prey that are not Contaminated

In Winter-run Chinook Salmon critical habitat upstream of the Delta, the proposed action is not likely to negatively impact contaminant sources. Primary sources of contamination in the Sacramento River upstream of the Delta are drainage and runoff from croplands and municipalities. Differences among the project scenarios in contaminated habitat and prey would most likely be caused by differences in flow levels, either because of differences in dilution of contaminants from drainage canals and other sources, or because of differences in contaminant loading resulting from inundation and runoff from croplands and municipal lands. The principal contaminants from croplands are fertilizers and pesticides, and these are applied to croplands primarily from late spring through early fall.

As indicated previously, differences in flows between the proposed action and COS would generally be small and, for both scenarios, modeled flow would be below levels that would cause inundation of croplands or cities. However, flow under WOA would often be much higher or much lower than proposed action flows.

During summer and early fall in drier years, flow under proposed action would regularly be two to three times as high as the corresponding WOA flow, so contaminants in the river would be much more diluted under the proposed action when compared to WOA. During winter and early spring, WOA flow would often be higher than proposed action flow, but use of fertilizers and pesticides is relatively low at these times of year. Flooding of the Sacramento River generally results primarily from pulse flows originating in unregulated tributaries of the river, which CalSim, a monthly time-step model, cannot model for purposes of comparing magnitudes or frequencies of flooding among the scenarios. However, as discussed for PBF3 regarding pulse flows for spawning gravels, Sacramento River flows would be much less controlled under WOA than under proposed action. Therefore, greater areas of croplands would likely be inundated under the WOA than under the proposed action and inundations would be more frequent, resulting in greater contaminant loading from the runoff. Overall, the results indicate that the

proposed action would not negatively impact Winter-run Chinook Salmon availability of uncontaminated habitat areas and prey relative to the COS and the WOA in the Sacramento River upstream of the Delta.

Increased habitat diversity potentially enhances food resources of Winter-run juveniles and higher flow generally increases habitat diversity. Higher flow in the Bay/Delta results in greater inundation of marshlands surrounding the Delta, Suisun Bay and San Pablo Bay, which potentially improves: 1) foodweb productivity, 2) access of juvenile Winter-run to more diverse food resources, 3) refuge of the juveniles from predators, and 4) refuge for resting from high velocity flows. Higher flows may also enhance foodweb productivity by transporting nutrients and plankton from productive habitats, including croplands and the Sutter and Yolo bypasses (DWR and Reclamation 2107 *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR*).

Winter-run juveniles are present in the Bay/Delta from December through May, with peak occurrence during February through April. During most of this period, Sacramento River flow at Freeport and Rio Vista, as well as Delta outflow, are substantially lower under the proposed action relative to the WOA (e.g. Figures 29-11 through 29-13, 32-11 through 32-13, and 41-11 through 41-13 in the CalSim II Flows section of Appendix D). Therefore, the proposed action is expected to negatively affect critical habitat in the Bay/Delta relative to the WOA, with respect to habitat diversity and food resources, but this conclusion has low certainty.

Elevated, unregulated winter and spring flow under the WOA has the potential to positively and negatively affect other water quality factors in estuarine Winter-run critical habitat relative to the PA. Higher January through May flows at Freeport and Rio Vista under the WOA and higher Delta outflow (Figures 29-10 through 29-14, 32-10 through 32-14, and 41-10 through 41-14 in the CalSim II Flows section of Appendix D) would dilute contaminants present in the Delta, Suisun Bay, San Pablo Bay and Central Bay, reducing their adverse effects, and could also flush contaminated sediments out of the Bay/Delta, potentially enhancing water and sediment quality in the critical habitat. However, as described above, high upstream WOA flows and increased pulse flows expected during winter and spring would potentially increase loading of contaminants related to runoff from inundated croplands, so the reduced upstream proposed action flows could result in better water quality in the Bay/Delta. Effects of flows on contaminants in other parts of the Delta are uncertain. Relative to the WOA, the PA has both positive and negative potential effects with respect to water quality in Winter-run critical habitat in the Bay/Delta, and the overall effect is uncertain.

Reduced winter-spring Delta inflow from the Sacramento River under the proposed action relative to the WOA (Figures 29-10 through 29-14 in the CalSim II Flows section of Appendix D) has the potential to reduce sediment supply and therefore turbidity during winter-spring. Turbidity helps juvenile salmon avoid predation (McElroy et al. 2018, Gregory and Levings 1998).

5.7.6 PBF6 - Riparian Habitat that Provides for Successful Juvenile Development and Survival

The effects of the proposed action on riparian habitat in Winter-run Chinook Salmon critical habitat upstream of the Delta are uncertain. Differences in riparian habitat would primarily result from differences in flow and its effect on riparian vegetation. As discussed previously, Sacramento River flow under the proposed action would generally be similar to flow under the COS, so differences in riparian habitat between these scenarios are expected to be insignificant. However, flow under the WOA scenario is generally much lower than proposed action flow during summer and early fall and much higher than proposed action flow during late winter and early spring. Also, as discussed for PBF5, inundation of floodplains is more likely under the WOA. These conditions suggest that riparian vegetation would

establish and grow more successfully during winter under the WOA scenario, but the low summer WOA flow could result in the loss of this vegetation. Therefore, the effect of the proposed action relative to the WOA on riparian habitat is uncertain.

5.7.7 PBF7 - Access Downstream so that Juveniles can Migrate from Spawning Grounds to San Francisco Bay and the Pacific Ocean

Emigration of juvenile Winter-run Chinook Salmon from spawning grounds to the Delta is potentially limited by flow and water temperature-related conditions throughout the Sacramento River upstream of the Delta. Winter-run Chinook Salmon juveniles emigrate from the upper and middle Sacramento River over a period of many months, beginning as early as July, shortly after the start of fry emergence, through the following March. Differences in modeled flows and water temperatures in juvenile Winter-run Chinook Salmon migration habitat are small between the proposed action and COS, but are large between the proposed action and WOA.

During the late fall through early spring period, flows under all three scenarios are high enough and water temperatures are low enough to sustain juvenile Winter-run Chinook Salmon. However, WOA flows in many years during the winter and early spring are much higher than proposed action flow and, because the WOA flows are uncontrolled, pulse flows are likely more frequent. Pulse flows stimulate juvenile salmon to initiate major downstream movement. Therefore, during these months the proposed action would adversely affect flow conditions for juvenile emigration relative to the WOA.

During the summer and early fall, proposed action flows are much higher than WOA flows, which would benefit emigrating juveniles. Water temperatures in the middle Sacramento River (Woodson Bridge gauge) are consistently below critical thresholds for emigrating Winter-run Chinook Salmon juveniles under all three project scenarios during every year from November through March. However, during July through September, the WOA water temperatures exceed the threshold for juvenile Winter-run Chinook Salmon in every year and the proposed action temperatures exceed the threshold in about half of the years. Also, the WOA temperatures during these months are 10 to 15 degrees Fahrenheit warmer than the corresponding proposed action temperatures.

Overall, the proposed action would provide less favorable conditions relative to the WOA scenario for emigrating juveniles during winter and early spring, because proposed action flows would generally be lower. The proposed action would provide more favorable conditions in the summer months compared to WOA because flows would be higher and water temperatures lower. On balance, the proposed action is not expected to adversely affect downstream access in critical habitat for juvenile Winter-run Chinook Salmon emigrating down river.

The proposed action is not expected to have effects on water temperature and dissolved oxygen concentration (DO) in critical habitat for Winter-run Chinook salmon in the Bay/Delta. These water quality parameters are major discriminators for comparing potential effects of the proposed action and the WOA on Winter-run Chinook in the Sacramento River upstream of the Delta. In the Bay/Delta, however, flow and water temperature of reservoir releases are generally considered to have little effect on water temperatures (Wagner et al. 2011, USFWS 2017b). However, this assessment has been based on experience with smaller flow and water temperature differences than those expected between the proposed action and WOA (USFWS 2017b), so the conclusion that the proposed action would have no effects on water temperature in the Bay/Delta relative to the Without Action scenario is uncertain. Other than near major effluents, DO in the Bay/Delta is primarily determined by water temperature. Juvenile Winter-run undergo smoltification before and while they reside in the Bay/Delta, so they are able to tolerate a wide range of salinities in the Bay/Delta.

Flow from the Sacramento, San Joaquin and other rivers tributary to the Delta, as well as tidal flows, affect the hydrodynamic of Delta channels and influence how juvenile Winter-run move through the Delta. The results of analyses of hydrodynamics and flow velocities to evaluate effects of the proposed action on routing of Winter-run juveniles in the Delta indicate that routing into the interior Delta, where the juveniles would be at higher risk from entrainment and reduced water quality (NMFS 2009), would be higher under the proposed action relative to the WOA.

Effects of the proposed action on entrainment of juvenile Winter-run at the Banks and Jones export facilities in the south Delta would be substantial compared to WOA, as the WOA scenario includes no exports from the Delta and therefore would have no entrainment at the south Delta facilities. The proposed action is expected to increase entrainment of individual Winter-run Chinook salmon relative to both current operations and WOA.

5.7.8 Effects of Conservation Measures

Spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action would be implemented for the benefit of salmonids, including Winter-run Chinook Salmon and elements of critical habitat. Construction may increase turbidity and contaminant exposure risk. Ultimately, restoration projects would improve access to spawning areas (PBF1) and availability of clean gravel for spawning substrate (PBF2). Construction may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to critical habitat for Winter-run Chinook Salmon.

5.8 Chinook Salmon, Central Valley Spring-run ESU

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing and migrating Spring-run Chinook salmon and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows.

For Spring-run Chinook salmon, the proposed action includes a pulse flow in the spring from Shasta Reservoir in years when the cold water pool is likely sufficient to protect winter-run egg incubation. The pulse may improve survival for Mill, Deer, and Butte Creek Spring-run migrating through the lower Sacramento River.

In addition to the pulse flow in the spring, several conservation measures would also minimize impacts of lower spring flows on Spring-run Chinook salmon juveniles. These include spawning and rearing habitat restoration on the Sacramento and lower San Joaquin rivers, tidal habitat restoration, and predator hot spot removal. Similar to winter-run Chinook salmon, OMR management establishes protective criteria to minimize and avoid entrainment based on historical salvage. Additional protective measures occur when environmental criteria indicate that entrainment is more likely and allow for more flexible operations when entrainment is less likely. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action as compared to WOA.

5.8.1 Lifestage Timing

General life stage timing and location information for Spring-run Chinook Salmon is provided in Table 5.8-1. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*.

Table 5.8-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Spring-run Chinook Salmon at Various Locations in the Central Valley (NMFS 2017, p.71).

| Relative Abundance | High | | | Medium | | | Low | | | | | |
|------------------------------------------|------|-----|-----|--------|-----|-----|-----|-----|-----|-----|-----|-----|
| (a) Adult Migration | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Delta ^a | | | | | | | | | | | | |
| San Joaquin Basin | | | | | | | | | | | | |
| Sac. River Basin ^{b,c} | | | | | | | | | | | | |
| Sac. River Mainstem ^{c,d} | | | | | | | | | | | | |
| b) Adult Holding^{b,c} | | | | | | | | | | | | |
| c) Adult Spawning^{b,c,d} | | | | | | | | | | | | |
| (b) Juvenile Migration | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sac. River at RBDD ^d | | | | | | | | | | | | |
| Sac. River at KL ⁱ | | | | | | | | | | | | |
| San Joaquin basin | | | | | | | | | | | | |
| Delta ^j | | | | | | | | | | | | |

Sources: ^aCDFG (1998); ^bYoshiyama et al. (1998); ^cMoyle (2002); ^dMyers et al. (1998); ^eLindley et al. (2004); ^fCDFG (1998); ^gMcReynolds et al. (2007); ^hWard et al. (2003); ⁱSnider and Titus (2000); ^jSacTrawl (2015)

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.

5.8.2 Conceptual Model Linkages

Central Valley (CV) Spring-run Chinook Salmon populations occur in several Central Valley streams. This section considers effects of the proposed action on the Sacramento River population. The SAIL conceptual model (Figure WR_CM1) was prepared especially for Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply equally well to the Spring-run population in Sacramento River. This conceptual model will be referenced throughout this section to explain links between the species and the effects of the action. The primary differences in the habitat requirements between the two runs (i.e., Winter and Spring) are the duration and the time of year that the different life stages use their habitats (NMFS 2014).

Reclamation proposes to store and release water from Shasta, Keswick Whiskeytown Dams. Storing water in the upper Sacramento River watershed is landscape level attribute in the conceptual model. The resulting dam releases and the resulting flows are environmental drivers that affect habitat attributes. The flows can influence water temperature, dissolved oxygen level (DO), the amount of stranding,

outmigration cues and the timing, condition and survival of rearing CV juvenile Spring-run Chinook salmon. These flows also influence the timing, condition and survival of eggs and alevins in the spawning redds, rearing juvenile CV Spring-run Chinook salmon and holding of adult CV Spring-run Chinook salmon prior to spawning in the upper Sacramento River. These habitat attributes further influence lower level attributes, such as flow affects dilution of contaminants and toxics; water temperatures affects food availability, predation, pathogens, and disease; river stage and flow velocity affects habitat connectivity, bioenergetics, food availability, and predation, entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

These inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven particularly successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redds (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering (Windell et al. 2017). Flow also affects the surface area of riverbed available for redd construction.

Eggs and emerging fry are often exposed to geomorphic flows, and spring attraction flows based on the lifestage timing. Potential effects of these geomorphic flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat, if present. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment “cap” that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989). These flows mobilize gravel and increase the overall quality of egg incubation habitat. Critical water temperature thresholds for CV Spring-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Rombough (1994) indicates that eggs at hatch generally require water temperatures no greater than about 53.5 degrees Fahrenheit because at higher temperatures DO is insufficient to satisfy metabolic demands. Central Valley Spring-run Chinook salmon eggs and alevins are assumed to be similarly affected by temperature.

The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017). The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Central Valley Spring-run Chinook salmon juveniles rear throughout the upper Sacramento (Keswick to Red Bluff) from November through May, with a peak rearing period during November through January, and emigrate from the upper River during this period (Table 5.8-11). Flows during fall and winter of dry and critically dry years generally have the greatest potential to adversely affect the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats.

Central Valley Spring-run Chinook salmon adults spawn in the Sacramento River from August through October with peak spawning during September (Table 5.8-1). Monitoring spring-run spawning in the mainstem Sacramento River is complicated due to lack of spatial/geographic segregation and temporal

isolation from fall-run. Most spring-run spawning occurs between the Anderson-Cottonwood Irrigation District Dam to Airport Road Bridge (NMFS 2017b). Fry emergence occurs up to 3.5 months after eggs are spawned (Moyle 2002), so effects of flow resulting from the proposed action in the upper Sacramento River on incubating spring-run eggs and alevins potentially occur from August through January, peaking in November and December.

Many of the factors that affect rearing and emigrating CV Spring-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. Juvenile spring-run spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. The majority of spring-run-sized juveniles occur in the middle Sacramento River at Knights Landing from November through May (Table 5.8-1), with two separate peak occurrences: December and March through April (Table 5.8-1). The two peaks may reflect differences in the timing of emigration from different Sacramento River tributaries. For instance, emigration of young-of-year juveniles from Butte Creek occurs earlier than that from Mill and Deer creeks (NMFS 2009).

Holding for adult Spring-run Chinook Salmon in the upper Sacramento River extends from late February through early October, peaking in late April through early August (Table 5.8-1).

5.8.3 Effects of Operation and Maintenance

The WOA scenario is described previously in the Winter-run Chinook salmon effects analysis. Sacramento River flows at Keswick Dam resulting from the WOA scenario were modeled in CalSim and reflect seasonal changes, with low summer and fall flows and high winter and spring flows (Figures 15-7 through 15-18 in the CalSim II Flows section of Appendix D). Flows in the middle Sacramento River under the WOA scenario would be similar to those in the upper Sacramento River, moderately low during November and May and much higher during December through April (see Appendix D, *Modeling*). CalSim modeling indicates that during the CV Spring-run Chinook holding period in the upper Sacramento River, flows at Keswick range from about 770 cfs in August to about 63,000 cfs in March, and 40 to 50 percent of years have flows below the current 3,250 cfs required minimum flow during July through September (see Appendix D, *Modeling*).

Other locations in the Sacramento River would show similar seasonal flow patterns. Modeling results of the WOA scenario indicate that flows in CV Spring-run Chinook Salmon habitat located in the Upper Sacramento during the August through January spawning and incubation period are generally low during August through November, but are high in December and January of years with wetter hydrologies (Figures 15-7 through 15-10, and 15-17 and 15-18 in the CalSim II Flows section of Appendix D).

In the WOA scenario, flows would generally be low in fall during years with dry hydrology and often fall below the currently required minimum flows for much of fall through spring (Figures 15-8 through 15-14, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The proposed action flows are higher during the fall and winter when compared to WOA, which is a benefit for spawning CV Spring-run Chinook Salmon adults and incubating eggs and alevins through increased spawning and rearing habitat. Since juveniles are youngest and most sensitive in the fall and early winter, the increased habitat conditions under the proposed action as compared to WOA would lead to increased growth rate and lower mortality of the individual juveniles and an increased population abundance. The higher proposed action flows as compared to WOA in summer would be beneficial to holding adults and increase areas suitable for redd construction, as described by Windell et al. 2017. Potential adverse effects of low flows on the upper Sacramento River are included in the Winter-run Chinook Salmon effects analysis detailed above.

Higher flows during the winter under WOA would also negatively influence spawning and egg/alevin incubation. If flows are sufficiently high, they result in excessive depths and flow velocities for constructing redds, and redds that were previously built are at risk of being scoured from the bed (NMFS 2017 CWF BO). In addition, under high flows adults may build redds in areas that are later dewatered or isolated from the main river channel when the flows decline. Modeling indicates that high flow events with rapid flow fluctuations are likely to occur in the Sacramento River under the WOA scenario. The higher flows in winter and spring could have adverse effects on rearing juvenile CV Spring-run Chinook Salmon including higher stranding risk because of increased use of flood plains and greater flow fluctuations, and higher contaminants loading from stormwater runoff. In general, higher flows are likely to benefit holding adults by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017).

In the without action scenario, as described in the Winter-run Chinook salmon section, the water temperatures in the upper Sacramento River would be substantially warmer because the shallow reservoir that would remain behind Shasta Dam would absorb significant heat during warm, sunny days.

The USEPA (2003) gives 64 degrees Fahrenheit as the critical 7-day average daily maximum (7DADM) water temperature for rearing salmonid juveniles. Also, the USEPA (2003) gives 68 degrees Fahrenheit as the critical 7DADM water temperature for migrating salmonid adults and 61 degrees Fahrenheit for holding adults. As discussed in the Winter-run Chinook Salmon section above, this reference is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM.

Under the WOA scenario, the elevated water temperatures in late spring, summer and early fall, would be poorly suited for spring-run adults. Monthly mean water temperatures in spawning habitat (i.e., HEC-5Q WOA scenario) would be high in the latter part of summer during the spawning and incubation period, ranging from about 63 to 72 degrees Fahrenheit. The critical temperature thresholds for spawning adults are the same as those for incubating eggs and alevins: 56 degrees Fahrenheit and 53.5 degrees Fahrenheit. This water temperature regime greatly exceeds both thresholds (Figures 5-17 and 5-18 in the HEC5Q Temperatures section of Appendix D). These thresholds would be exceeded under the WOA scenario in almost all years (Figures 5-11 through 5-18 and 5-7 in the HEC5Q Temperatures section of Appendix D). Such conditions would likely preclude survival of incubating CV Spring-run Chinook Salmon eggs and alevins. During early fall, water temperatures would exceed the 56 degrees Fahrenheit threshold in about half of the years projected and would exceed the 53.5 degrees Fahrenheit threshold in all years projected (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). During the remaining months of the CV Spring-run Chinook Salmon spawning and incubation period of fall through winter, water temperatures under the WOA conditions would be consistently below 52 degrees Fahrenheit, suitable for incubating eggs and alevins (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). However, Sacramento River Spring-run Chinook Salmon have largely finished spawning by mid-fall (Table 5.8-1). Therefore, unless the population successfully shifted its spawning to later in the winter, Spring-run Chinook Salmon would likely be eliminated from the Sacramento River mainstem under without action conditions.

During February through April, the first part of the CV Spring-run adult holding and spawning period in the upper Sacramento River, mean water temperatures under the WOA scenario are consistently below the 61 degrees Fahrenheit threshold for holding adults, and water temperatures are below this threshold in most years during May (Figures 5-9 through 5-14 in the HEC5Q Temperatures section of Appendix D). They are also below the threshold in all years during October (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). During June through September, however, the water temperatures are above the

threshold in almost every year (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D).

During the November through May period, temperature would range from about 38 degrees Fahrenheit during January to 63 degrees Fahrenheit during May (Figures 5-8 through 5-14 in the HEC5Q Temperatures section of Appendix D). Under the WOA scenario, water temperatures would exceed the 61 degrees Fahrenheit threshold only in May and the exceedences would occur in 5% of the years in the historical record. Water temperatures during the November through May period at other locations in the upper Sacramento River would generally be similar to those at Keswick Dam, but in May, water temperatures would range up to 69 degrees Fahrenheit at the Red Bluff Diversion Dam (RBDD), with about 75 percent of years exceeding the 61 degrees Fahrenheit threshold. Locations upstream of RBDD would have cooler temperatures than those at RBDD, but would have exceedences of the 61 degrees Fahrenheit threshold in May of a substantial percentage of years. The mean May temperatures would generally be highest in dry and critically dry water years (Tables 5-1 through 5-3, 6-1 through 6-3, 7-1 through 7-3, 8-1 through 8-3, 9-1 through 9-3, and 10-1 through 10-3 in the HEC5Q Temperatures section of Appendix D). The frequent exceedences of the 61 degrees Fahrenheit threshold that would occur during May at some locations in the upper Sacramento River would potentially negatively impact rearing Spring-run Chinook Salmon juveniles. However, the exceedences would rarely occur in the most upstream locations. Furthermore, by May most juveniles have probably matured enough to acquire greater warm water temperature tolerance and most have emigrated from the upper Sacramento River (Table 5.8-1).

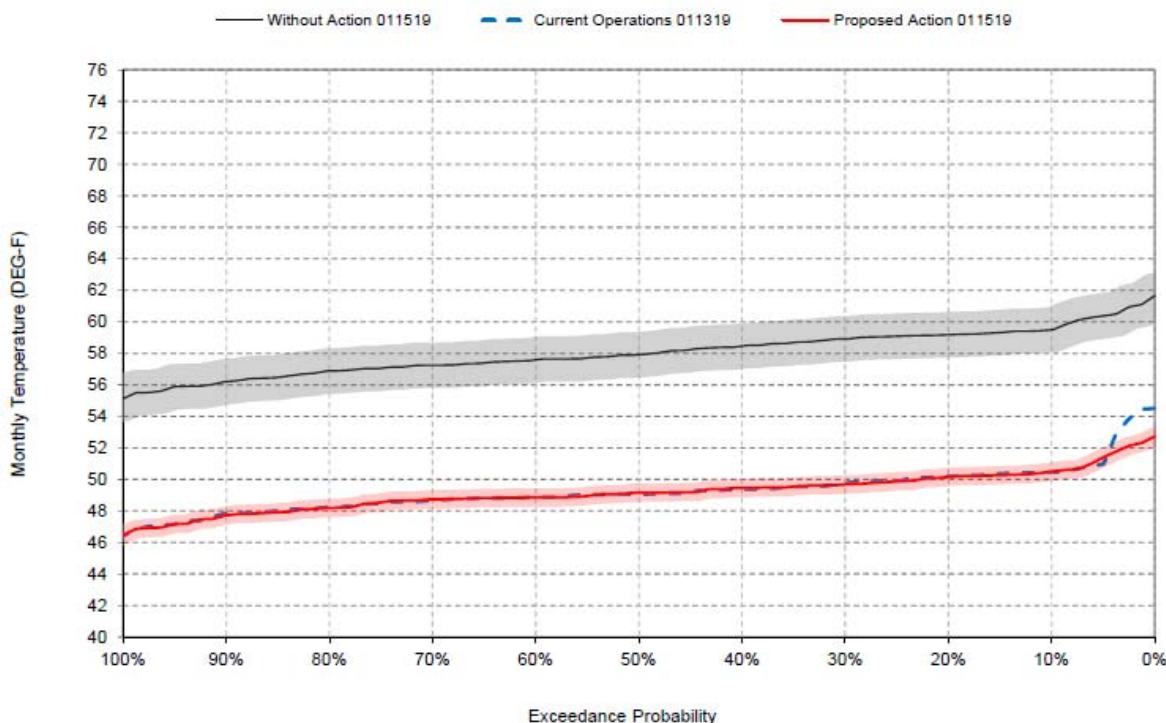


Figure 5.8-1. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, May

In the upper Sacramento River at Keswick, the WOA scenario monthly average water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults from January through April and in

October (Figures 5-7 and 5-10 through 5-13 in the HEC5Q Temperatures section of Appendix D), but would exceed the threshold in about 6 percent of years in May and in every year during June through September (Figures 5-14 through 5-18 in the HEC5Q Temperatures section of Appendix D). Water temperatures conditions under the WOA scenario in the summer months, June through September, would be highly stressful to adult CV Spring-run migrating upriver in the middle Sacramento River as well as those holding in the upper river.

The main difference between the juveniles in the middle Sacramento River and those in the upper river with respect to these adverse effects is that the juveniles in the middle river would generally be less sensitive to the effects because their greater age and size would afford them greater robustness. The low fall flows under the WOA scenario would likely result in reduced conditions in juvenile rearing habitats in the middle Sacramento River. During November and May, the flows would fall below the normal minimum flow requirements in about 37 percent of years projected.

In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing, the WOA scenario monthly mean water temperatures would remain below the 64 degrees Fahrenheit threshold from November through March (Figures 14-8 through 14-12 in the HEC5Q Temperatures section of Appendix D), but would exceed the threshold during the warmest 5 percent of years in April and the warmest 85 percent of years in May, with a maximum water temperature of 75 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC5Q Temperatures section of Appendix D).

In the middle Sacramento River at Knights Landing, the WOA scenario monthly average water temperatures would consistently be below the 68 degrees Fahrenheit threshold for immigrating adults from January through April (Figures 14-10 through 14-13 in the HEC5Q Temperatures section of Appendix D). Under the WOA scenario, water temperatures would also exceed the threshold during May of about half of the years, during June through September in every year, and during October of about 20 percent of the years on record. (Figures 14-7 and 14-14 through 14-18 in the HEC5Q Temperatures section of Appendix D).

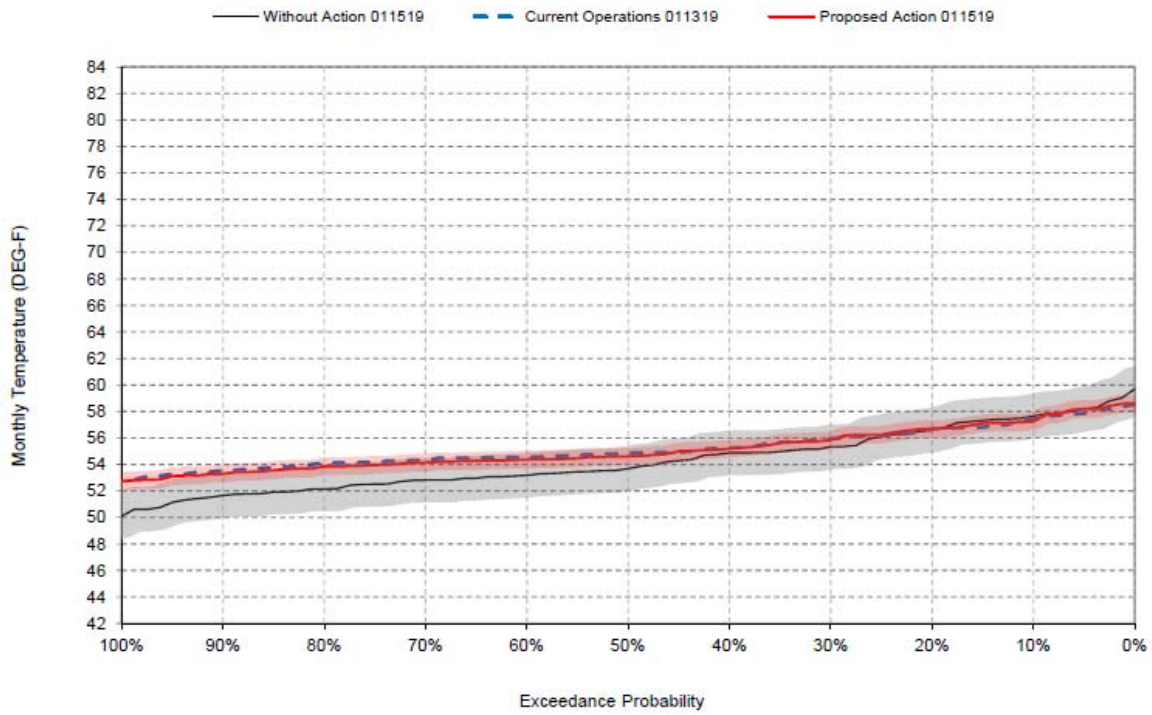


Figure 5.8-2. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, November

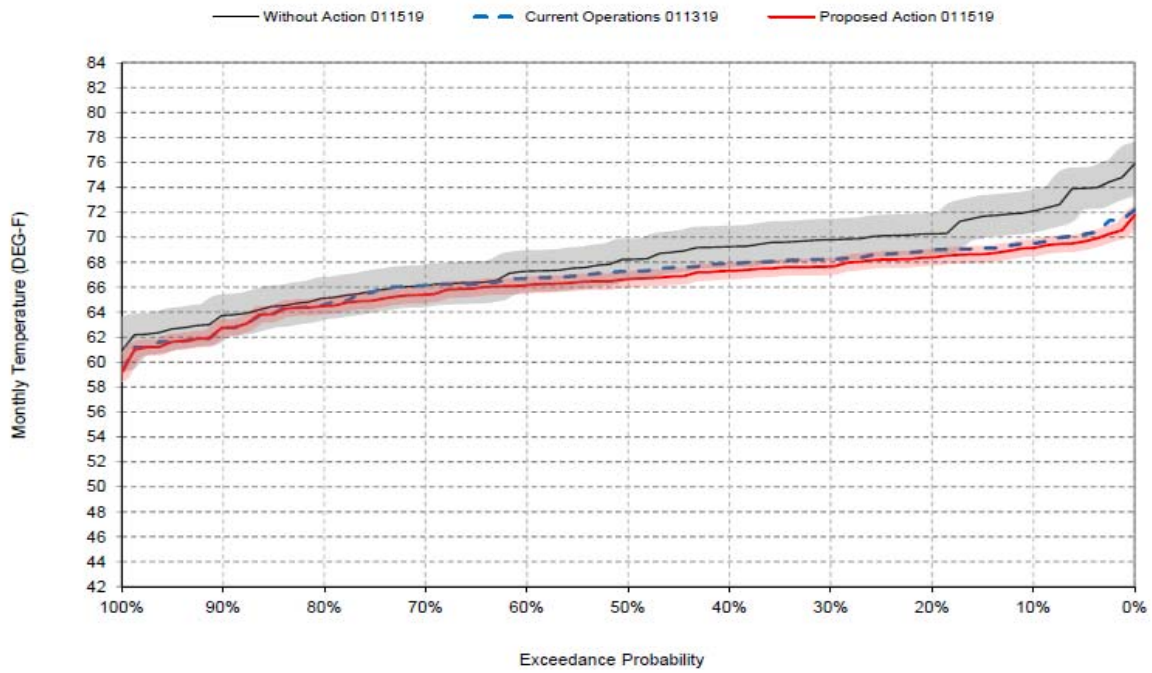


Figure 5.8-3. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, May

CalSim modeling indicates that from January through April, the first half of the period during which spring-run adults migrate upstream through the middle Sacramento River to holding habitat in the upper river, the WOA scenario flows at Wilkins Slough would range from about 2,500 cfs in April to about 24,000 cfs in March (Figures 19-10 through 19-13 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 3,250 cfs in all four months to about 63,000 cfs in March (Figures 15-10 through 15-13 in the CalSim II Flows section of Appendix D). During the second part of the migration and holding period (May through October), the WOA flows at Wilkins Slough would range from 0 cfs in May through August to about 20,000 cfs in May (Figures 19-7 and 19-14 through 19-18 in the CalSim II Flows section of Appendix D). At Keswick, the WOA flows would range from about 772 cfs in August to about 32,000 cfs in May (Figures 15-7 and 15-14 through 15-18 in the CalSim II Flows section of Appendix D). The lowest flows at Keswick Dam during May through August would be low enough to create potential passage problems for immigrating adults, and this is even more likely for Wilkins Slough, where flows in June through August would be about 1,000 cfs or lower in about half of the years. The effects of low flow on the middle Sacramento River and for adults holding in the upper river are expected to be similar to those described by Windell et al. 2107.

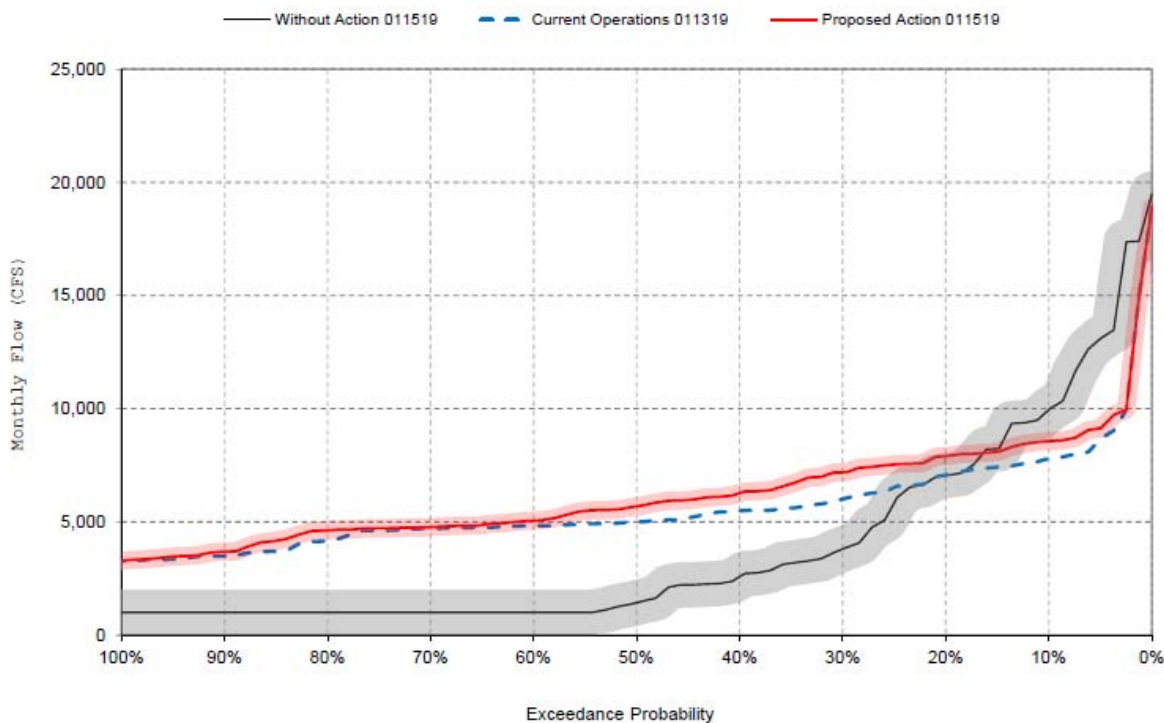


Figure 5.8-4. Modeled Sacramento River Flows at Wilkins Slough, June

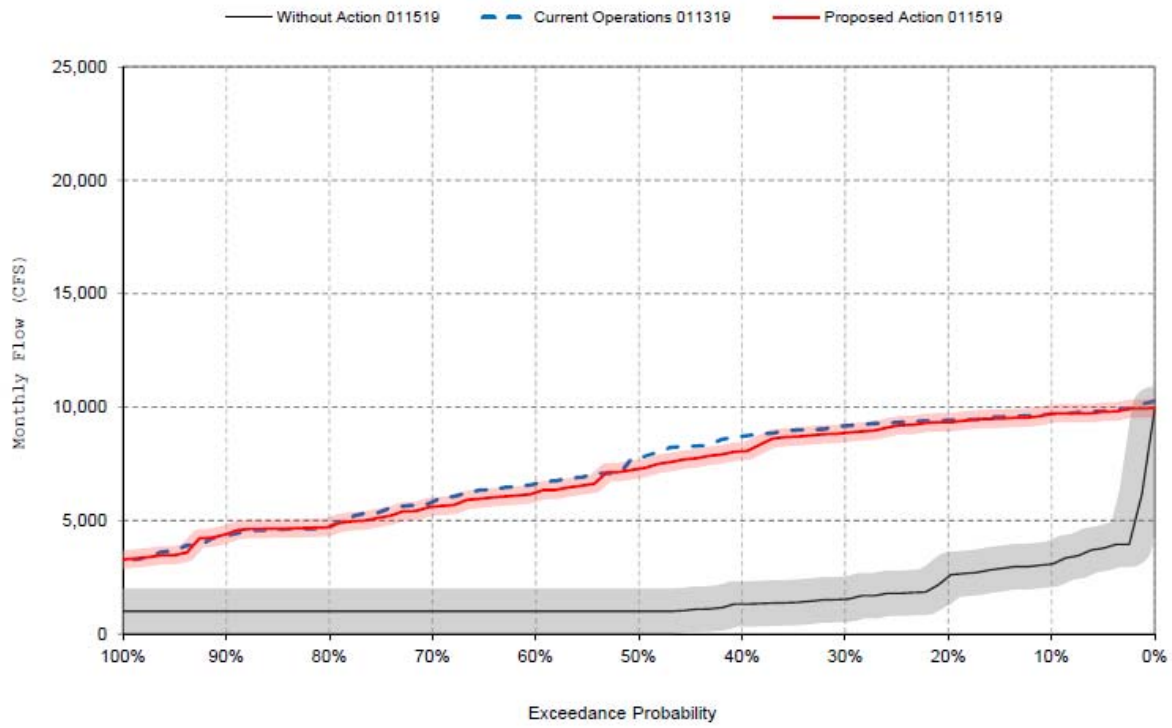


Figure 5.8-5. Modeled Sacramento River Flows at Wilkins Slough, July

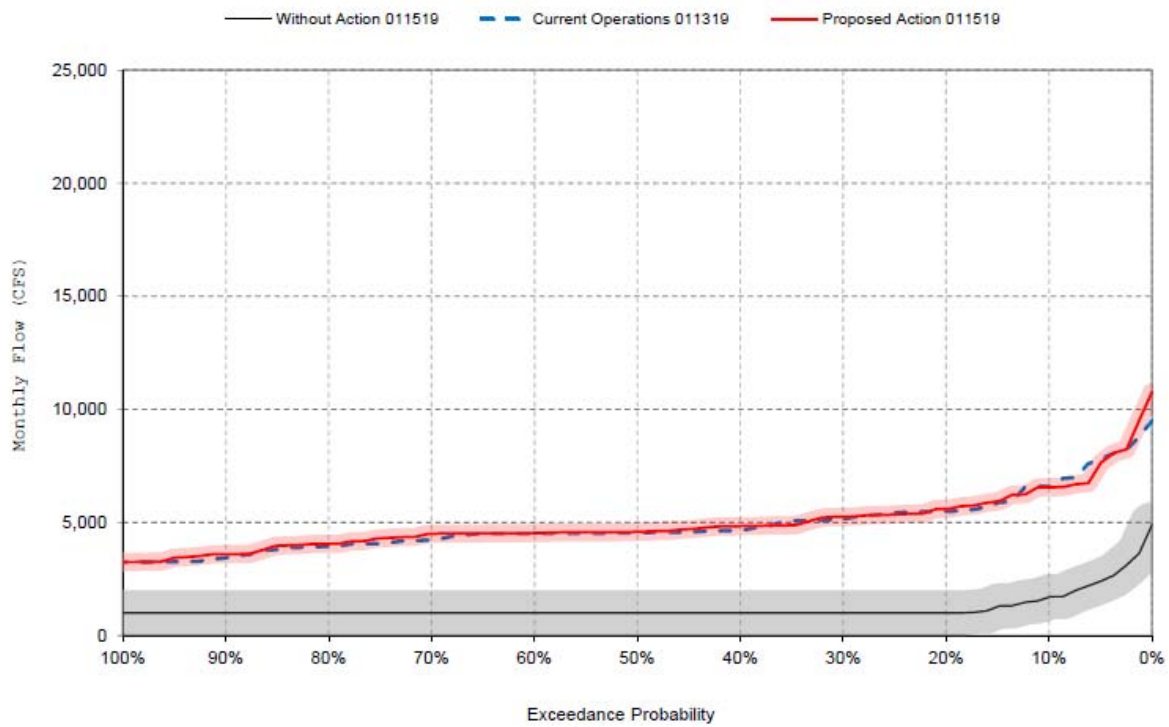


Figure 5.8-6. Modeled Sacramento River Flows at Wilkins Slough, August

5.8.3.1 Seasonal Operations of the CVP/SWP

Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Flows under the proposed action are generally lower than flows under the WOA scenario during the peak seasonal timing of CV Spring-run Chinook juvenile rearing (November-May; Figure 5.8-7) in all watersheds. In particular, flows are reliably lower from January to May (Figure 5.8-7), a trend especially pronounced in wetter water year types. In contrast, flows under the proposed action are higher than WOA in the summer and fall. The likelihood of flows occurring in the proposed action that are less than the minimum instream flow requirements during these months is very low for all water year types. Lower flows during the juvenile outmigration period under the proposed action could have both beneficial and adverse effects on rearing juvenile CV Spring-run Chinook Salmon.

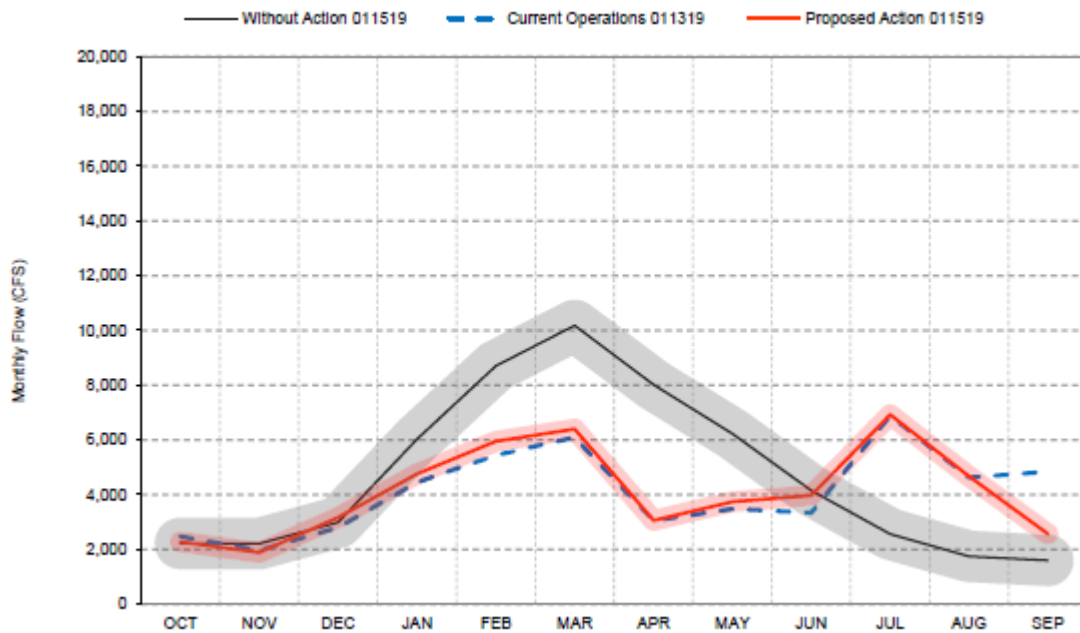


Figure 5.8-7. CalSimII estimates of Feather River Long-Term average flow below the Thermalito Afterbay in September-November and December-February.

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing individuals and their habitat. Beneficial effects are anticipated to be reduced stranding risk resulting from increased use of flood plain habitat and larger flow fluctuations, and reduced contaminant loading from stormwater runoff. Adverse effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows.

Several conservation measures proposed for Sacramento Winter-run Chinook salmon would also offset any minimal adverse effects of reduced spring flows on Spring-run Chinook Salmon juveniles. These include spawning and rearing habitat on the Sacramento and Stanislaus Rivers, cold water pool management on the Sacramento River, cold water pool management tools and infrastructure on the Sacramento River, predator hot spot removal and small screen program.

Under the WOA scenario, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would occur. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where CV Spring-run Chinook Salmon juvenile rearing occurs. Resulting water temperatures under the WOA scenario in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are similar to COS and proposed action temperatures during the November to May period, but the proposed action is up to 7 degrees cooler than the without action during the critical summer holding period for Spring-run Chinook Salmon adults (Figure 5-SR-5).

The increased summer flows of the proposed action, compared to the WOA, are likely to have significant benefits for holding adults by reducing water temperatures in holding areas, and associated benefits to dissolved oxygen.

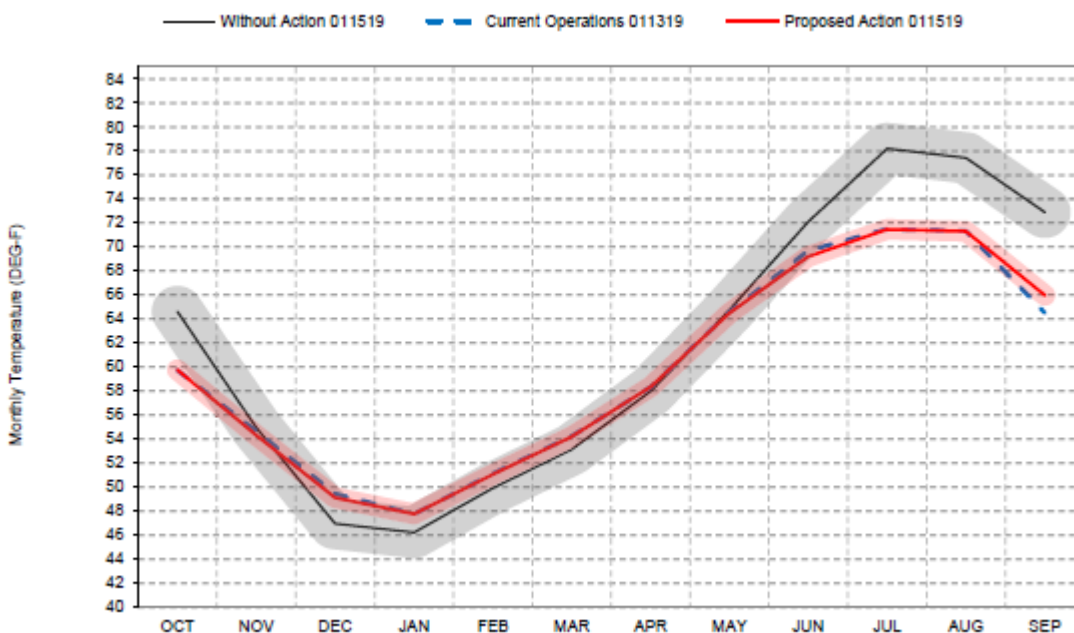


Figure 5.8-8. Long-term average RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

5.8.3.2 Upper Sacramento River Seasonal Operations including Shasta Cold Water Pool Management

The effects of cold-water releases on Spring-run Chinook Salmon are expected to be similar to those experienced by Winter-run Chinook, but of smaller magnitude due to the seasonal timing of Spring-run Chinook Salmon spawning and juvenile rearing and the distribution of their redds.

Under the proposed action operations, flow and water temperature management in the upper Sacramento River would be largely the same as that under COS. The primary difference between the proposed action and the COS for the Sacramento River upstream of the Delta is the water temperature management of Shasta and Keswick reservoirs, especially with respect to the TCD.

5.8.3.2.1 Egg to Fry Emergence

5.8.3.2.1.1 River Flow

During summer and fall, primary operational considerations are flows required for Delta outflows, instream demands, and temperature control for Winter-run and Spring-run Chinook Salmon spawning and incubation. Proposed action flows are well above the WOA flows for the first three months (August through October) of the spring-run spawning and incubation period (Figures 15-17, 15-18, and 15-7 in the CalSim II Flows section of Appendix D). Low flows would be exacerbated under WOA, resulting in negative impacts to Spring-run Chinook Salmon spawning and incubation. Spring-run Chinook Salmon habitat conditions are expected to be improved by increased flows provided by the proposed action.

Flow during the entire August through January period rarely fall below 3,250 cfs under COS, as indicated by CalSim modeling. Modeling indicates that lowest flows under the proposed action conditions are expected to be similar to the flows of the COS scenario (Figures 15-7 through 15-10, and 15-17 and 15-18 in the CalSim II Flows section of Appendix D).

Differences in flows between the proposed action and COS are small in most months, but flows are substantially higher for the COS modeling scenario in September of years with wetter hydrology (e.g., a COS flow of about 17,000 cfs corresponds to a proposed action flow of about 12,000 cfs and a COS flow of about 10,000 cfs corresponds to a proposed action flow of about 6,000 cfs) (Figure 15-18 in the CalSim II Flows section of Appendix D). After applying the Weighted Usable Area analysis for spawning habitat of Fall-run Chinook salmon juveniles, which has been used as a surrogate for Spring-run Chinook Salmon in the Sacramento River (ICF 2016 *CWF BA Appendix 5D Methods*), the proposed action has lower September flows than COS, which would result in an increase in spawning habitat Weighted Usable Area for Spring-run Chinook Salmon in this month (Figure 5.8-9). Although the Weighted Usable Area analyses indicate a potential decrease in rearing habitat in wetter years under proposed action flows than COS flows, the reductions in flow predicted for the proposed action could potentially affect other undetermined rearing habitat attributes of spring-run juveniles than those measured for the Weighted Usable Area analyses.

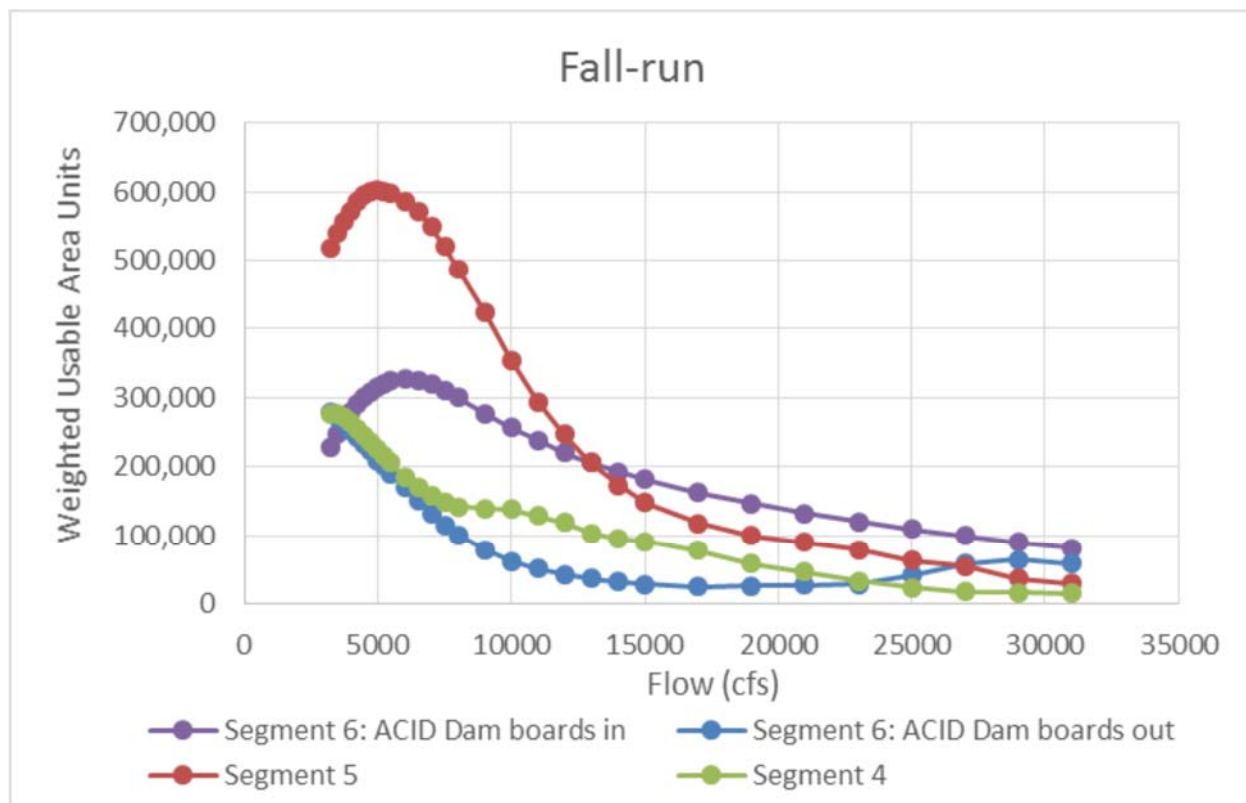


Figure 5.8-9. Spawning WUA Curves for Fall-run Chinook salmon in the Sacramento River, Segments 4 to 6. The fall-run curves were used to quantify Spring-run Chinook Salmon WUA, as discussed in the text. ACID = Anderson-Cottonwood Irrigation District.

5.8.3.2.1.2 Water Temperature

Reclamation proposes new water temperature management measures that include a water temperature maximum of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence (see below) in most years from May 15 to October 31.

The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under the proposed action and the COS in the upper Sacramento River during the first three months of the Spring-run Chinook Salmon spawning and incubation period than would be possible under the WOA conditions. Under the HEC-5Q proposed action and the COS, monthly mean water temperatures at Keswick Dam range from about 50 to 66 degrees Fahrenheit during August through October (Figures 5-17, 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). During November, water temperatures range from about 52 to 58 degrees Fahrenheit, and during December and January, they range from 43 to 55 degrees Fahrenheit (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average temperatures near Keswick Dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam.

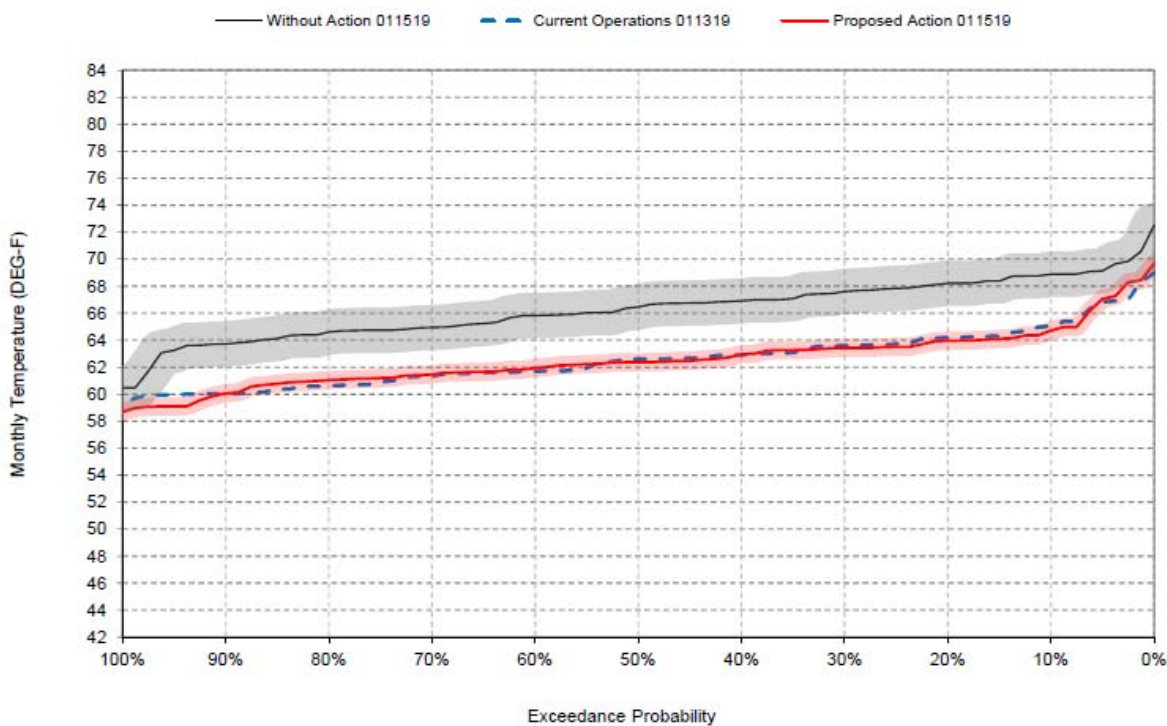


Figure 5.8-10. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA and COS scenarios, October

As discussed in the Winter-run Chinook Salmon section, the proposed action has reduced temperatures by up to 2 degrees in October of most years. The proposed action water temperatures exceed the 56 degrees Fahrenheit threshold approximately 20% of the time in November (see Figure below), but otherwise rarely in the fall. The proposed action exceeds 53.5 at Keswick approximately 8% of the time in August, while under the current operations temperatures at Keswick exceed 53.5 degrees Fahrenheit approximately 23% of the time. In September, the proposed action exceeds 56 degrees Fahrenheit at Keswick 10% of the time, while under the current operations water temperatures exceed 56 degrees Fahrenheit at Keswick approximately 7% of the time. Water temperatures in December and January would be consistently below the 56 degrees Fahrenheit threshold and would exceed the 53.5 degrees Fahrenheit threshold in about 10 percent of years in December and one percent in January (Figures 5-9 and 5-10 in the HEC5Q Temperatures section of Appendix D).

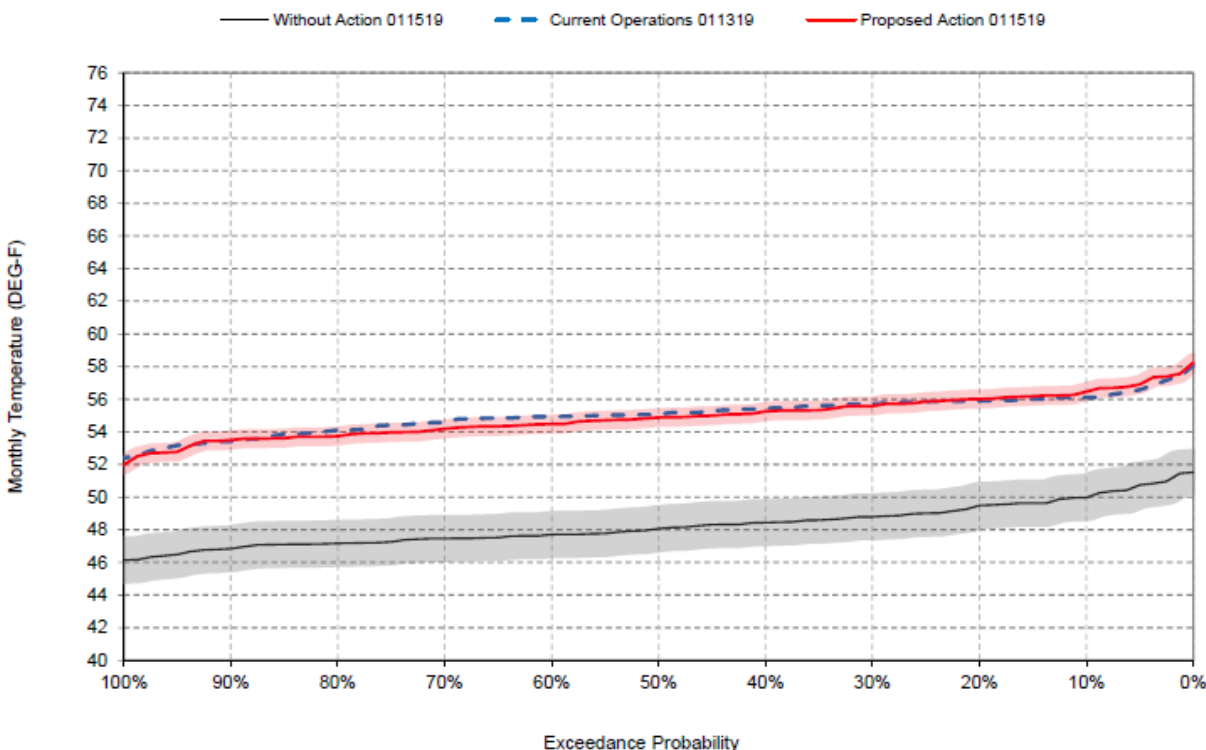


Figure 5.8-11. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA and COS scenarios, November

Water temperatures under the proposed action are much lower than those under the WOA scenario from April through October (Figures 5-13 through 5-18 and 5-7 in the HEC5Q Temperatures section of Appendix D), whereas water temperatures under the proposed action are much higher than those under the WOA scenario during November through January (Figures 5-8 through 5-10 in the HEC5Q Temperatures section of Appendix D). These results indicate that the proposed action, relative to the WOA, provides a clear benefit to Spring-run Chinook Salmon eggs and alevins incubating in the upper Sacramento River during the spawning months (August through October). During November through January, when spawning is completed but eggs and alevins remain in some of the redds, water temperatures are suitable for egg and alevin incubation under the proposed action and COS scenarios, except during November, when water temperatures exceed the 56 degrees Fahrenheit threshold in 20 percent of years and the 53.5 degrees Fahrenheit threshold in more than 80 percent of years. Under the WOA scenario, water temperatures during November through January are suitable for incubating eggs and alevins, except perhaps during January in the coldest 30 percent of years, when the mean temperatures are under 40 degrees Fahrenheit (Figure 5.8-12). Such cold water temperatures are below the suitable temperature range for maximum egg and alevin survival (Moyle 2002). As noted above, the higher water temperature under the WOA scenario during the Spring-run Chinook Salmon spawning months would greatly impact the Sacramento River Spring-run Chinook Salmon population. On balance, this effect would be much greater than the adverse effect of the higher water temperatures in November of some years under the proposed action and the COS. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Spring-run Chinook Salmon eggs and alevins relative to the COS.

Under the WOA, Spring-run Chinook Salmon eggs and alevins would mostly likely be eliminated from the Upper Sacramento River. Comparatively, the proposed action and the COS are beneficial to incubating Spring-run Chinook Salmon eggs and alevins. The proposed temperature management under the proposed action is expected to improve water temperatures compared to WOA and reduce operational difficulties in maintaining river habitats.

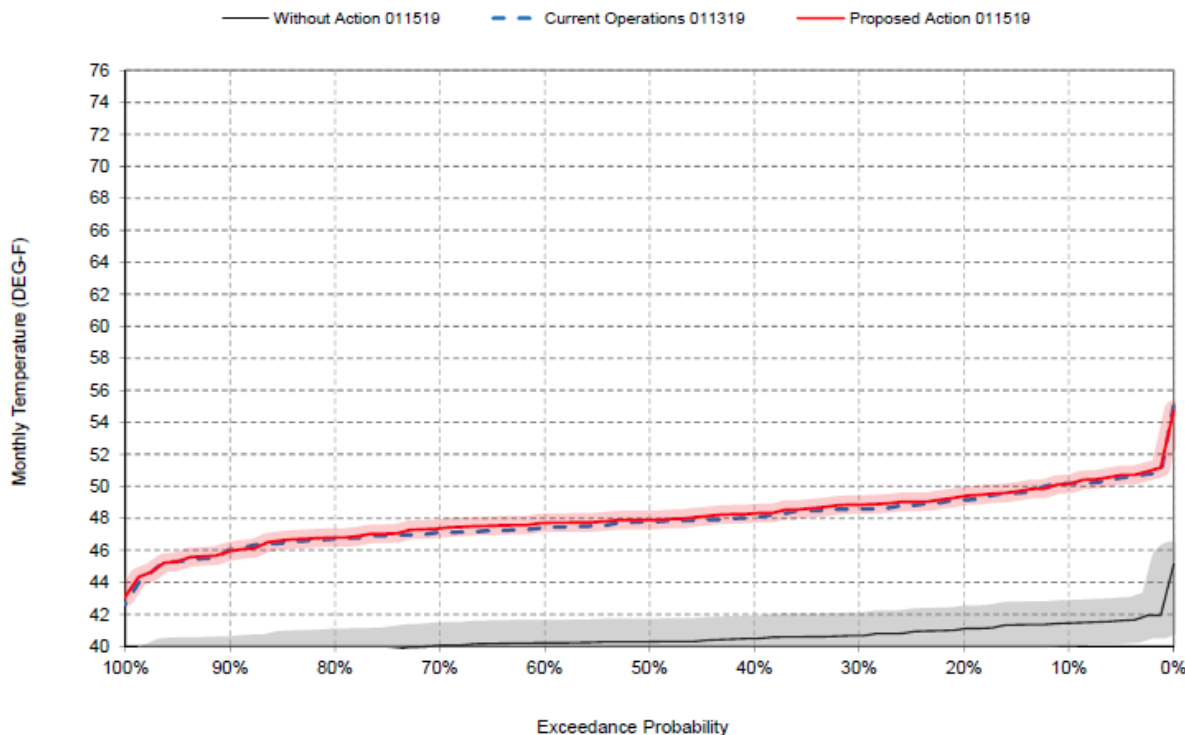


Figure 5.8-12. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the proposed action, WOA and COS scenarios, January

5.8.3.2.2 Rearing to Outmigrating Juveniles in Rivers

5.8.3.2.2.1 River Flow

Under proposed action operations, flow and water temperature management during the juvenile rearing and emigration period in the upper Sacramento River would be largely the same as that under COS. CalSim modeling indicates that upper Sacramento River flows during the November through May period of juvenile rearing in the upper Sacramento River are generally similar between the proposed action and the COS (Figures 15-8 through 15-14 in the CalSim II Flows section of Appendix D) except for higher flows during November under the COS scenario.

The CalSim modeling shows large seasonal changes in the differences between the proposed action and the WOA scenario and COS in upper Sacramento River flow. In November, there is little difference in flow between the WOA and proposed action scenarios, except in the highest flows years, when the proposed action flows tend to be higher. The COS flows are well above the WOA flows at most flow levels (Figure 15-8, and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the

CalSim II Flows section of Appendix D). In December and February, proposed action and COS flows are generally below WOA flows for years with dry hydrology, and are generally higher in wet years, except for the wettest Decembers (Figures 15-9 and 5-11 in the CalSim II Flows section of Appendix D). In January, proposed action and COS flows are generally moderately lower than the WOA flows and during March and April, they are well below the WOA flows (Figures 15-10, 15-12, and 15-13 in the CalSim II Flows section of Appendix D). In May, the proposed action and COS flows are well below the WOA flows in wetter years, and are slightly higher in drier years (Figure 15-14 in the CalSim II Flows section of Appendix D). These seasonal changes result primarily from Shasta Reservoir storage releases under the proposed action and COS during late fall, when uncontrolled flows are low, and also from diversions to Shasta Reservoir storage under the proposed action and COS scenarios during winter and spring, when uncontrolled flows are often high. Diversion to storage is higher in spring than in winter because the flood control pool in the reservoir can be reduced during spring as flood risk declines.

The flows resulting from differences between the WOA scenario and the proposed action and COA scenarios would likely impact Spring-run Chinook Salmon juveniles and their habitats, although the nature of the effect is undetermined. From January through April, WOA flows would often be nearly twice as high as the proposed action and COS flows during years with dry hydrology. The proposed action and COS flows in such years would generally be at the required minimum of 3,250 cfs. The Weighted Usable Area for rearing habitat of fall-run Chinook salmon juveniles, which has been used as a surrogate for Spring-run Chinook Salmon Weighted Usable Area analyses in the Sacramento River (ICF 2016 *CFW BA Appendix 5D Methods*), is at or near its maximum at 3,250 cfs (USFWS 2005). This flow was the lowest flow included in the USFWS study. Depending on the reach sampled in the study, flow of approximately 6,000 cfs, which is the most frequent flow level for dry hydrology under the WOA scenario, was estimated to have similar to much lower juvenile rearing habitat Weighted Usable Area than the 3,250 cfs flow (USFWS 2005). Although the Weighted Usable Area analyses indicate potentially greater juvenile rearing habitat Weighted Usable Area in dry years under the proposed action and COS scenarios than under the WOA scenario, the reductions in flow predicted for these scenarios would potentially affect other rearing habitat attributes of Spring-run Chinook Salmon juveniles than those measured for the Weighted Usable Area analyses, with potentially negative impacts to juveniles, but this conclusion is uncertain.

WOA flows during January through May of years with wetter hydrology would generally be greater, and often much greater, than flows under the proposed action and COS scenarios. Higher WOA flows in winter and spring could have both beneficial and adverse effects on rearing juvenile Spring-run Chinook Salmon. Potential benefits include more inundation of floodplain and side-channel habitat, better feeding conditions, reduced competition and predation, lower water temperatures and higher DO, and enhanced emigration flows, while impacts include higher stranding risk because of increased use of flood plains and greater flow fluctuations, and higher contaminants loading from stormwater runoff. On balance, the effect of lower winter and spring flows during most years under the proposed action and COS scenarios relative to the WOA scenario on Spring-run Chinook Salmon juveniles and their rearing habitat is highly uncertain.

5.8.3.2.2 Water Temperature

Under the proposed action and COS (proposed action and COS HEC-5Q modeling scenarios), monthly mean water temperatures at Keswick during the November through May upper Sacramento River juvenile rearing period would range from about 43 degrees Fahrenheit during January and February to 54 degrees Fahrenheit in May (Figures 5-8 through 5-14 in the HEC5Q Temperatures section of Appendix D). These temperatures are well below the 61 degrees Fahrenheit critical water temperature threshold for juvenile Spring-run Chinook Salmon, indicating that water temperature conditions in the upper Sacramento River

are well suited for juvenile Spring-run Chinook Salmon. It should be noted, however, that unlike conditions during summer and fall, when reservoir operations create relatively stable flow and water temperature conditions (See Winter-run Chinook salmon, *Water Temperature*), the mean monthly water temperatures in winter and spring do not fully capture the water temperature conditions to which the juvenile Spring-run Chinook Salmon would be exposed, because water temperatures often vary greatly over the course of a month, and even over a day. This caveat, however, applies to all results of all the modelling scenarios.

Water temperatures under the proposed action and COS are much higher than those under the WOA scenario during November through February (Figures 5-8 through 5-11 in the HEC5Q Temperatures section of Appendix D), are similar in March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), and are much lower than those under the WOA scenario in April and May (e.g., Figures 5-13 and 5-14 in the HEC5Q Temperatures section of Appendix D). On balance, water temperature conditions under the proposed action and the COS would provide moderate benefits relative to the WOA conditions to juvenile Spring-run Chinook Salmon rearing in the upper Sacramento River.

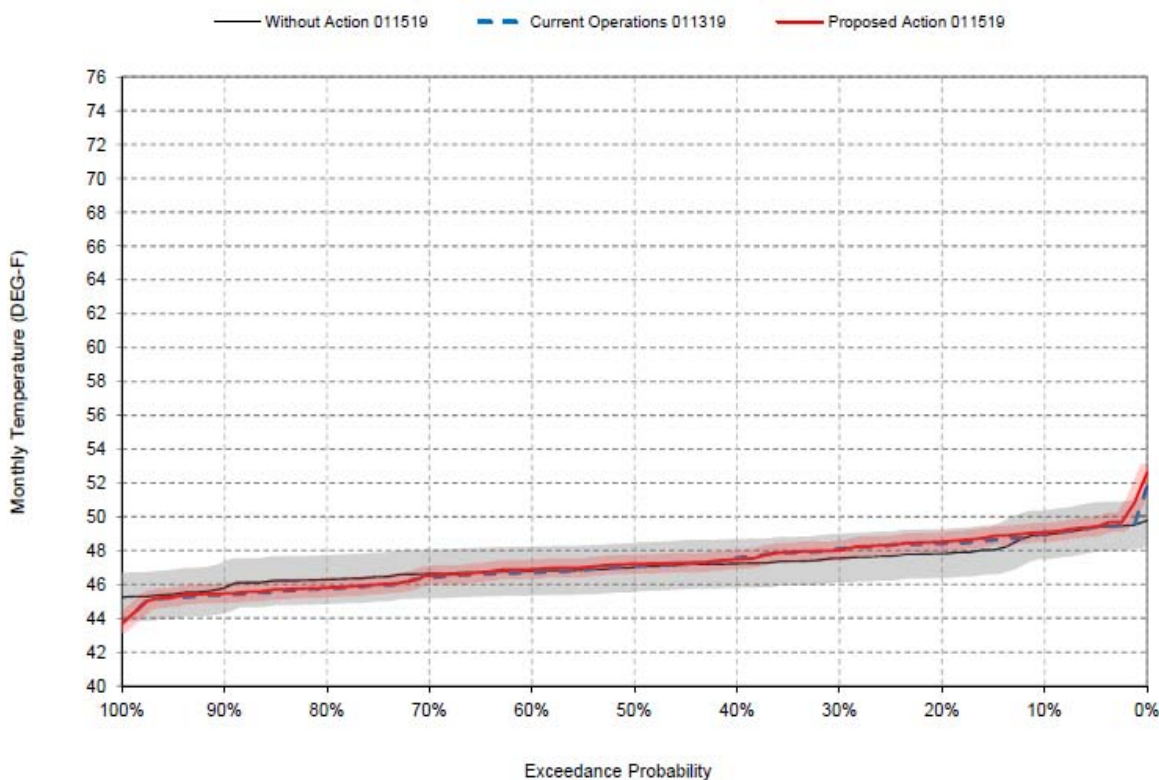


Figure 5.8-13. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, proposed action and COS scenarios, March

5.8.3.2.3 Rearing to Outmigrating Juveniles in Bay-Delta

5.8.3.2.3.1 River Flow

Similar upper Sacramento River, the CalSim modeling shows large seasonal changes in the differences in middle Sacramento River flow between the WOA scenario and the proposed action and COS. In November, there are small to moderate differences in flow between the WOA and proposed action scenarios, with higher flows under the WOA scenario in the middle-high range of flow years, and lower flows under the WOA scenario in the lower flow years, but the COS flows are consistently above the WOA flows in all but the highest flow years (Figure 19-8, and Tables 17-1 through 17-3, 18-1 through 18-13, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D). In December through February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years (Figure 19-9 through 19-11, and Tables 17-1 through 17-3, 18-1 through 18-13, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D), and in March and April, the WOA flows are consistently higher than the proposed action and COS flows (Figures 19-12 and 19-13 in the CalSim II Flows section of Appendix D). In May, the WOA flows are substantially higher than the proposed action and COS flows for the 60 percent of highest flow years and are substantially lower for the 25 percent of lowest flow years (Figure 19-14 in the CalSim II Flows section of Appendix D).

Flows resulting from differences between the WOA scenario and the proposed action would likely affect Spring-run Chinook Salmon juveniles and their habitats. The lower November and May flows under the proposed action scenario during years with drier hydrology would likely result in reduced conditions in juvenile rearing habitats, including less habitat complexity, side channel habitat structure, refuge habitat, and greater disease potential.

The lower proposed action flows in December through April could have adverse effects on rearing juvenile Spring-run Chinook Salmon. Potential adverse effects include less floodplain and side-channel habitat, reduced feeding conditions, increased competition and predation, higher water temperatures and higher DO, and decreased emigration flows.

5.8.3.2.3.2 Water Temperature

Under the proposed action and COS modeling scenarios, monthly average water temperatures from November through March below the Colusa Basin Drain would range from about 44 to about 60 degrees Fahrenheit, thereby remaining well below the 64 degrees Fahrenheit threshold (Figures 14-8 through 14-12 in the HEC5Q Temperatures section of Appendix D). However, during April and May, water temperatures would range from about 53 to about 72 degrees Fahrenheit, exceeding the 64 degrees Fahrenheit threshold in 5 percent of years in April and about 85 percent of years in May, with a maximum water temperature of about 71 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC5Q Temperatures section of Appendix D).

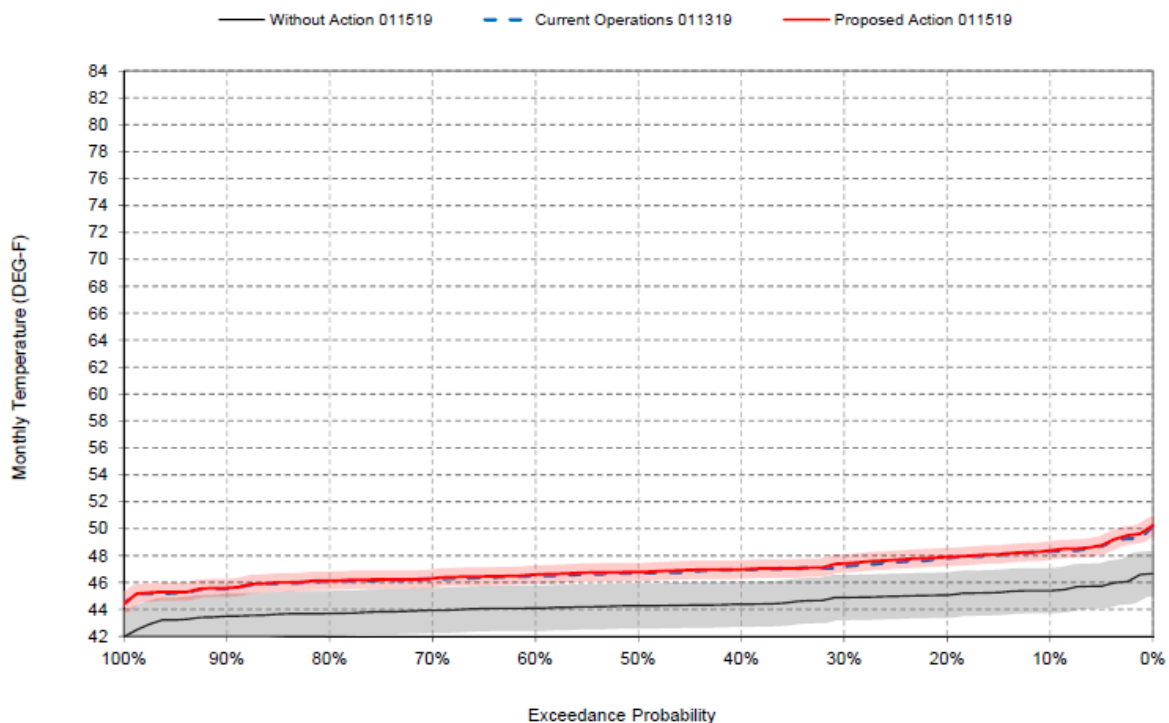


Figure 5.8-14. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, January

There is little difference in water temperatures between the proposed action and COS modeling scenarios during any of the months that juvenile Spring-run Chinook Salmon rear in or emigrate from the middle Sacramento River (Figures 14-8 through 14-14 in the HEC5Q Temperatures section of Appendix D). The maximum difference between the proposed action and COS exceedance curves is approximately 1 degree Fahrenheit in May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). Water temperatures for both scenarios exceed the 64 degrees Fahrenheit threshold for most years during May, approximately 5 percent of years in April, and no water temperature exceeding this threshold during November through March.

Water temperatures under the proposed action and COS are substantially or moderately above the WOA scenario water temperatures during most years in November through April (Figures 14-8 through 14-13 in the HEC5Q Temperatures section of Appendix D), and are moderately below the WOA scenario water temperatures during most years in May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). Water temperatures during most years in the November through April period are suitable for juvenile Spring-run Chinook Salmon that rear in and emigrate from the middle Sacramento River under the WOA and the proposed action and COS scenarios. Under all three modeling scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances than the proposed action and COS, especially in warmer years. These results indicate that water temperature conditions would too warm for juvenile Spring-run Chinook Salmon rearing and emigrating in the middle Sacramento River during May under WOA, and that the proposed action improves these conditions although temperatures are still not ideal. It should be noted that May is the last

month during spring or summer that Spring-run Chinook Salmon juveniles are found in the middle river, and it is likely that when water temperatures are too high they emigrate to the ocean before May.

5.8.3.2.4 Adult Migration from Ocean to Rivers

Continuing their upstream migration from the Delta, Spring-run Chinook Salmon adults enter the middle Sacramento River as early as January and ultimately make their way to the upper river, where they hold, beginning as early as February, until they are ready to spawn (Windell et al. 2017).

CalSim modeling indicates that from January through April, the first half of the period during which spring-run adults migrate upstream through the middle Sacramento River to holding habitat in the upper river, the WOA scenario flows at Wilkins Slough would range from about 2,500 cfs in April to about 24,000 cfs in March (Figures 19-10 through 19-13 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 3,250 cfs in all four months to about 63,000 cfs in March (Figures 15-10 through 15-13 in the CalSim II Flows section of Appendix D). During the second part of the migration and holding period (May through October), the WOA flows at Wilkins Slough would range from 0 cfs in May through August to about 20,000 cfs in May (Figures 19-14 through 19-18 and 19-7 in the CalSim II Flows section of Appendix D), and at Keswick, the WOA flows would range from about 772 cfs in August to about 32,000 cfs in May (Figures 15-14 through 15-17 in the CalSim II Flows section of Appendix D). The lowest flows at Keswick Dam during May through August would be low enough to create potential passage problems for immigrating adults, and this is even more likely for Wilkins Slough, where flows in June through August would be about 1,000 cfs or lower in about half of the years. The effects of low flow on the middle Sacramento River and for adults holding in the upper river are expected to be similar to those described by Windell et al. 2017.

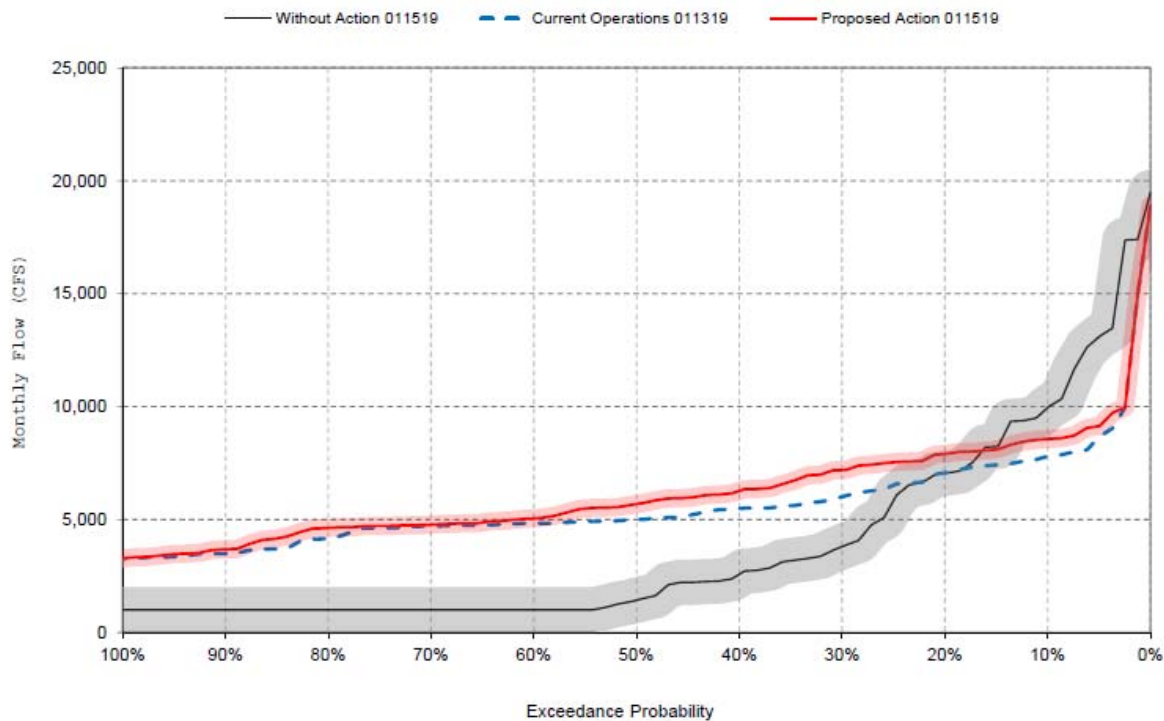


Figure 5.8-15. Modeled Sacramento River Flows at Wilkins Slough, June

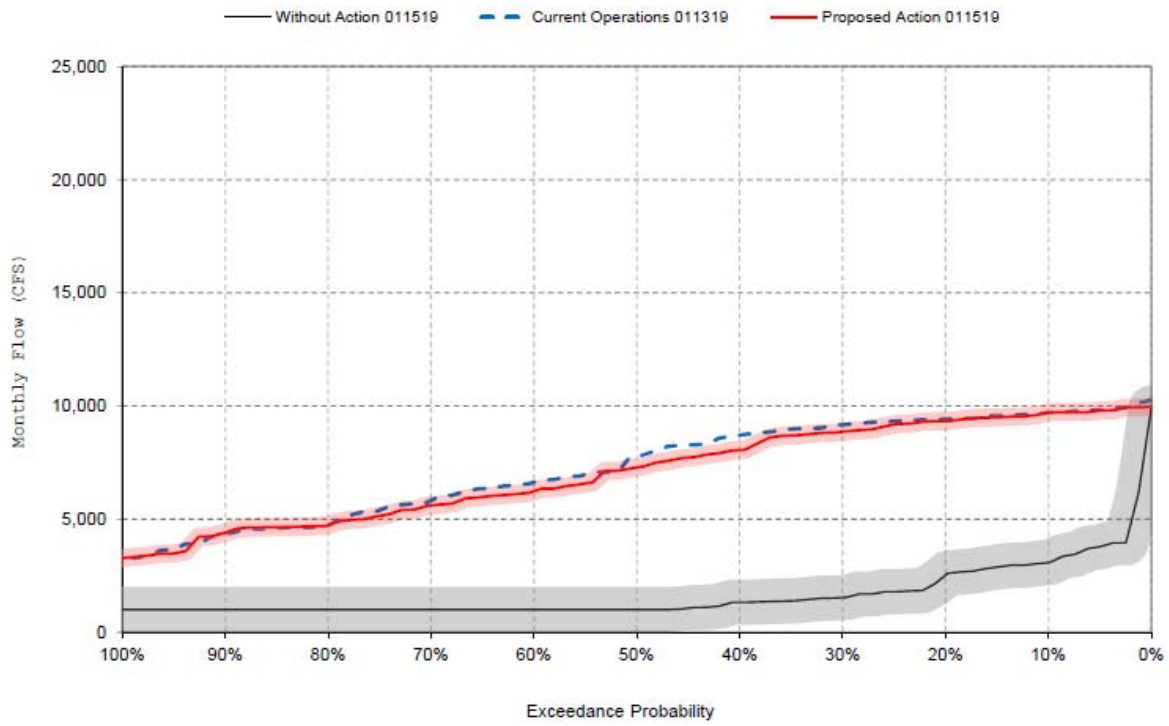


Figure 5.8-16. Modeled Sacramento River Flows at Wilkins Slough, July

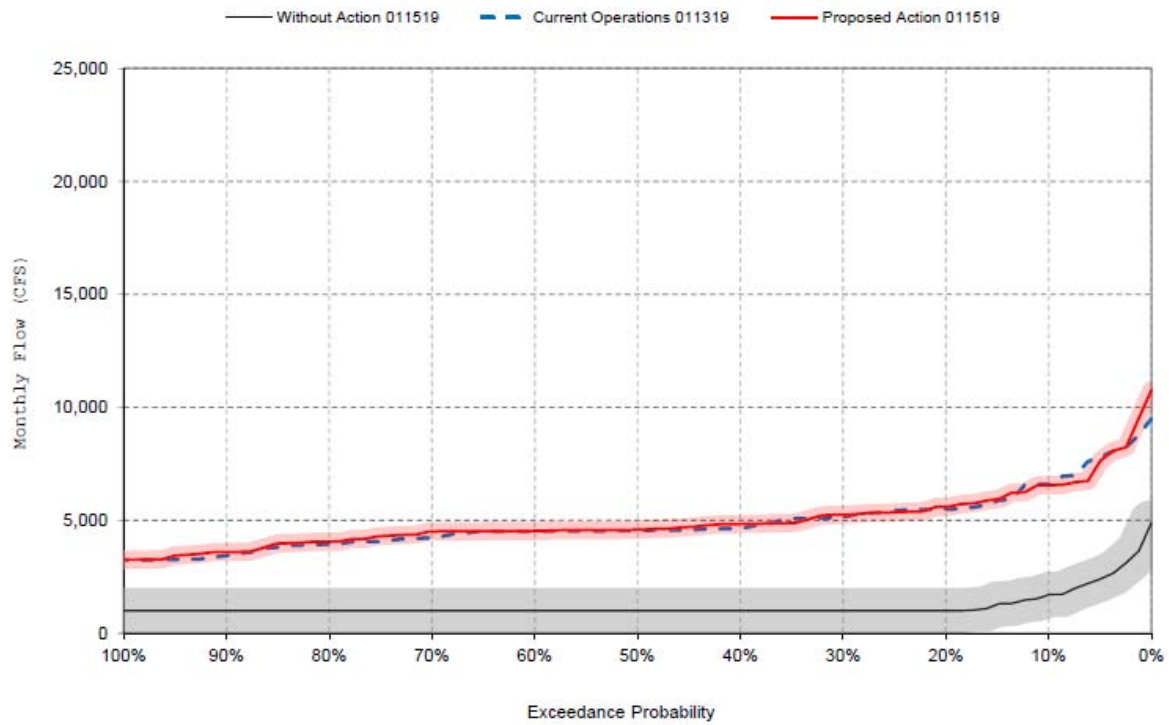


Figure 5.8-17. Modeled Sacramento River Flows at Wilkins Slough, August

During the January through October period of Spring-run Chinook Salmon immigration and holding, flows would generally be similar between the proposed action and COS (Figures 19-10 through 19-18, and 19-7; 15-10 through 15-18, and 15-7; and Tables 15-1 through 15-3, 16-1 through 16-3, 17-1 through 17-3, 18-1 through 18-3, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D), except for higher flows (up to ~2,500 cfs higher) at Wilkins Slough during May and June period for the proposed action scenario for flows in the range from about 5,000 cfs to 11,000 cfs (Figure 19-14 and 19-15 in the CalSim II Flows section of Appendix D), and much higher flows (up to ~7,000 cfs) at Wilkins Slough during September for the COS scenario for flows in the range from about 8,000 cfs to 16,000 cfs (Figure 19-18 in the CalSim II Flows section of Appendix D). The differences in flow occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults. There are also substantial flow differences between the proposed action and COS at Keswick Dam during June and September (Figures 15-15 and 15-18 in the CalSim II Flows section of Appendix D), but these differences are within a range of flows (6,000 cfs to 17,000 cfs) not expected to substantively affect holding Spring-run Chinook Salmon adults.

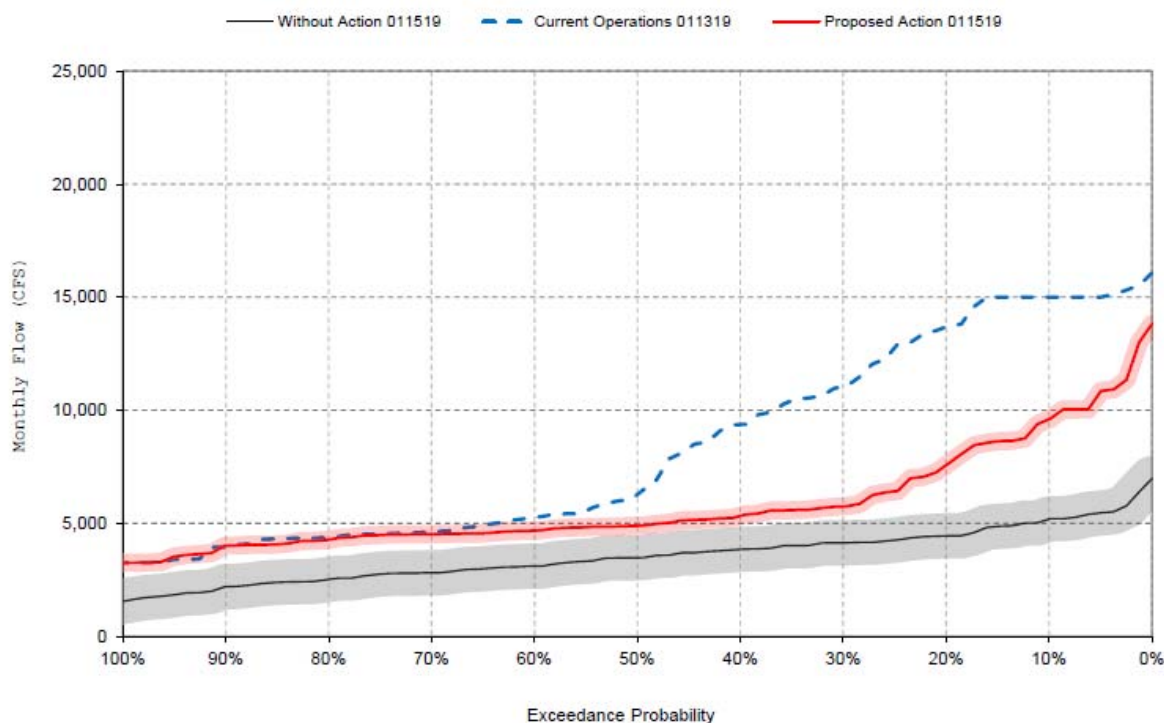


Figure 5.8-18. Modeled Sacramento River Flows at Wilkins Slough, September

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the WOA, proposed action and COS. In January and February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years at both Wilkins Slough and Keswick Dam (Figures 19-10, 19-11, 15-10, and 15-11; and Tables 15-1 through 15-3, 16-1 through 16-3, 17-1 through 17-3, 18-1 through 18-3, and 19-1 through 19-3 in the CalSim II Flows section of Appendix D). In March and April, the WOA flows are generally higher than the proposed action and COS flows at both locations (Figures 19-12, 19-13, 15-12 and 15-13 in the CalSim II Flows section of Appendix D). In May, the WOA flows at Wilkins Slough are substantially higher than the proposed action and COS flows for the 60 percent of highest flow years and are substantially lower for the 25 percent of lowest flow years (Figure 19-14 in the CalSim II Flows section of Appendix D), while at Keswick Dam, the WOA flows are higher than the proposed action and COS flows for about 40 percent of the highest flow years and are similar in the other years (Figure 15-14 in the CalSim II Flows section of Appendix D). For the remainder of the adult immigration and holding period (June through October), the proposed action and COS flows were generally higher or much higher than the WOA flows at both locations (Figures 19-15 through 19-18 and 19-7, and 15-15 through 15-18 and 15-7 in the CalSim II Flows section of Appendix D). The higher flows during May through October in years with dry hydrologies at Wilkins Slough and Keswick Dam under the proposed action and COS relative to the WOA conditions would likely benefit adult Spring-run Chinook Salmon migrating in the middle Sacramento River and holding in the upper river by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks (Windell et al. 2017).

5.8.3.2.4.1 Water Temperature

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action are similar to WOA water temperatures during May (Figure 14-14 in the HEC5Q Temperatures section of Appendix D), generally above the WOA scenario water temperatures from January through April (Figures 14-10 through 14-13 in the HEC5Q Temperatures section of Appendix D), and below the WOA scenario water temperatures during June through October (Figures 14-15 through 14-18, and 14-7 in the HEC5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick Dam, water temperatures under the proposed action and COS are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures during January and February (Figures 5-10 and 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in all years during April through September in all but 7 percent of years in October (Figures 5-13 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D).

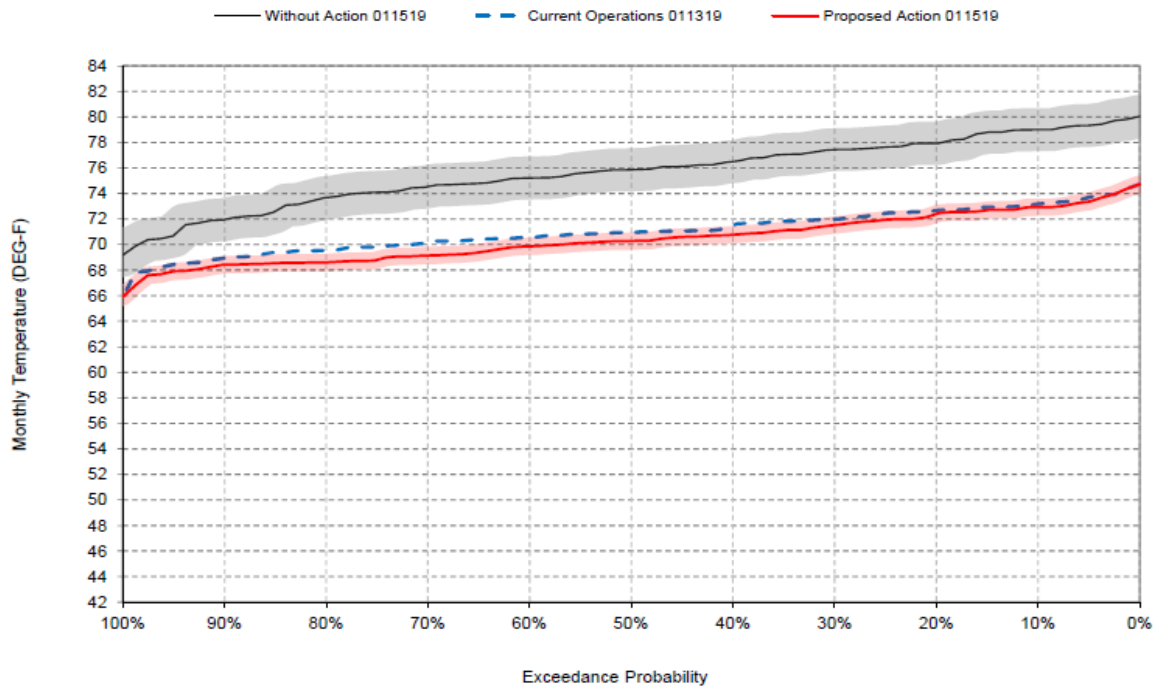


Figure 5.8-19. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, June

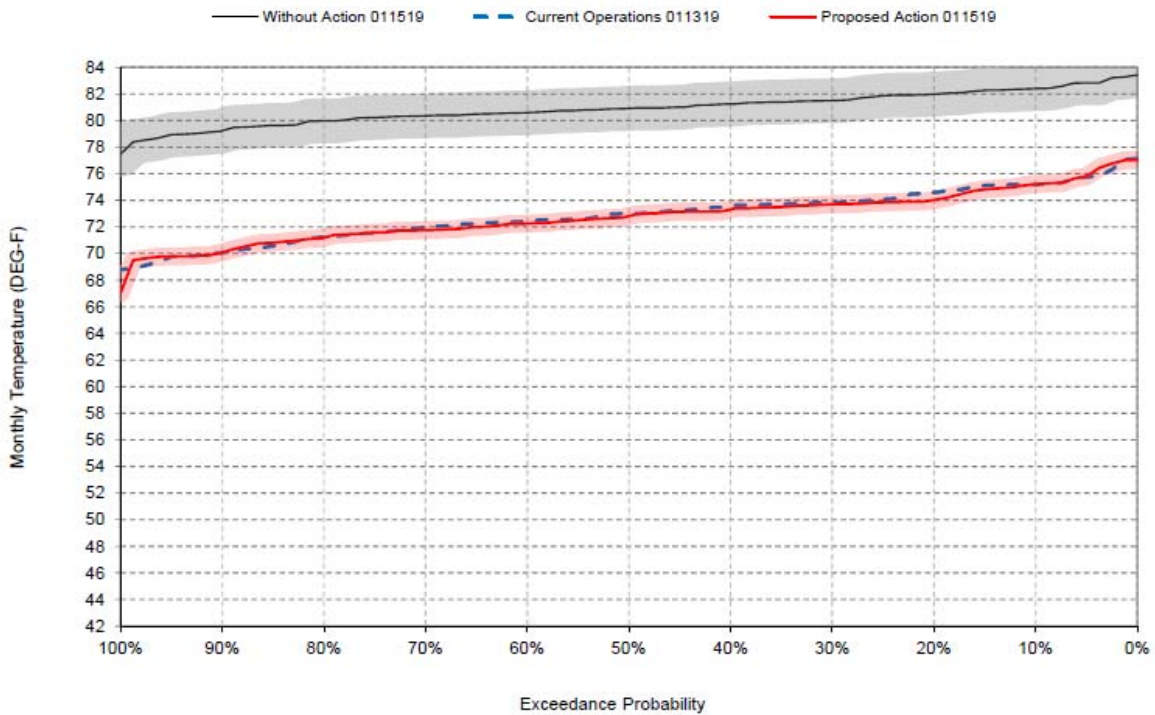


Figure 5.8-20. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, August

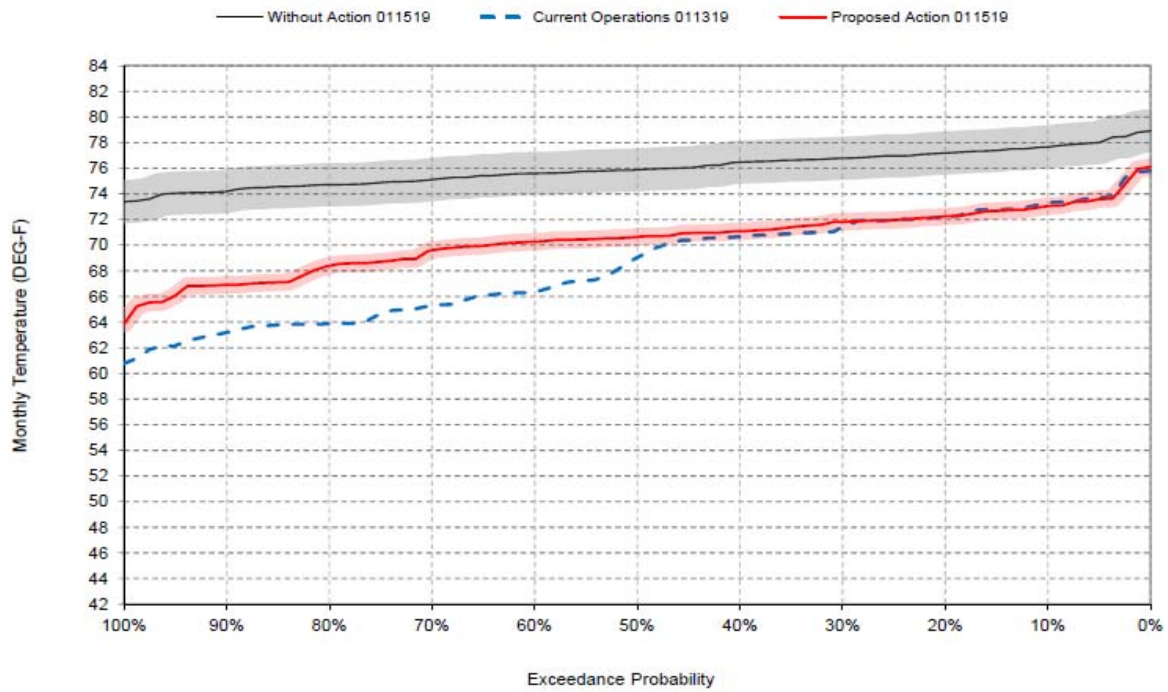


Figure 5.8-21. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, COS and proposed action scenarios, September

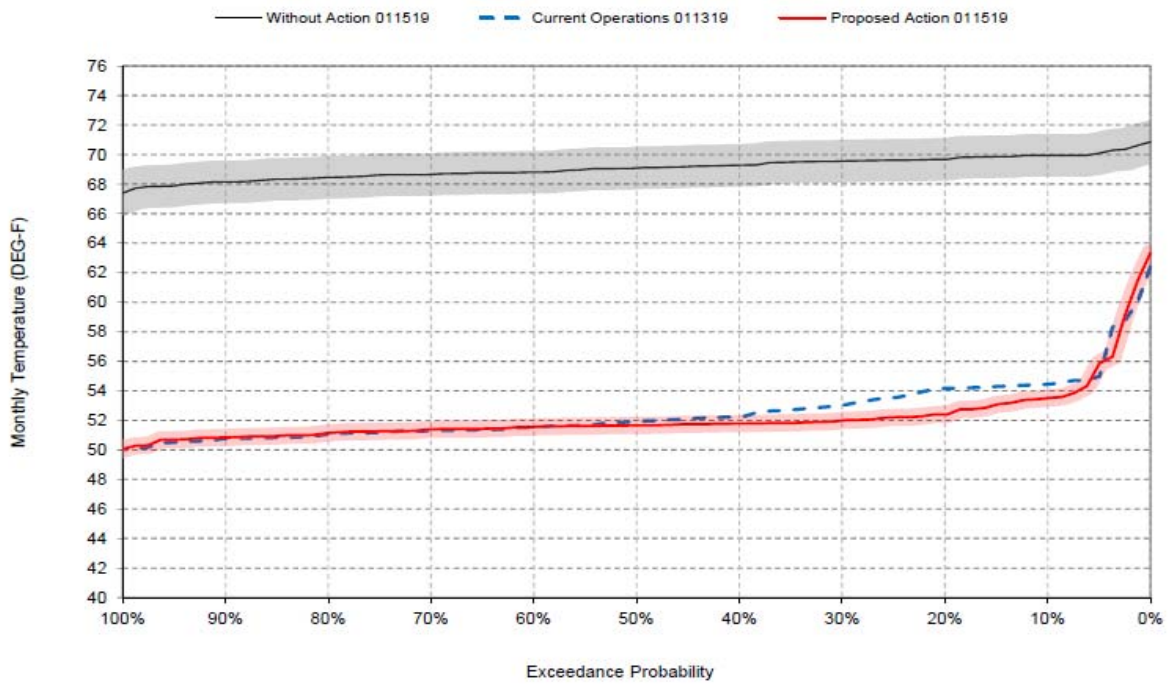


Figure 5.8-22. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the WOA, COS and proposed action scenarios, August

Water temperatures during the January through April period under all three scenarios are suitable for adult spring-run immigrating in the middle Sacramento River or holding in the upper river. However, in May, water temperatures in the middle river below the Colusa Basin Drain are predicted to exceed the threshold for immigrating adults in a large percentage of years under both the WOA scenarios and the proposed action, with a greater percentage of years predicted to exceed the threshold under the WOA scenario (Figure 14-14 in the HEC5Q Temperatures section of Appendix D). During June through September, the 68 degrees Fahrenheit threshold is exceeded at Knights Landing during every year under the WOA scenario and in most years under the proposed action and COS, but the exceedances are typically much greater under the WOA scenario (e.g., Figures 14-15 through 14-18 in the HEC5Q Temperatures section of Appendix D). In October, the threshold is exceeded in much lower percentages of years, and the water temperatures are consistently higher for the WOA scenario (Figure 14-7 in the HEC5Q Temperatures section of Appendix D).

At Keswick Dam, the 61 degrees Fahrenheit threshold for holding adults is not exceeded in any years during January through April under any of the scenarios and is exceeded in only 4 percent of years in under the WOA scenario in May (Figures 5-10 through 5-14 in the HEC5Q Temperatures section of Appendix D). In June through September, the threshold is exceeded in nearly every year under the WOA scenario, but in only a few years under the proposed action and COS (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D). In October, the threshold is exceeded in no years under the WOA scenario and in less than 10 percent of years under the proposed action and COS, although water temperatures under the proposed action and COS are lower than those under the WOA scenario, except in the warmest 8 percent of years (Figure 5-7 in the HEC5Q Temperatures section of Appendix D). During the summer months (June through September), when water temperatures are generally stressful for adult Spring-run Chinook Salmon in the Sacramento River, the water temperatures under the WOA conditions in both the middle and upper Sacramento River would generally be much higher than those under the proposed action or COS. It is unlikely that migrating adult Spring-run Chinook Salmon could survive the elevated water temperatures in the middle Sacramento River predicted for the summer months under the WOA modeling scenario or that eggs of the adult spring-run holding in the upper Sacramento River could survive the predicted high summer water temperatures.

5.8.3.2.5 Adults Holding in Rivers

5.8.3.2.5.1 River Flows

Flows under WOA are generally similar to proposed action and COS flows during February (Figures 15-11 in the CalSim II Flows section of Appendix D), are much higher than proposed action and COS flows during March and April and during May of wetter years (Figures 15-12 through 15-14 in the CalSim II Flows section of Appendix D), and are lower than proposed action and COS flows during June through October (Figures 15-15 through 15-18, and 15-7 in the CalSim II Flows section of Appendix D). In general, higher flows are likely to benefit holding and spawning adult Winter-run by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, lower risk from anglers, and a greater area of river bed with suitable attributes for redds (Windell et al. 2017). The proposed action and COS scenarios would have much higher flows than the WOA scenario during summer, when flow is generally low and so more likely to limit Spring-run Chinook Salmon holding and spawning success. Therefore, the proposed action and COS are expected to be beneficial to Spring-run Chinook Salmon relative to the WOA conditions.

Flows during the February through October period would generally be similar between the proposed action and COS modeling scenarios (Figure 15-11 through 15-18, and 15-7; and Tables 15-1 through 15-3, 16-1 through 16-3, and 17-1 through 17-3 in the CalSim II Flows section of Appendix D). The largest

differences between these scenarios would occur in June for the upper 60 percent of flows, when proposed action flows would be greater than the COS flows, and in September for the upper 50 percent of flows, when the COS flows would be greater than the proposed action flows. The differences occur over a range of flows from about 9,000 cfs (June) or 7,000 cfs (September) to about 16,000 cfs, all of which are suitable flows for holding and spawning adults (e.g., USFWS 2003), so the differences are not expected to substantially affect the adults.

5.8.3.2.5.2 Water Temperatures

In the upper Sacramento River at Keswick Dam, water temperatures under the proposed action and COS are similar to WOA water temperatures during March (Figure 5-12 in the HEC5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures in February (Figure 5-11 in the HEC5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in April through October, except for the warmest Octobers (Figures 5-13 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario are predicted to exceed the 61 degrees Fahrenheit holding threshold in almost all years during June through September, and the 56 and 53.5 degrees Fahrenheit spawning threshold in most years during May through October. In contrast, water temperatures under the proposed action and COS are predicted to exceed the 61 degrees Fahrenheit holding threshold in no years for every month in the February through October period and are rarely predicted to exceed the 56 and 53.5 degrees Fahrenheit thresholds, except for 15 to 75 percent of years during July through October. These results indicate that the proposed action, relative to the WOA, provides a clear benefit to adult Spring-run Chinook Salmon individuals holding and spawning in the upper Sacramento River. In view of the improved water temperature management operations planned for the proposed action, this action is expected to benefit the Spring-run Chinook Salmon adults relative to the WOA.

There are few differences in water temperatures between the proposed action and COS during any of the months that adult Spring-run Chinook Salmon hold and spawn in the upper Sacramento River (Figures 5-11 through 5-18, and 5-7 in the HEC5Q Temperatures section of Appendix D). At Keswick Dam, under the proposed action and COS, the mean water temperatures would be below the 61 degrees Fahrenheit threshold for holding adults for all months from February through October, except for August through October in, at most, 4 percent of years.

5.8.3.3 Spring Pulse Flows

5.8.3.3.1 Egg to Fry Emergence

As described in the proposed action, Reclamation will release pulse flows in the spring if projected storage on May 1 in Shasta Reservoir is above 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

Spring pulse releases are not at the time of year of egg incubation, and rather would be timed to attract juvenile Spring-run to move downstream. Spring pulses could benefit late redds by increasing dissolved oxygen in the water for eggs. Late eggs emerging from the gravel could be exposed to redd dewatering on the ramp-down side of a spring pulse.

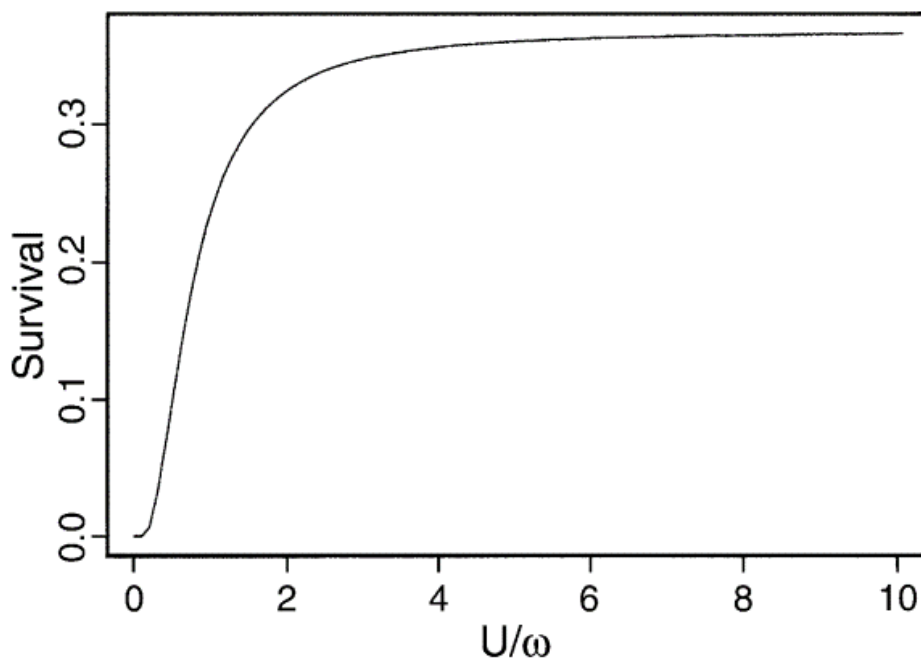
5.8.3.3.2 Rearing to Outmigrating Juveniles

Spring pulse flows would benefit juvenile salmonids by triggering their outmigration (Kjelson et al.,1981). The NMFS Southwest Fisheries Science Center has run statistical models using tagging data from Spring-run Chinook Salmon and Fall-run Chinook Salmon from 2012-2017 and found a significant increase in smolt survival is observed when Sacramento River flow at Wilkins Slough is above 9,100 cfs during the smolts outmigration period (Cordoleani et al, 2019).

One hypothesis may be that decreased travel time leads to decreased interactions with predators. The XT model (Anderson, 2005) provides an estimated equation for survival in rivers based on predation. Anderson’s XT model, re-written in terms of mostly physical parameters, is:

$$S = \exp (-\rho\alpha\sqrt{x^2 + w^2t^2})$$

Where ρ is the predator density, alpha is the cross-sectional area, x is the travel distance, w is the random encounter velocity, and t is the travel time. Increasing flow in the Sacramento River leads to increasing river velocity, which would lead to increasing average migration velocity and decreasing travel time. Figure 5.8-23 below, reproduced from Anderson (2005), shows anticipated survival based on average migration velocity divided by the random component of the encounter velocity, w.



Anderson (2005)

Figure 5.8-23. XT Model Survival vs Average Migration Velocity U, divided by the Random Component of the Velocity w.

Shown another way, below is a plot of the X-T model for dimensionless travel time units (Figure 5,8-24). As can be seen from the plot below, reduced travel time is highly valuable for increased survival.

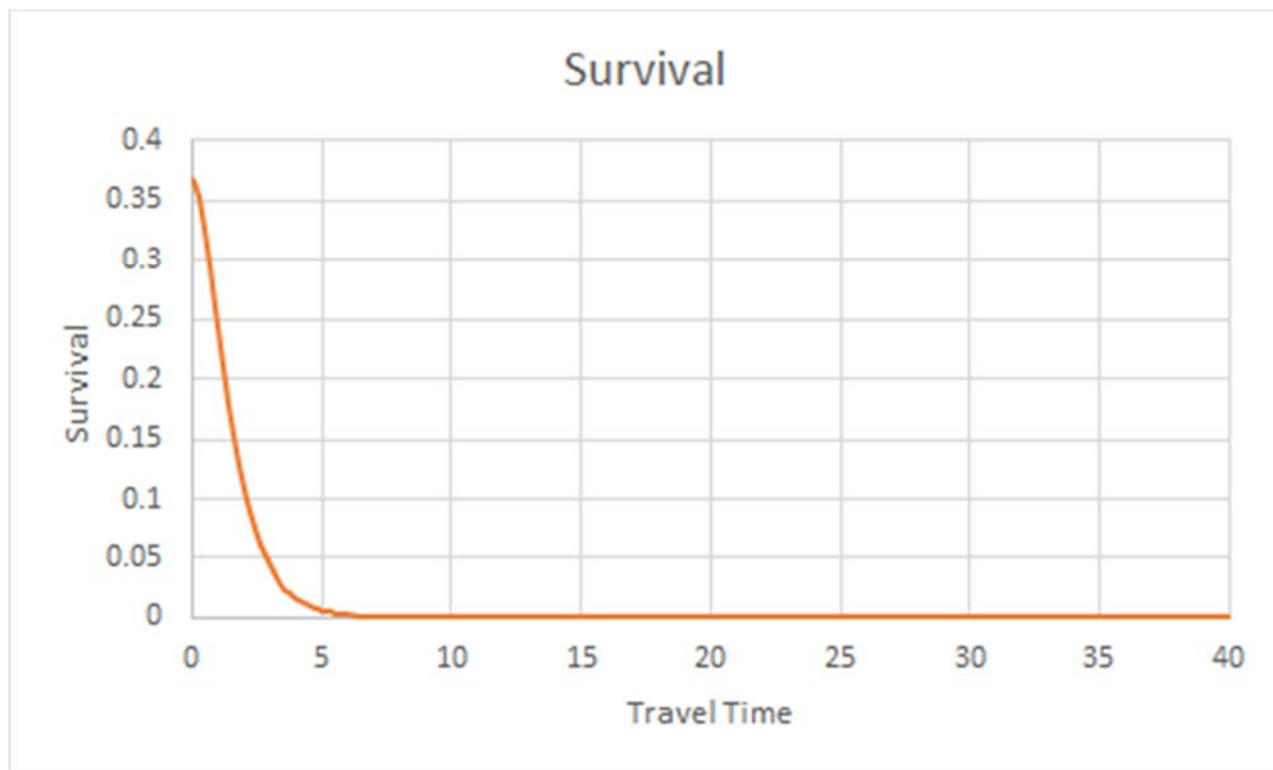


Figure 5.8-24. XT Model for Dimensionless Travel Time Units

Higher flows in the Sacramento River lead to higher velocities and lower travel times, reducing predation.

The random encounter velocity w relates to the predator perception and reaction distance. Reaction distance depends on water clarity and light level (Vogel and Beauchamp, 1999). Water clarity is often measured by Secchi disk depth. The following plots, created from data published in Snider and Titus (2000) and the Fall Mid-water trawl from CDFW, both show an inverse correlation between flow and Secchi depth. As expected, with higher flow, water clarity is less. More sediment is mobilized with higher flows, as higher flows generate more shear stress, as described by the equations of sediment transport (Shields, 1936).

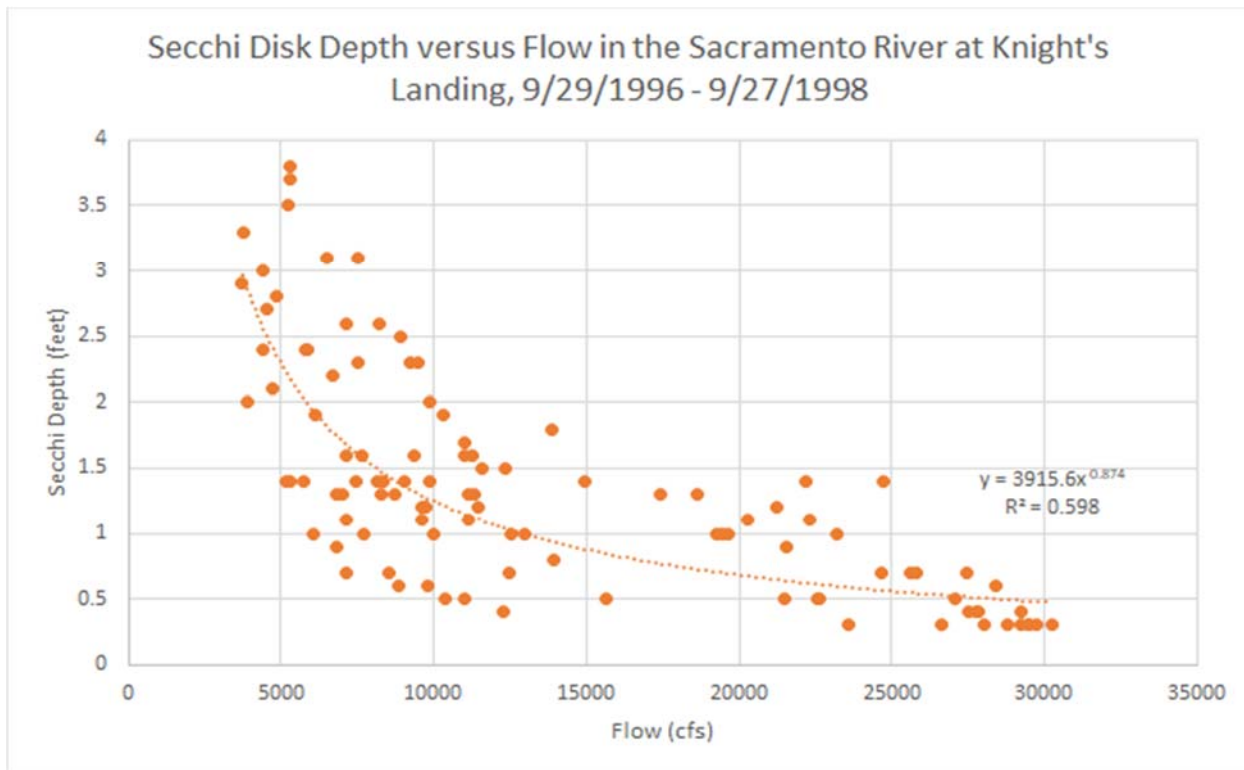


Figure 5.8-25. Turbidity vs. Flow. Data from Snider and Titus, 2000

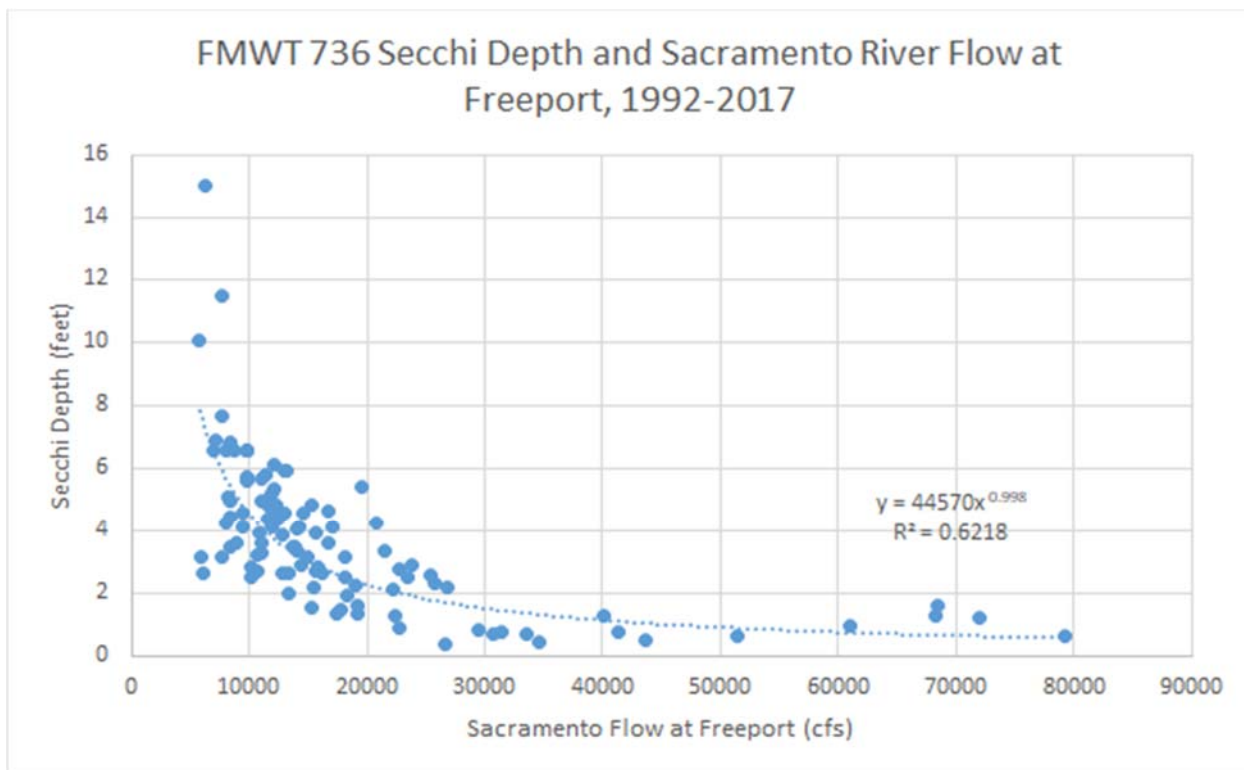


Figure 5.8-26. Turbidity vs. Flow. Data from Fall Mid-water Trawl station 736

Decreased water clarity with higher flows would reduce predator perception distance, which would increase survival according to the XT model.

5.8.3.4 *Fall and Winter Refill and Redd Maintenance*

Under WOA, fall flows are low. Under the proposed action, Reclamation proposes to increase fall flows based on Shasta Reservoir storage to avoid dewatering Winter-run and Fall-run Chinook salmon redds. Higher flows than the WOA during this September – November period could benefit rearing Spring-run Chinook Salmon by increasing the inundated area of rearing habitat, and associated food and temperature benefits.

5.8.3.5 *Clear Creek Flow Releases*

Spring-run Chinook Salmon inhabit Clear Creek and is designated critical habitat for the species from the downstream of the Whiskeytown Reservoir to the confluence with the Sacramento River. Spring-run Chinook Salmon would be exposed to Reclamation's operation of Whiskeytown Reservoir and Clear Creek releases.

5.8.3.5.1 Egg to Fry Emergence

Under COS, Eggs and emerging fry are exposed to the effects of Whiskeytown temperature controls in Clear Creek, based on the timing of these controls (60°F at IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31) overlapping with the seasonal occurrence of this life stage in Clear Creek (September-November; Table 5.8-1), and the presence of spawning individuals upstream of the IGO gage in Clear Creek (CDFW 2011). Development of incubating Spring-run Chinook Salmon eggs is heavily influenced by water temperature with temperatures < 54°F considered optimal, 54-58°F suboptimal, and water temperatures above 58°F causing chronic to acute stress (Stillwater Sciences 2006).

Effects of egg and fry exposure to Whiskeytown temperature controls in Clear Creek was modeled in HEC 5Q. The proposed action reduces water temperatures in Clear Creek compared to the WOA, at both IGO and the creek mouth, by 5-13°F (HEC 5Q Temperature Results; insert proper citation) in the months of September and October, at a 50% exceedance probability.

This temperature reduction as compared to WOA would result in an increased likelihood of achieving temperature compliance at IGO, leading to improved survival of incubating Spring-run Chinook Salmon eggs. However, any eggs incubating in Clear Creek prior to September 15 or downstream of the compliance point at IGO could be subjected to water temperatures in the chronic to acute stress range (above 58°F), especially at lower exceedance probabilities (< 50%), and certain water year types. Furthermore, the incubation period (September 15-November) temperature threshold used in this action (56°F at IGO gage) falls within the suboptimal temperature range for incubating Spring-run Chinook Salmon eggs, which could result in less than optimal survival. There are water temperature benefits of the proposed action when compared to WOA. The optimal incubation temperatures for this species are < 54°F.

5.8.3.5.2 Rearing to Outmigrating Juveniles in Rivers

Few, if any, rearing and outmigrating juveniles would be exposed to the effects of spring attraction flows given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (November–February; Table 5.8-1). However, rearing juveniles would likely be exposed to the effects of geomorphic flows, which are likely to occur contemporaneously

with peak storm flows in Clear Creek after January 1 (to maximize geomorphic effectiveness), since there may be rearing juveniles in Clear Creek throughout the winter, spring, and summer after emergence.

Implementing geomorphic flows that will disperse spawning gravel will minimize project effects to this population. Spawning habitat requirements for salmon are complex and involve the fulfillment of a variety of geomorphic and fluvial conditions. The geomorphic flow augmentation reestablishes sustainable sediment transport downstream of Whiskeytown Dam. This is necessary to support and maintain distinct morphological units such as backwaters, riffles and pools. The ecological goal of gravel augmentation is to create self-sustaining morphological units that have the physical characteristics necessary for the different life stages of salmonids (Pasternak 2010).

Geomorphic flow releases also have the potential to degrade water quality via increased suspended solids and turbidity, leading to direct physiological impacts on rearing and outmigrating juvenile health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility. The effects of this exposure could also include displacement of rearing fish from suitable habitat, leading to increased predation and exposure to increased water temperatures.

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Under WOA, geomorphic flows would occur whenever storage levels get high enough for spilling into the Gloryhole Spillway, but would be unlikely to occur. Proposed geomorphic flows up to the safe release capacity (approximately 900 cfs) represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse effects associated with geomorphic flow releases are expected to occur with low frequency, and be of low magnitude, compared to COS.

Few, if any, rearing and outmigrating Spring-run Chinook Salmon juveniles would benefit from the effects of Whiskeytown water temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (November–February; Table 5.8-1).

5.8.3.5.3 Adult Migration from Ocean to Rivers

Some migrating adults would be exposed to the effects of geomorphic flows under the proposed action given the likely timing of these flows (contemporaneous with peak storm flows after January 1 through April) and the peak timing of this life stage in Clear Creek (March-September with peak abundance May-June; Table 5.8-1). Exposure to the effects of these high flows could result in adverse effects on migrating adults if improperly shaped, however flows will be developed in coordination with the Clear Creek Implementation Team. Therefore, effects include the potential for stranding leading to increased predation, and degraded water quality from increased discharges of suspended solids and turbidity leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost) will be avoided and minimized. These flows would be uncontrolled under the WOA conditions, and thus, the species could be exposed to natural flood conditions and adverse effects stated above.

Spring attraction flows would affect a large portion of the migrating adult Spring-run Chinook population in Clear Creek given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (May-June; Table 5.8-1). The anticipated time frame for spring attraction flows (May-June) suggests that spring attraction flows are very unlikely to occur during a peak storm flow event. In addition, if occurring outside of a peak storm flow event, the magnitude of spring attraction flows (10 TAF with daily release up to safe release capacity [900 cfs]) would not produce the 3000-3500 cfs needed to transport sediment in Clear Creek (McBain and Trush 2001, Pittman and Matthews 2004). These factors would reduce the likelihood of adverse effects resulting from increases in suspended solids and turbidity, which could lead to physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost). Spring attraction flows benefit migrating adult Spring-run Chinook in Clear Creek (Clear Creek Technical Team 2018), and indicate that the number of migrating adults observed and the distance of their upstream migration both increase following spring attraction flows. Adult upstream migrating salmon are attracted to increased flow and cues fish to natal habitats.

Migrating adults would also benefit from Whiskeytown water temperature controls in Clear Creek under the proposed action and COS, based on the starting date of temperature compliance (June 1) and the seasonal timing of this life stage in Clear Creek (peak abundance May-June; Table 5.8-1). The water temperature objective at the IGO gage beginning June 1 is 60°F, well under the 65°F upper bound of the suboptimal range of water temperatures for migrating adult Spring-run Chinook Salmon (Stillwater Sciences 2006), and approximately 3°F cooler than projected water temperatures in June at the IGO gage under the WOA scenario.

5.8.3.5.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed to the effects of geomorphic flows given the likely timing of these flows (contemporaneous with peak storm flows after January 1) and the peak timing of this life stage in Clear Creek (March-September with peak abundance May-July; Table 5.8-1). Exposure to the effects of these high flows could result in adverse effects on holding adults if improperly shaped. Effects include the potential for stranding leading to increased predation, increased water temperature, and degraded water quality from increased discharges of suspended solids and turbidity leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost). These effects are not anticipated since flows will be shaped in coordination with the Clear Creek Implementation Team. Potential benefits of geomorphic flows included increased gravel mobilization that will increase spawning habitats and create a habitat complexity.

Spring attraction flows would affect a large portion of the holding adult Spring-run Chinook population in Clear Creek given the likely timing of these flows (May-June [Clear Creek Technical Team 2018]), and the peak timing of this life stage in Clear Creek (May-July; Table 5.8-1). These are expected to be beneficial for the species, by increasing cues that will support CV Spring-run to return natal streams. The anticipated timeframe for spring attraction flows (May-June) suggests that they are very unlikely to occur during a peak storm flow event. In addition, if occurring outside of a peak storm flow event, the magnitude of spring attraction flows (10 TAF with daily release up to safe release capacity [900 cfs]) would not produce the 3000-3500 cfs needed to transport sediment in Clear Creek (McBain and Trush 2001, Pittman and Matthews 2004). These factors would reduce the likelihood of any adverse effects resulting from increases in suspended solids and turbidity, which could lead to physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost).

Holding adults would also benefit from Whiskeytown water temperature controls in Clear Creek under the proposed action, based on the starting date of water temperature compliance (June 1) and the seasonal timing of this life stage in Clear Creek (peak abundance May-June; Table 5.8-1). The temperature objective at the IGO gage beginning June 1 is 60°F, under the 60.8°F upper limit of the optimal range of water temperatures for holding adult Spring-run Chinook Salmon (Stillwater Sciences 2006), and approximately 3°F cooler than projected water temperatures in June at the IGO gage under the WOA scenario.

5.8.3.6 Feather River

The follow section applies to the Feather River below the FREC boundary.

5.8.3.6.1 Egg to Fry Emergence

5.8.3.6.1.1 Flow Effects

Eggs and emerging fry of Spring-run Chinook would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (September-February; Table 5.8-1; NMFS 2016), minimum instream flow requirements in the HFC (Table 5.8-2), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the SAIL Upper River (CM1) conceptual model, these flows, combined with other environmental drivers, affect water temperature, DO levels, sedimentation, substrate composition, and other habitat attributes that influence redd quality, which in turn determines egg-to-fry survival. Insufficient flow during this life stage may result in higher water temperatures, lower DO in redds, and redd dewatering, each of which may lead to elevated egg mortality. Insufficient flow may also limit the habitat area available for redd construction, thereby limiting available habitat for this life stage. Excessive flow during this life stage may scour redds, and higher flows may attract spawning adults further upstream into the Low Flow Channel (LFC), where spawning habitat is less abundant, and the effects of superimposition are greater (Sommer et. al. 2001).

Table 5.8-2. Feather River High Flow Channel minimum instream flow requirements

| Preceding April – July Unimpaired runoff (Percent of Normal) | High Flow Channel Minimum Instream Flow | | |
|--------------------------------------------------------------------|-----------------------------------------|-------------|------------------|
| | Oct-Feb (cfs) | March (cfs) | April-Sept (cfs) |
| 55% or greater | 1,700 | 1,700 | 1,000 |
| Less than 55% | 1,200 | 1,000 | 1,000 |

Under the Without Action (WOA) scenario, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.8-27). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA

scenario would be lower in the summer and fall and higher in the winter and spring compared to current operations and the proposed action (Figures 5.8-28 and 5.8-29).

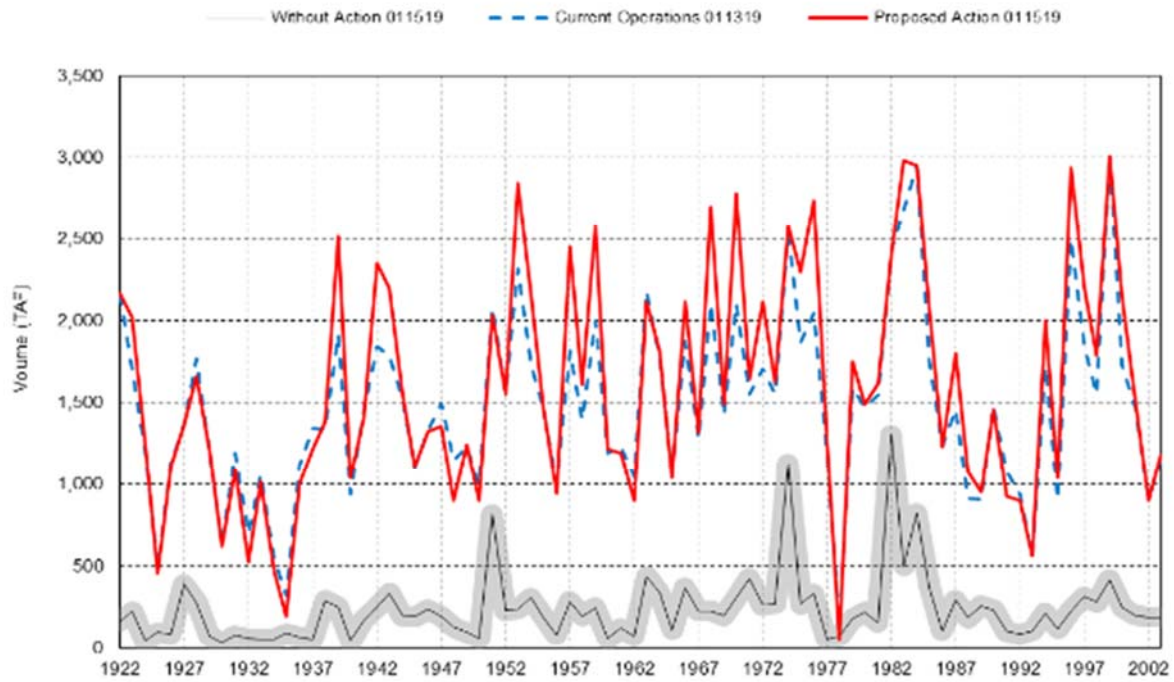


Figure 5.8-27. CalSimII estimates of mean Oroville storage (Thousand Acre-Feet [TAF]) for the period 1923–2002 under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

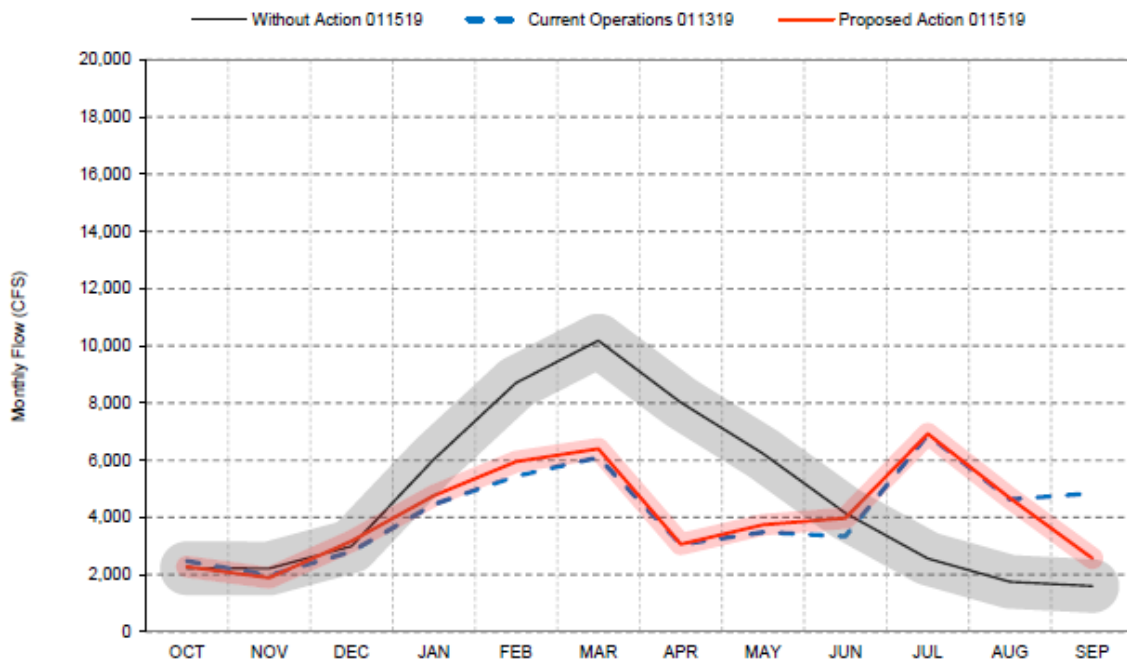


Figure 5.8-28. CalSimII estimates of Feather River long-term average flow below Thermalito Afterbay under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

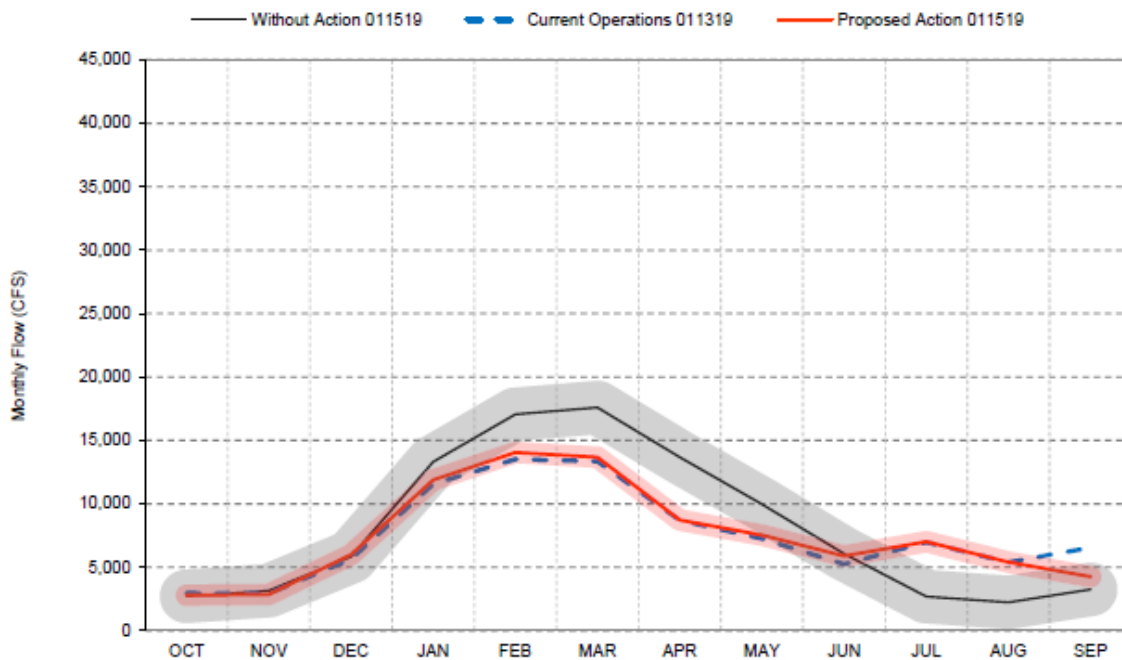


Figure 5.8-29. CalSimII estimates of Feather River mouth long-term average flow under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Feather River flows below Thermalito Afterbay under the WOA scenario would be similar to or lower than flows under the COS and proposed action scenarios during the peak seasonal timing of Spring-run Chinook egg incubation (September-November), but would be similar or slightly higher during the months of December to February (Figure 5.8-30). Specifically, higher flows under the COS and proposed action scenarios would occur more frequently in September and October than under the WOA scenario (Figure 5.8-31). Additionally, flows under the WOA scenario would have a higher likelihood of falling below the required minimum flow stipulated in applicable NMFS/USFWS BOs for October (1,200 – 1,700 cfs, depending on preceding April – July unimpaired runoff) and September (1,000 cfs) (Table 5.8-2 and Figure 5.8-31).

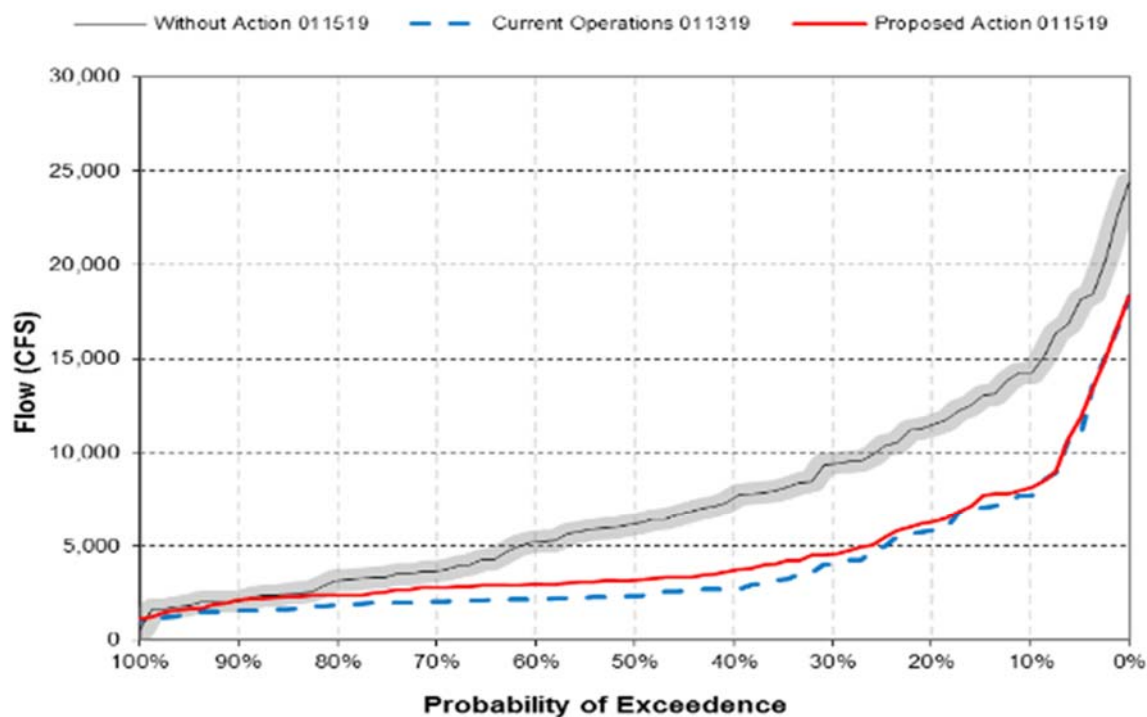
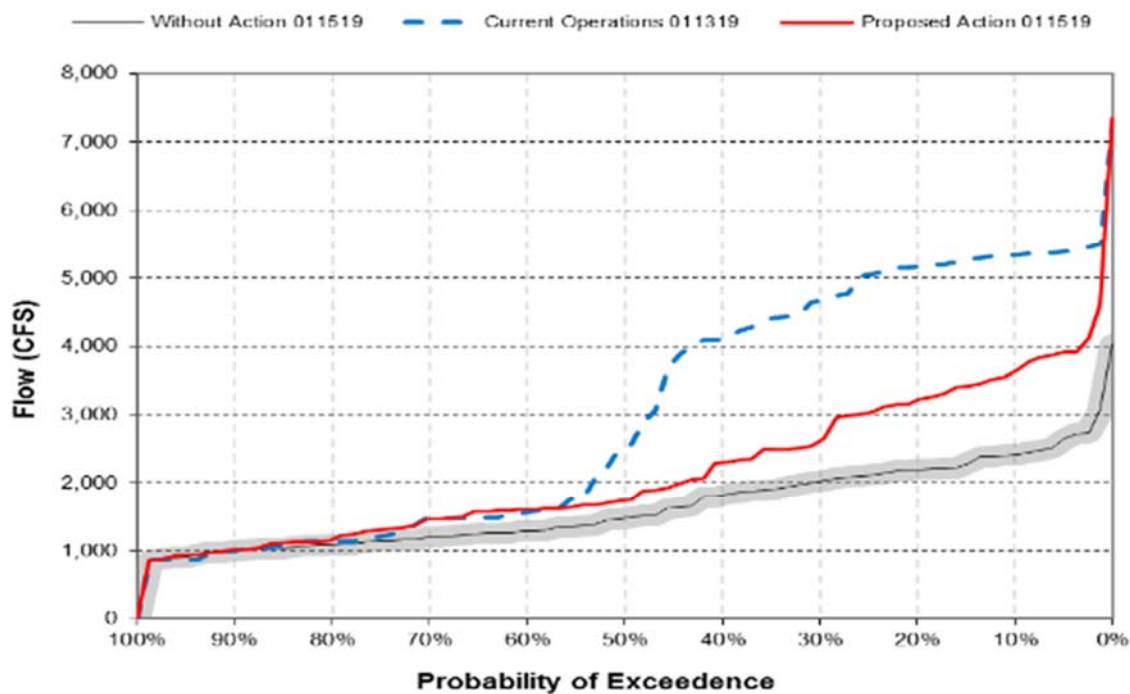


Figure 5.8-30. CalSimII estimates of Feather River flow below the Thermalito Afterbay in September-November and December-February under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

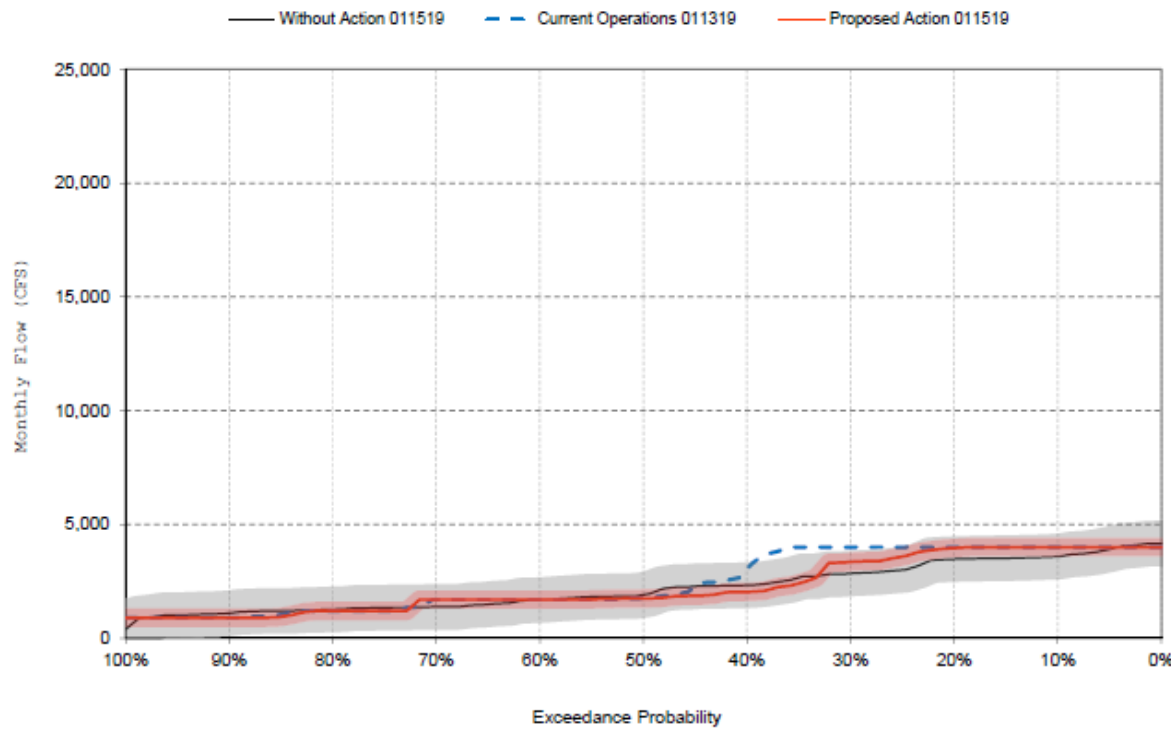
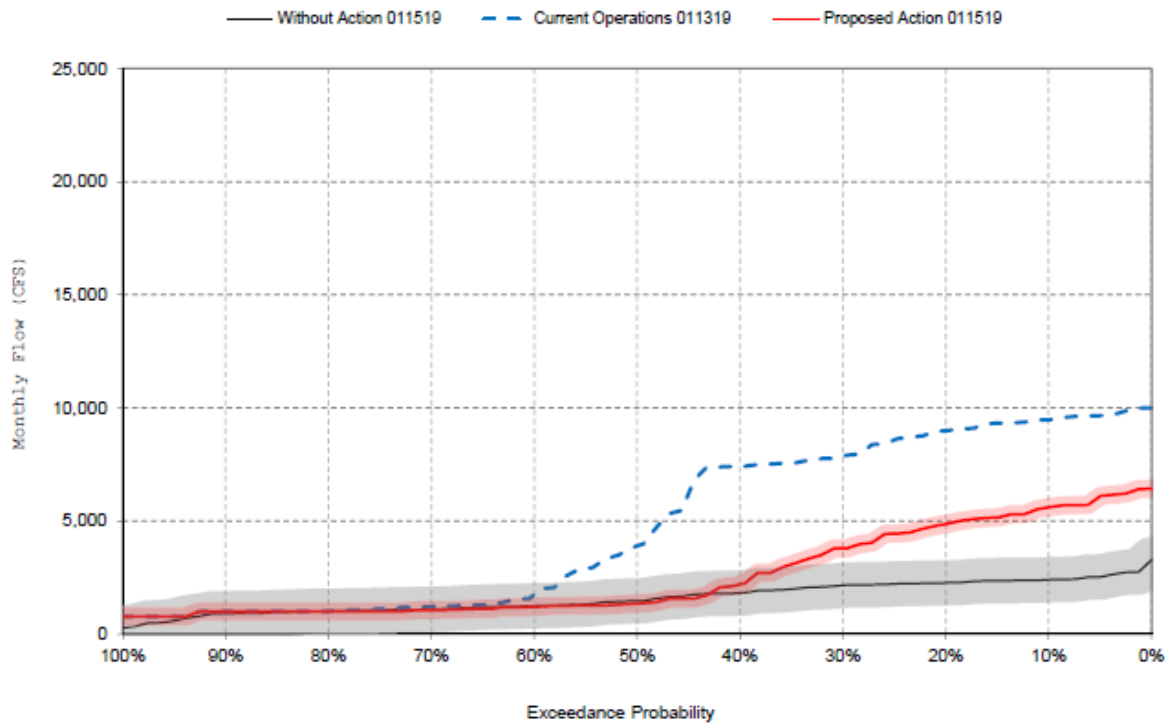


Figure 5.8-31. CalSimII estimates of Feather River flow below the Thermalito Afterbay in September and October under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Flows in the Feather River HFC during the egg incubation period would be similar to or higher under the proposed action and COS than under the WOA scenario, and in below normal, dry, and critical water year types, flows are reliably higher under the proposed action scenario than WOA scenario in September and October (Figure 5.8-32). Importantly, CalSimII model output indicates projected flows under the proposed action and COS scenarios would increase the likelihood that September and October minimum instream flow criteria are achieved. Differences in flows between the proposed action and COS are generally small across all months except September (Figures 5.8-28, 5.8-30, and 5.8-31). However, the proposed action is anticipated to result in reliably higher flows than both WOA and COS scenarios during October of below normal, dry, and critically dry years. October is the first month of elevated minimum instream flow criteria in the Feather River HFC and a critical period for Spring-run Chinook egg incubation.

Flows below the minimum requirements (Table 5.8-2) could have a number of adverse effects on this life stage, including higher water temperatures, lower DO in redds, and potential for redd dewatering, all of which may lead to elevated egg mortality. Insufficient flow may also limit the extent of river bed available for redd construction, thereby limiting available habitat for this life stage. Conversely, the predicted flows under the WOA scenario are considerably higher than under the proposed action and COS in January through February (Figure 5.8-28). Although these flows are not expected to effect upstream migration, and therefore superimposition in the Low Flow Channel, the high flows during this incubation and emergence period could result in redd scouring, which could adversely affect this life stage. Therefore, flows under the WOA scenario could have a potentially significant adverse effect on this life stage. Because the potential adverse effects of low flows on this life stage are anticipated to be less severe, or most beneficial, under the proposed action scenario, flow-related actions under the proposed action scenario are anticipated to produce low- to medium-level population benefits for this life stage.

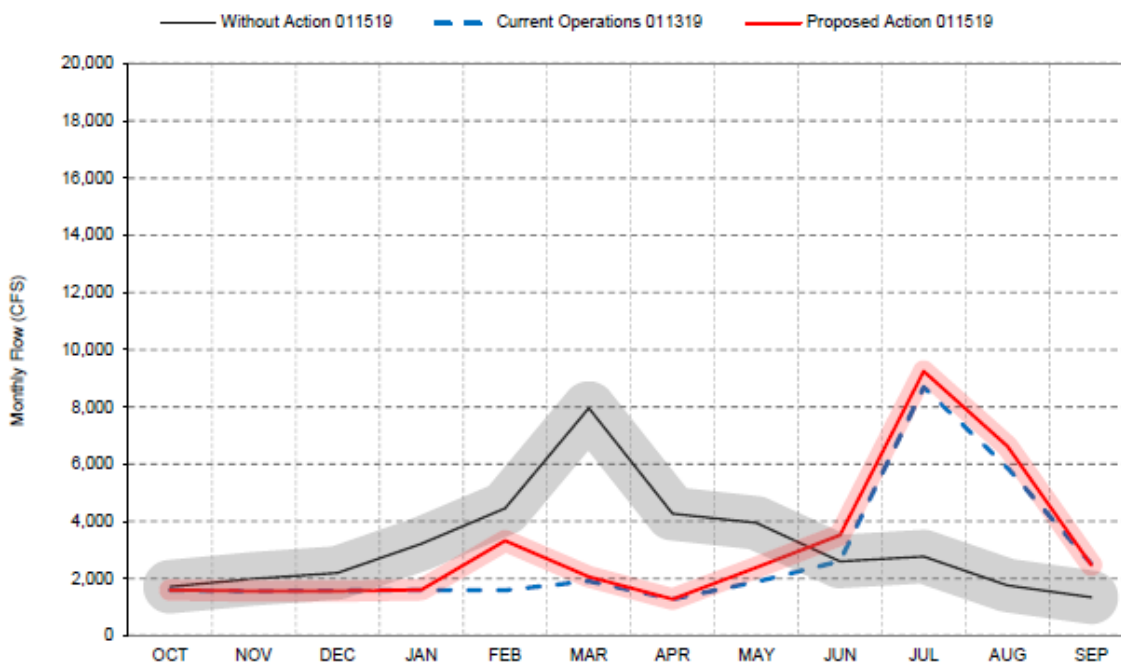


Figure 5.8-32. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for below normal water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

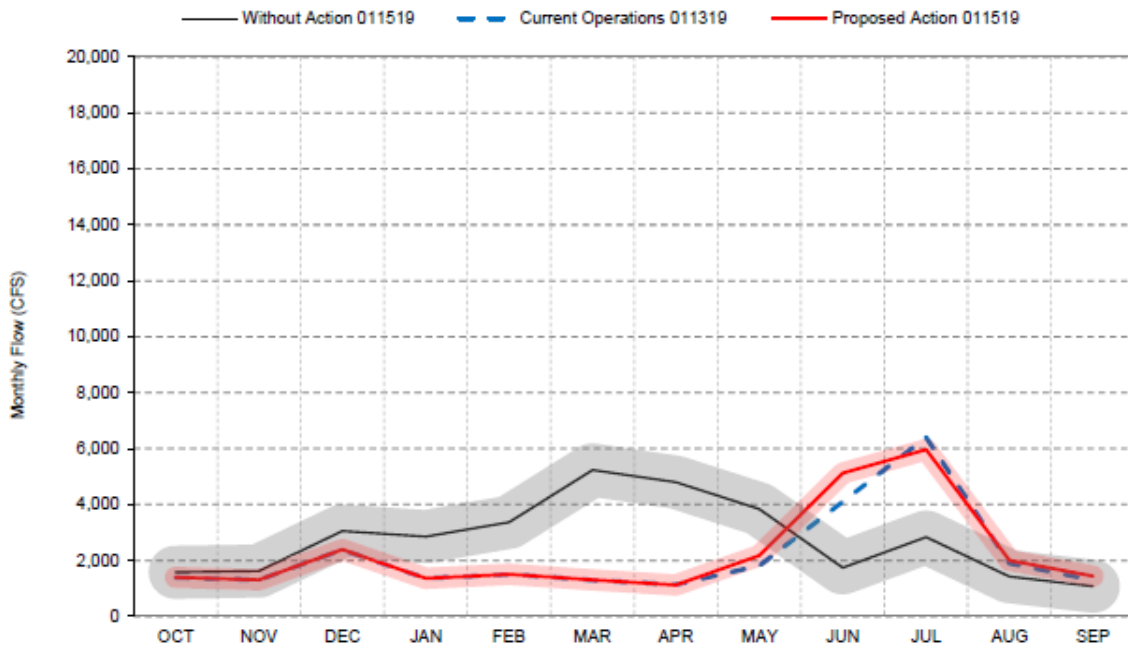


Figure 5.8-33. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for dry water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

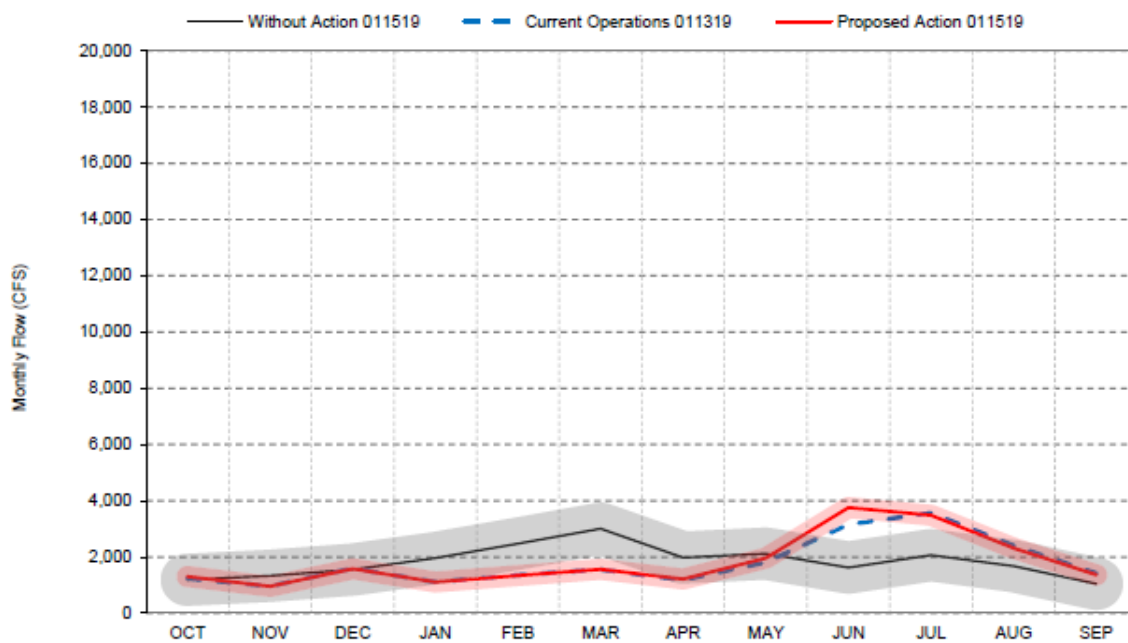


Figure 5.8-34. CalSim II estimates of Feather River flow below Thermalito Afterbay in September and October for critically dry water years under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

5.8.3.6.1.2 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to influence condition and survival of Spring-run Chinook eggs. Effects of elevated water temperatures include an inability to satisfy metabolic demand and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). Spring-run Chinook Salmon eggs require temperatures < 54°F for optimal development and survival and 54-58°F for suboptimal development and survival. Temperatures above 58°F may cause chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River during summer and fall are heavily influenced by flow releases from Lake Oroville, which are determined by operations and storage releases. Eggs and emerging fry of Spring-run Chinook would be exposed to the effects of operations and water releases that affect water temperatures in the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (September-February; Table 5.8-1 & NMFS 2016x), and the timing of the temperature objectives that influence flow releases (Table 5.8-3).

Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in the Oroville Facilities relicensing Settlement Agreement (Article A108.1(b) [(i) curtailment of pump-back operation, (ii) shutter removal on Hyatt Intake, (iii) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF, then a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Table 5.8-3. Maximum Daily Mean Water Temperature Objectives for the HFC (NMFS BO and USFWS BO)

| Maximum Daily Mean Water Temperature Objectives for the HFC (measured at the downstream FERC project boundary) | |
|---------------------------------------------------------------------------------------------------------------------------|------------------|
| Period | Temperature (°F) |
| January 1 – March 31 | 56 |
| April 1 – 30 | 61 |
| May 1 – 15 | 64 |
| May 16 – 31 | 64 |
| June 1 – August 31 | 64 |
| September 1 – 8 | 61 |
| September 9 – 30 | 61 |
| October 1 – 31 | 60 |
| November 1 – December 31 | 56 |

Under the WOA, Lake Oroville would not be operated to control storage or flow releases, and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where Spring-run Chinook egg incubation occurs. Resulting water temperatures under the WOA scenario in the HFC at Gridley Bridge, as modeled by the RecTemp temperature model, would be generally lower during the winter and higher during the summer and fall, with peak annual water temperatures of approximately 78 °F occurring in July and August (Figure 5.8-35).

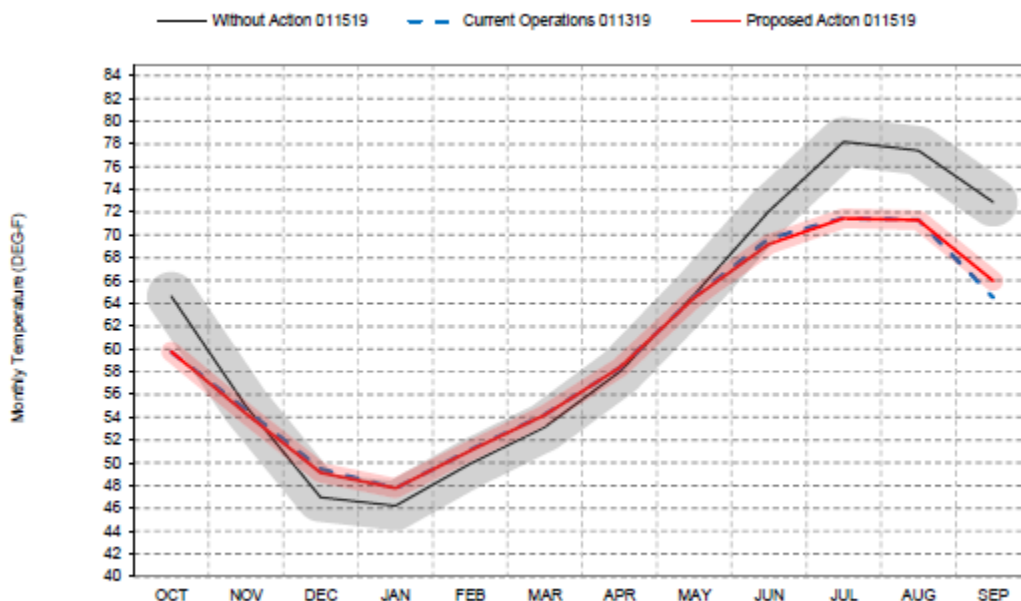


Figure 5.8-35. RecTemp average estimated Feather River water temperatures at Gridley Bridge under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

Under the proposed action and COS, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those estimated under the WOA scenario between June and October, and water temperatures that are roughly equivalent between November and May (Figure 5.8-35). Water temperatures at Gridley Bridge under the WOA scenario would range between 60 and 78 °F in September and October, which is well above levels that may cause chronic to acute stress and would increase the likelihood of temperature-related mortality (Stillwater Sciences 2006) during the peak timing of Spring-run Chinook egg incubation. Water temperatures under the proposed action and COS would be appreciably lower than under the WOA during the same period, ranging from approximately 57 to 68 °F; however, would still be suboptimal for development and survival and may also cause chronic to acute stress (Stillwater Sciences 2006). Optimum temperatures for egg incubation are reached after mid-November under all three scenarios (Figure 5.8-35). In addition, modeled water temperatures at Gridley Bridge indicate a higher likelihood of temperature compliance under the proposed action and COS (Table 5.8-3 and Figure 5.8-36 through 41).

Water temperatures exceeding the objectives and the biological thresholds for this life stage of Spring-run Chinook Salmon would have adverse effects on individuals, including acute to chronic physiological stress and increased likelihood of egg mortality. Water temperatures in the Feather River HFC during the egg incubation period under the proposed action and COS are similar to or lower than WOA water

temperatures and have a higher likelihood of meeting the temperature objectives during the peak egg incubation period (September–October), which would benefit this life stage. Therefore, potential adverse effects of flow releases and water temperatures would be minimized for this life stage under the proposed action and COS scenarios, which is anticipated to produce low- to medium-level population benefits for this life stage.

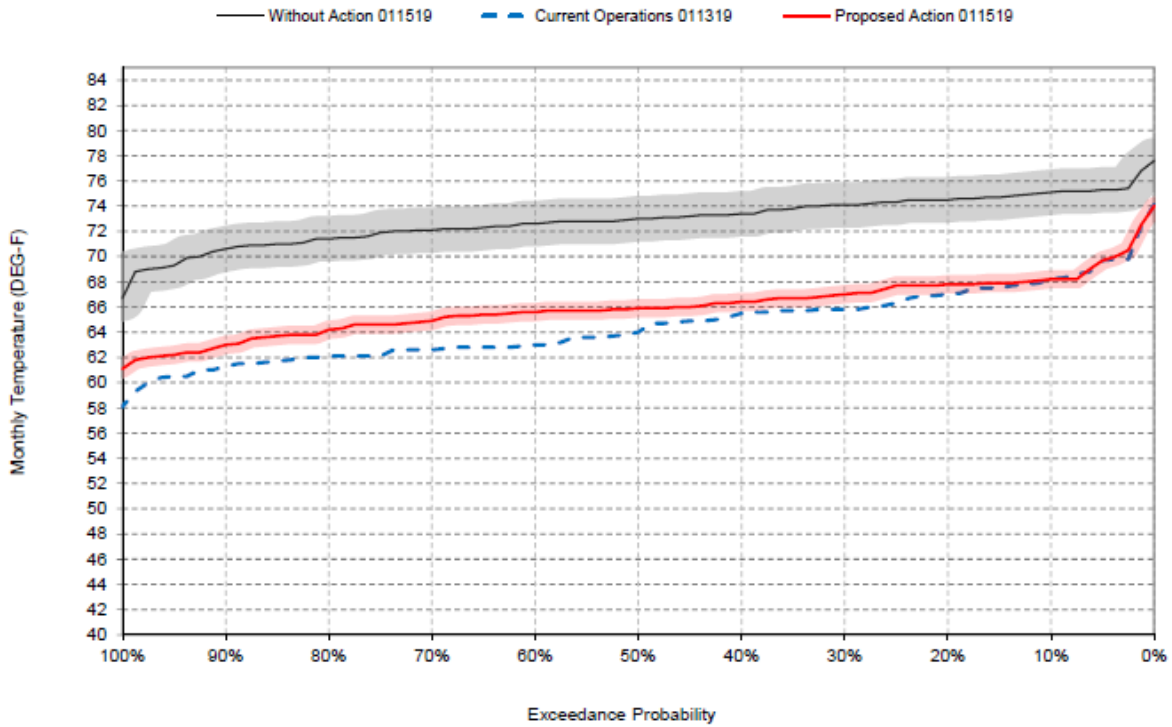


Figure 5.8-36. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in September under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

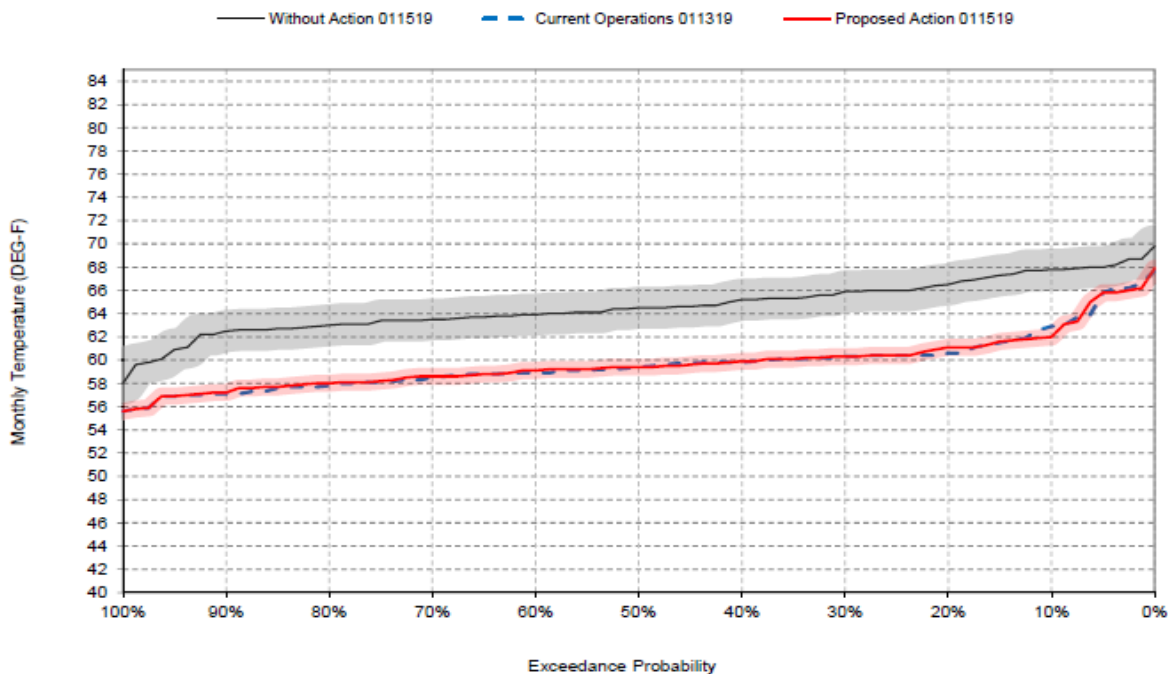


Figure 5.8-37. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in October under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

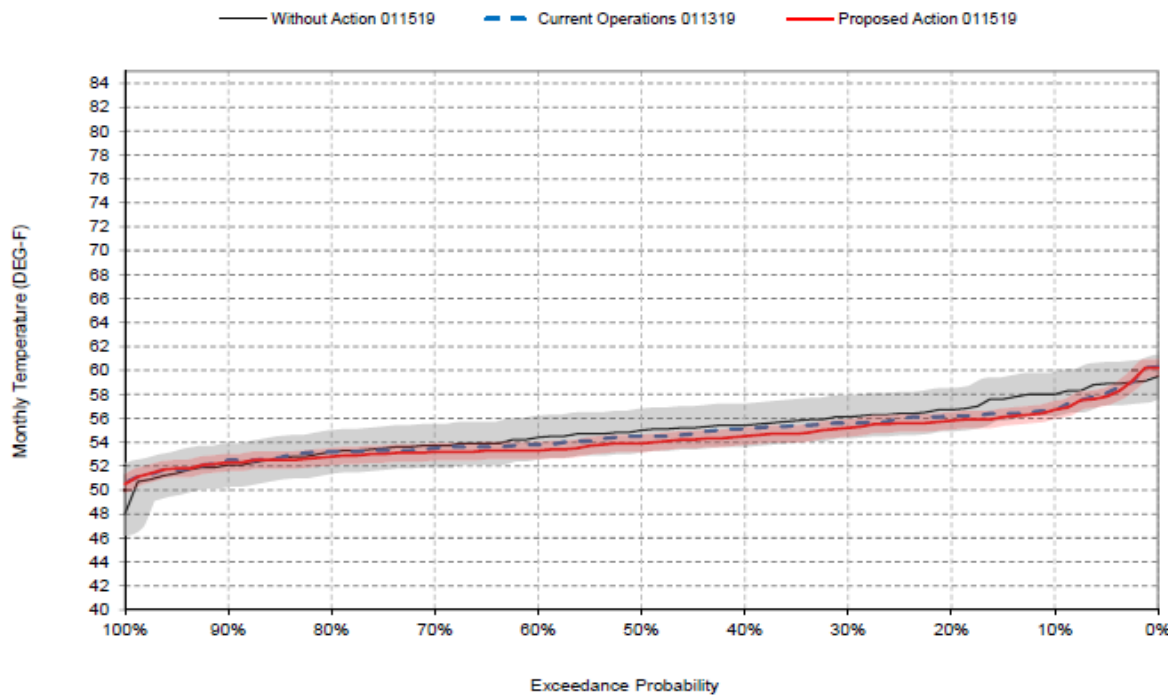


Figure 5.8-38. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in November under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

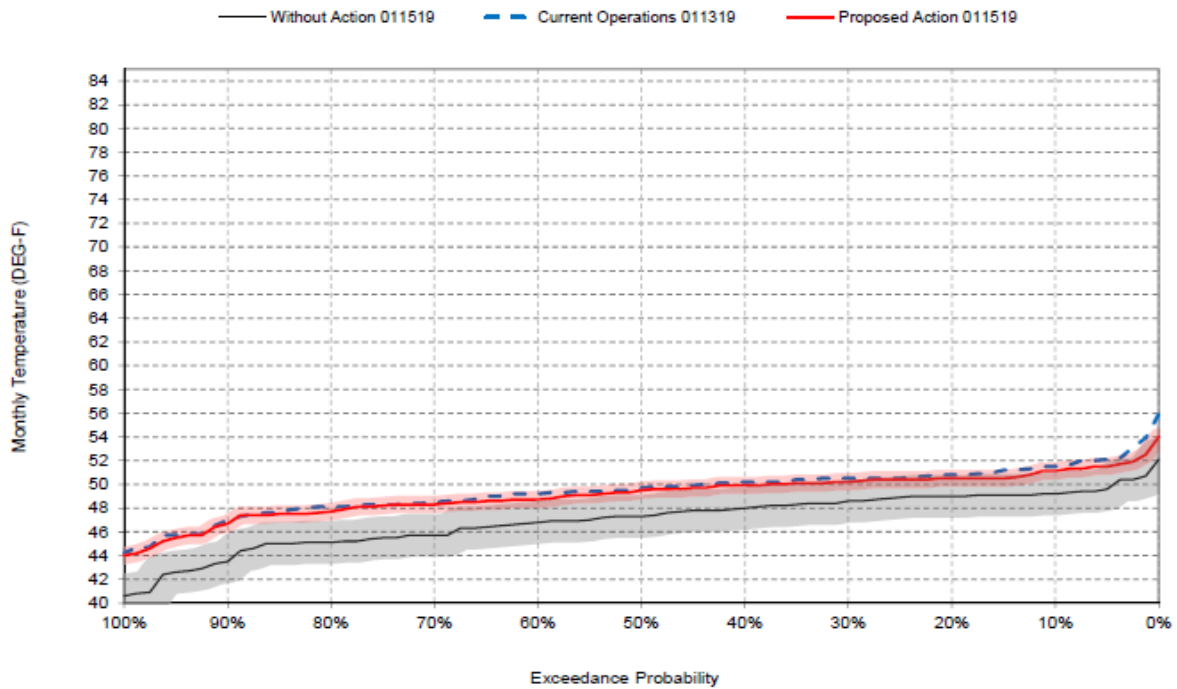


Figure 5.8-39. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in December under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

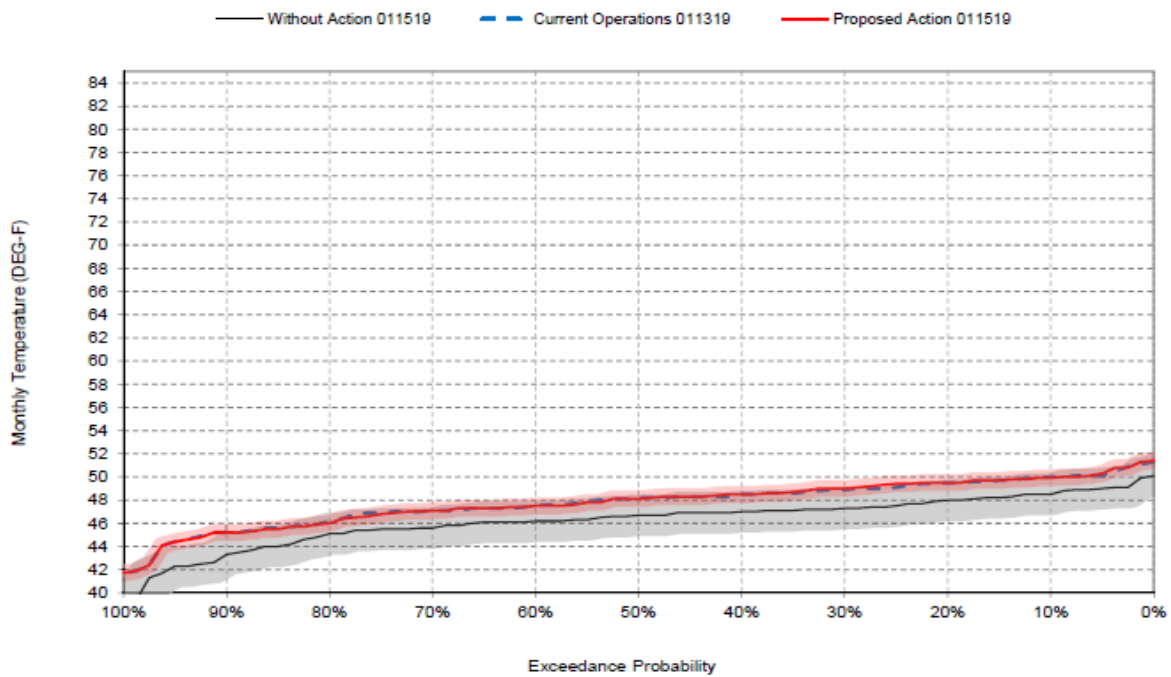


Figure 5.8-40. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in January under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

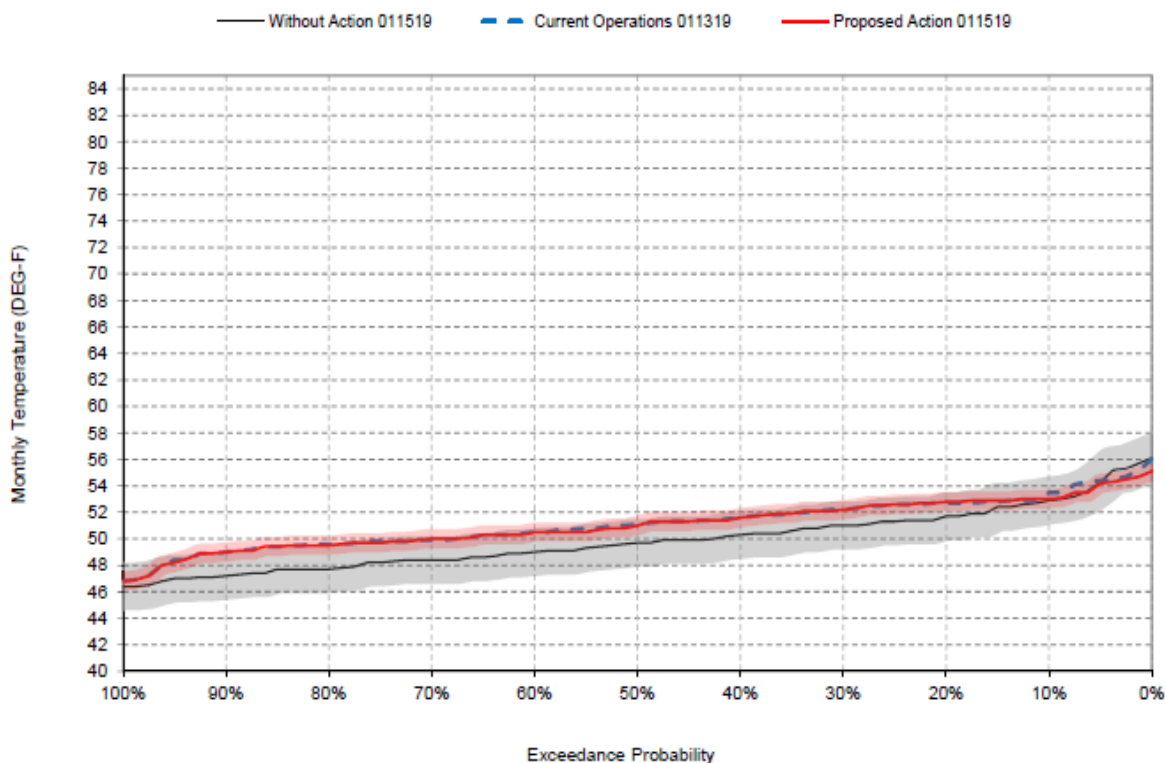


Figure 5.8-41. RecTemp estimates of Feather River water temperature exceedance probabilities at Gridley Bridge in February under the WOA (Without Action), COS (Current Operations), and proposed action scenarios.

5.8.3.6.2 Rearing to Outmigrating Juveniles in Rivers

5.8.3.6.2.1 Flow Effects

Rearing to outmigrating juvenile Spring-run Chinook would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance November-May; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 3), and compliance with Water Rights Decision 1641 (D-1641).

Under the Without Action (WOA), Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.8-27). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA would approximate uncontrolled flows, with generally lower summer and fall flows and higher winter and spring flows compared to proposed action and COS (Figures 5.8-28 and 5.8-29).

5.8.3.6.2.1.1 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of rearing individuals. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, reduction in growth due to increased metabolic demands, decreased productivity, and eventual mortality. Rearing juvenile Spring-run Chinook require temperatures < 60°F for optimal development and survival, and 60-65°F for suboptimal, with temperatures above 65°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River from November to May are relatively less influenced by flow releases from Lake Oroville than in summer and fall, given the larger flow volumes, and colder air temperatures during these months. Rearing Spring-run Chinook Salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance November-May; Table 5.8-1 & NMFS 2016x), and the timing of the temperature objectives (year-round objectives; Table 5.8-2).

Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in the Oroville Facilities relicensing Settlement Agreement Article A108.1(b) [(i) curtailment of pump-back operation, (ii) shutter removal on Hyatt Intake, (iii) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.8-31). Temperatures at Gridley Bridge under the WOA are the same or lower than temperatures under the proposed action and COS from November to March, which coincides with the peak seasonal timing of rearing Spring-run Chinook. However, the risk of temperature-related stress and mortality are substantially reduced or not present during this period as temperatures remain well within the optimal range (< 60°F) for this life stage and under the Feather River HFC temperature objectives for these months. However, April and May water temperatures under the COS, and more so the proposed action, are lower than the WOA during a period at moderate risk of temperature-related stress and mortality, increasing the likelihood of temperature-related stress and mortality occurring during juvenile rearing under some conditions of the WOA. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action and COS, especially during below normal, dry, and critically dry water year types (Figure 5.8-32). Therefore, water temperature-related actions in these scenarios are anticipated to produce low-level population benefits for this life stage.

5.8.3.6.3 Migrating Adults

5.8.3.6.3.1 **Flow Effects**

Migrating adult Spring-run Chinook Salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (peak

abundance March-June; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.8-2), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the SAIL Bay-Delta to Upper River (CM6) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of migrating adult Spring-run Chinook Salmon (Johnson et. al., 2016, Windell et. al., 2017). Instream flow from Lake Oroville releases may also heavily influence the strength of navigational cues utilized by migrating adults and the propensity of these fish to stray from migratory pathways leading to high quality spawning habitat.

Feather River flows below Thermalito Afterbay under the WOA generally approximate or are significantly higher than flows under the proposed action and COS during the peak seasonal timing of Spring-run Chinook adult migration (peak abundance March-June; Table 5.8-1 & NMFS 2016). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, although some risk exists under the WOA in June of critically dry years, when flows are lower under the WOA than COS and proposed action scenarios (Figure 5.8-30). Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the March to June period, but are still significant, with relatively equal differences across the range of exceedance probabilities.

5.8.3.6.3.1.1 Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult Spring-run chinook require temperatures < 56°F for optimal survival, and 56-65°F for suboptimal, with temperatures above 65°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures in the Feather River during summer are heavily influenced by flow releases from Lake Oroville, which are determined by operations and storage releases. Migrating adult Spring-run Chinook Salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (peak abundance March-June; Table 5.8-1 & NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.8-2).

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Temperatures at Gridley Bridge under the COS and proposed action are the same or lower than temperatures under the WOA from March to June, which coincides with the peak seasonal timing of migrating adult Spring-run Chinook. The risk of temperature-related stress and mortality are present during this period as temperatures are projected to be in or near the suboptimal range (<56-65°F) for this life stage from March to May and potentially above the chronic to acute stress threshold (> 65°F) in June (Figure 5.8-31). Water temperatures under the COS, and more so the proposed action, are lower than the WOA during May and June, a period at moderate to high risk of temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the COS, and more so the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.8-32).

5.8.3.6.4 Holding Adults

Holding adult Spring-run Chinook Salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (March-September with peak abundance May-August; Table 5.8-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 7), and compliance with Water Rights Decision 1641 (D-1641). As indicated by the SAIL Bay-Delta to Upper River (CM7) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, and other habitat attributes that influence the condition and survival of holding adult Spring-run Chinook Salmon (Johnson et. al., 2016, Windell et. al., 2017).

Feather River flows below Thermalito Afterbay under the WOA both exceed and are lower than flows under the proposed action and COS during the peak seasonal timing of Spring-run Chinook holding (March-September with peak abundance May-August; Table 5.8-1 & NMFS 2016). In particular, WOA flows are reliably higher than the proposed action and COS in May and equal to or lower than the proposed action and COS from June to August. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, and all water year types, except in August and September under the WOA scenario. Under this scenario the likelihood of flows declining below applicable minimum instream flows for the Feather River HFC in August and September is increased under the WOA (Figure 5.8-30). Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the March to September period, but are still significant, with the proposed action projected to be reliably higher in May and June and the COS projected to be reliably higher in September.

Exposure to the effects of differences in flow during this life stage could include variation in water temperature and DO, and the amount and quality of holding habitat used to shelter from predators, and rest during the gamete maturation phase. COS and proposed action flows are lower than WOA flows in May, however, proposed action and COS action flows are not anticipated to decline below minimum instream flow standards or to a level that is anticipated to result in substantial loss of suitable holding habitat in the Feather River HFC. COS and proposed action flows are predominantly higher than WOA flows from June to August, which is anticipated to result in significant water temperature benefits for holding adults as this period coincides with mid- and late-summer increases in air temperature. These flows are also anticipated to improve the likelihood of adequate holding adult habitat as additional migrants enter the Feather River HFC throughout the summer. As a result, conditions for holding adult Spring-run Chinook will be improved during the majority of the peak seasonal timing of this life stage.

Water temperatures in the Feather River from May to September are heavily influenced by flow releases from Lake Oroville with increased flow releases generally mitigating some of the effects of elevated summer air temperatures on water temperature in the Feather River HFC. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where Spring-run Chinook hold prior to spawning. As a result, water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model become increasingly higher than those projected under the COS and proposed action as summer progresses from May to September (Figure 5.8-31).

Under the COS and proposed action scenarios operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent

from November to May. Temperatures at Gridley Bridge under the COS and proposed action are the same or lower than temperatures under the WOA from May to August, which coincides with the peak seasonal timing of holding adult Spring-run Chinook. The risk of temperature-related stress and mortality are present during the majority of this period as temperatures are projected to be at or near the suboptimal range (<60.8-66.2°F) for this life stage from May to August and potentially above the chronic to acute stress threshold (> 66.2°F) in July, August, and September. June to August water temperatures under the COS, and more so the proposed action, are lower than the WOA, a period at high risk of temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the COS, and more so the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.8-32).

5.8.3.7 American River Seasonal Operations, including 2017 Flow Management Standard and “Planning Minimum”

Reclamation’s proposed action includes a minimum release with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. Reclamation’s proposed action also includes a “planning minimum” to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible and improve habitat conditions for steelhead and Fall-run Chinook salmon. The Flow Management Standard (FMS) also includes the provision for spring pulse flows, with the purpose of providing a juvenile salmonid (Fall-run Chinook salmon and steelhead) emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River.

Rearing juvenile Spring-run Chinook Salmon may be present in the American River from November to May. The American River corridor downstream of the Watt Street bridge is designated critical habitat for the species.

5.8.3.7.1 Rearing to Outmigrating Juveniles in Rivers

Spring-run Chinook Salmon juveniles may be present in the American River for rearing and exposed to effects of Reclamation's water releases from Folsom Dam during their rearing period. Excessively high water temperatures have been identified as one of the factors threatening Spring-run Chinook Salmon in the Central Valley and a factor for listing of the species. Without Reclamation’s proposed action, there would be no Folsom reservoir operations to control storage or releases. The proposed action and COS would result lower flows below Nimbus Dam during the species rearing period during average water years, with the largest difference in flow between March and May. All three modeled hydrologies (WOA, proposed action and COS) indicated flows spike at the beginning of February, between 6,000 cfs and 6,500 cfs. The proposed action and COS result in higher temperatures between November and February. From February to May, all three model runs indicate similar temperatures, however under WOA conditions river temperature increases over the proposed action and COS.

The implementation of the proposed FMS measures would provide suitable habitat conditions in the lower American River for Chinook Salmon, particularly during drought conditions, and improve conditions for rearing to outmigrating Juveniles.

5.8.3.7.1.1 Stanislaus River Stepped Release Plan

The Stanislaus River is not designated critical habitat for Spring-run Chinook Salmon and while spring-running fish may be present, they are not currently considered part of the listed ESU. However, since no

genetic testing has occurred, Reclamation is providing this analysis to ensure future coverage under the ESA if proven to be listed CV Spring-run Chinook Salmon.

A nonessential experimental population of Spring-run Chinook Salmon in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River was designated to allow reintroduction of the species below Friant Dam as part of the San Joaquin River Restoration Program (SJRRP) (78 FR 79622, December 31, 2013). Observations show that spring running Chinook occur in the Stanislaus and Tuolumne Rivers and that these fish would not be considered as experimental under the SJRRP, and as a result, they are addressed in this document.

5.8.3.7.1.1.1 Egg to Fry Emergence

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 and October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December 2003, which would indicate likely spawning timing in late September or October. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult spring-running Chinook Salmon (Anderson et al. 2007), and 114 adults were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FISHBIO 2015). Rotary screw trap (RST) data provided by Stockton U.S. Fish and Wildlife Service (USFWS) corroborates the spring-running Chinook Salmon adult timing by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-running Chinook emigration (Franks 2014). Recently emerged fry start to show up at rotary screw traps in late December to mid-January most years and could be indicative of spring-run or fall-run Chinook.

Under WOA conditions, the lower level river outlets of New Melones Dam would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open and assumed to pass a flow of approximately 8,000 cfs. Inflow exceeding this capacity would be stored in New Melones Reservoir until the releases exceed capacity of the outlets. If necessary, the spillway would prevent overtopping of the Dam and to protect the structural integrity of the Dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height. Spring-running Chinook salmon distributions are expected to be similar to WOA as Goodwin Dam would still represent a complete barrier to further upstream migration. WOA water temperatures within the Stanislaus River would represent those of unimpeded flows coming off the western Sierra Nevada that travel through the CVP storage and conveyance facilities on the Stanislaus River that would be operated only to the extent necessary to fulfill flood control operations. Operations of non-CVP facilities would still occur as they are occurring today. Modeled flows below Goodwin Dam are depicted below in Figure 5.8-42. Stanislaus Modeled Flows. The early running Chinook would likely not survive the summer and any that do survive to spawn in early fall would not successfully reproduce due to high water temperature in WOA.

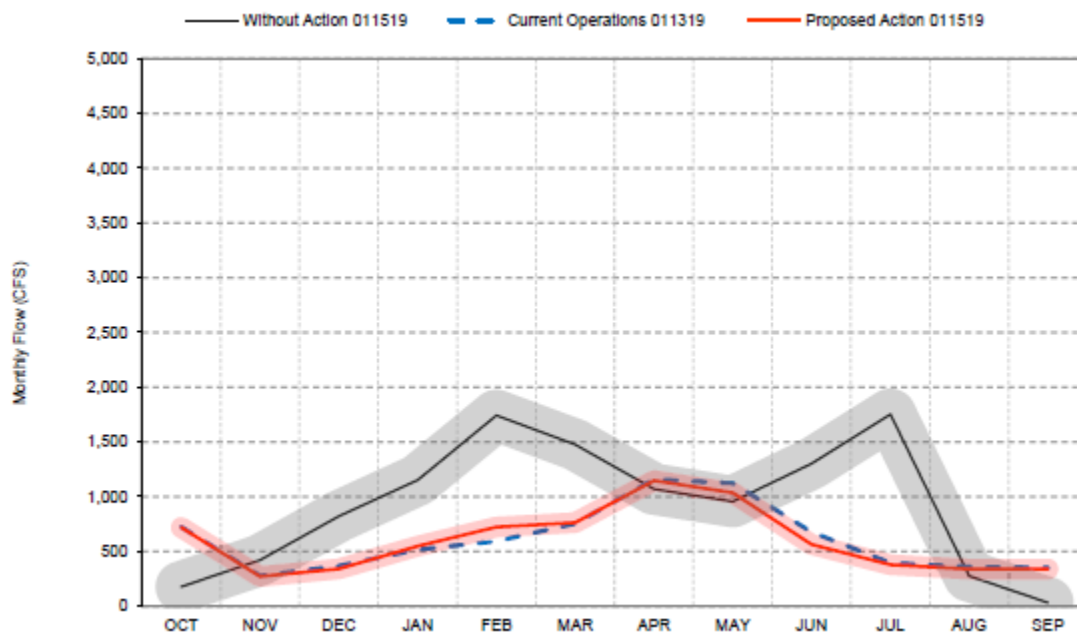


Figure 5.8-42. Modeled flows under WOA, Current Operations Scenario (COS) and Proposed Action Scenario

Current operations of New Melones under the Interim Plan of Operations (IPO), which has been in effect since 1997, were developed prior to completion of current tools to understand hydrology in the Stanislaus River Basin, and the water delivered from New Melones was overallocated in many years and was not able to consistently meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries. The primary reason for this is that the IPO requires water releases early in the season that have resulted in inadequate water available later in the season to meet water quality and/or flow requirements. Reclamation also currently operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed by Appendix 2-E of the NMFS 2009 BO.

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries.

Where adult spring-running Chinook Salmon returning to the San Joaquin River are expected to exhibit various life-history patterns on both temporal and spatial scales, the juvenile stage typically exhibits more life-history variability than adults and have a stronger dependence on riverine habitat for successful survival than adults (SJRRP 2010). A review of numerous studies performed for the SJRRP (2010) identified a range of suitable water temperatures for all life stages of salmonids. The findings of this review were compiled into Table 5.8-4: Temperature Objectives for the Restoration of Central Valley Chinook Salmon.

Table 5.8-4. Temperature Objectives for the Restoration of Central Valley Chinook Salmon

| Monthly Water Temperature Objectives for the San Joaquin River Restoration Program | | | | | | | | | | | | |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-----|------|-----|----------------------------------------------------------------------------------------------------|-----|-----|-----|-----|
| Spring-Run and Fall-Run Chinook Salmon | | | | | | | | | | | | |
| Life Stage | Jan | Feb | Mar | Apr | May | June | Jul | Aug | Sep | Oct | Nov | Dec |
| Adult Migration | | | Optimal: ≤59°F (15°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C) | | | | | | | | | |
| Adult Holding (Spring-Run Only) | | | | Optimal: ≤55°F (13°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C) | | | | | | | | |
| Spawning | | | | | | | | Optimal: ≤57°F (13.9°C) Critical: 60 – 62.6°F (15.5 – 17°C) Lethal: 62.6°F or greater (17°C) | | | | |
| Incubation and Emergence | | | | | | | | Optimal: ≤55°F (13°C) Critical: 58 – 60°F (14.4 – 15.6°C) Lethal: >60°F (15.6°C) | | | | |
| In-River Fry/Juvenile | Optimal: ≤60°F (15.6°C), young of year rearing: ≤62.6°F (18°C), late season rearing (primarily spring-run) Critical: 64.4 – 70°F (18-21.1°C) Lethal: >75 °F (23.9°C), prolonged exposure | | | | | | | | | | | |
| Floodplain Rearing* | Optimal: 55 – 68°F (13 – 20°C), unlimited food supply | | | | | | | | | | | |
| Outmigration | Optimal: ≤60°F (15.6°C) Critical: 64.4 – 70°F (18 – 21.1°C) Lethal: >75°F (23.9°C), prolonged exposure | | | | | | | | | | | |

Sources: EPA 2003, Rich 2007, Pagliugh 2008, Gordus 2009

Note:

* Floodplain rearing temperatures represent growth maximizing temperatures based on floodplain condition. No critical or lethal temperatures are cited assuming fish have volitional access and egress from floodplain habitat to avoid unsuitable conditions.

Shaded box indicates life stage is present Key:

*F = degrees Fahrenheit

*C = degrees Celsius

Source: Conceptual Models of Stressors and Limiting Factors for San Joaquin River Chinook Salmon

The New Melones SRP will be implemented similar to current operations with a default daily hydrograph, and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under current operations for Critical, Dry, and Below Normal water year types; Above Normal and Wet year types follow daily hydrographs for Below Normal and Above Normal year types from 2-E, respectively. As a result, flows would be reduced in Above Normal and Wet year types. This difference between the proposed action and the COS during Above Normal and Wet years, where the minimum release requirement for wetter water year types is reduced from COS to promote storage for potential future droughts and preserve coldwater pool, leads to improved cold water pool performance in droughts, benefiting Spring-running Chinook salmon eggs.

5.8.3.7.2 Rearing to Outmigrating Juveniles

The SRP provides improved cold water pool performance in droughts, but would reduce flow releases in Above Normal and Wet years. This could result in less inundated rearing habitat, lower outmigration flows, and potentially warmer temperatures in some years, affecting rearing of outmigrating juvenile CV Spring-running Chinook salmon.

5.8.3.8 Alteration of Stanislaus River Dissolved Oxygen Requirement

Under WOA conditions, flow would be uncontrolled through the CVP project facilities and Spring-running Chinook distribution would be similar to currently, as Goodwin Dam would represent a complete barrier to further upstream migration. There would be no temperature management. Early running Chinook spawners would likely not survive the warm water in late summer and fall and would be unable to reproduce.

Current operations are required to meet a year-round dissolved oxygen minimum of 7 mg/L, from June 1 to September 30 at Ripon to protect salmon, steelhead, and trout in the river (CDFW 2018). However, maintaining dissolved oxygen concentrations above 7 mg/L in the Stanislaus River at Ripon is challenging during drought conditions, and, based on recent studies, does not appear to be warranted to protect salmonids in the River (Kennedy and Cannon 2005, Kennedy 2008).

Reclamation proposes to move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year. Based on multi-year observations of salmonid abundance in the River Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge, which is approximately 31 miles upstream from Ripon. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that dissolved oxygen concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Without the proposed action, there would be no water temperature management. Therefore, the proposed temperature compliance point is beneficial to the species, because the majority of salmonid eggs, alevin and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L.

Juvenile spring-run Chinook are found in the Stanislaus River from Goodwin Dam downstream to Oakdale. Because the fish are located primarily at least twice this distance upstream from Ripon, the dissolved oxygen concentration is likely to be at this level or higher where the majority of these fish occur. Additionally, there should be no impact to outmigrating juvenile Spring-run Chinook Salmon since their outmigrations is from November through the end of May (Table 5.8-1). Based on the typical seasonal occurrence of this life stage in the River (mid-January – late June), no adult migrating Spring-run Chinook Salmon would be affected by the relaxation of dissolved oxygen requirements at Ripon (June 1 - September 30). As the majority of adult Chinook Salmon that are holding in the Stanislaus River from March to mid-September (Table 5.8-1) are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L, holding adult Spring-run Chinook Salmon are not expected to be impacted from this action. Based on the typical seasonal occurrence of this life stage in the Stanislaus River (mid-January – late June), no adult migrating Spring-run Chinook Salmon would be expected to be exposed to the effects of the alteration of dissolved oxygen requirements at Ripon.

5.8.3.9 Bay-Delta Seasonal Operations

Reclamation and DWR propose to operate the C.W. Bill Jones Pumping Plant and the Harvey O. Banks Pumping Plant. These pumping plants affect the hydrodynamics of the south and central Delta resulting in effects to Spring-run Chinook Salmon entrainment, routing and through Delta survival. Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to negatively impact juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, 2) “far-field” mortality resulting from altered hydrodynamics. See Winter-run Chinook salmon effects section for more detail concerning “far-field” and “near-field”.

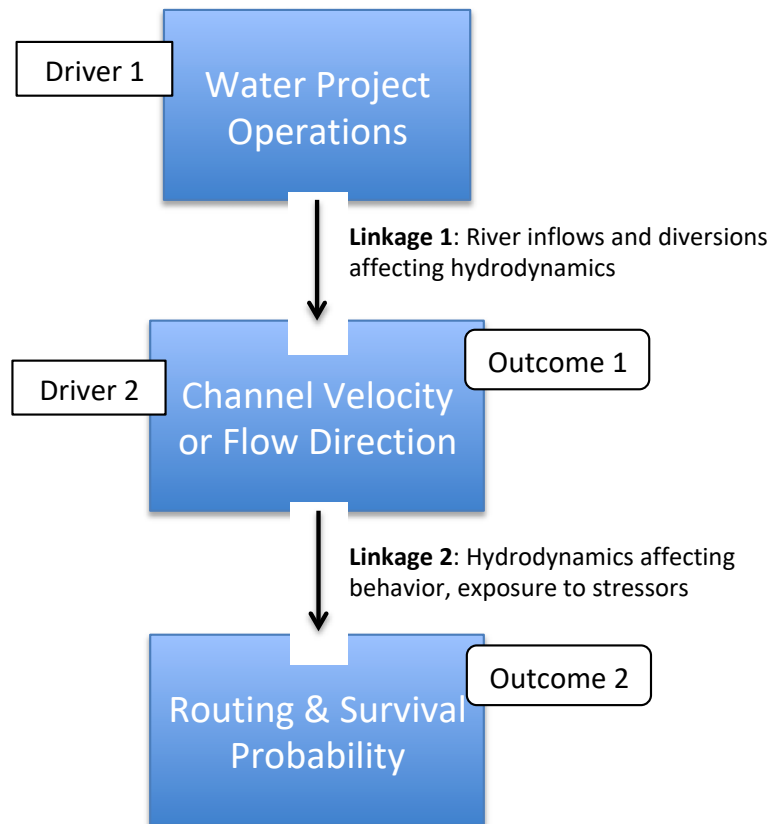
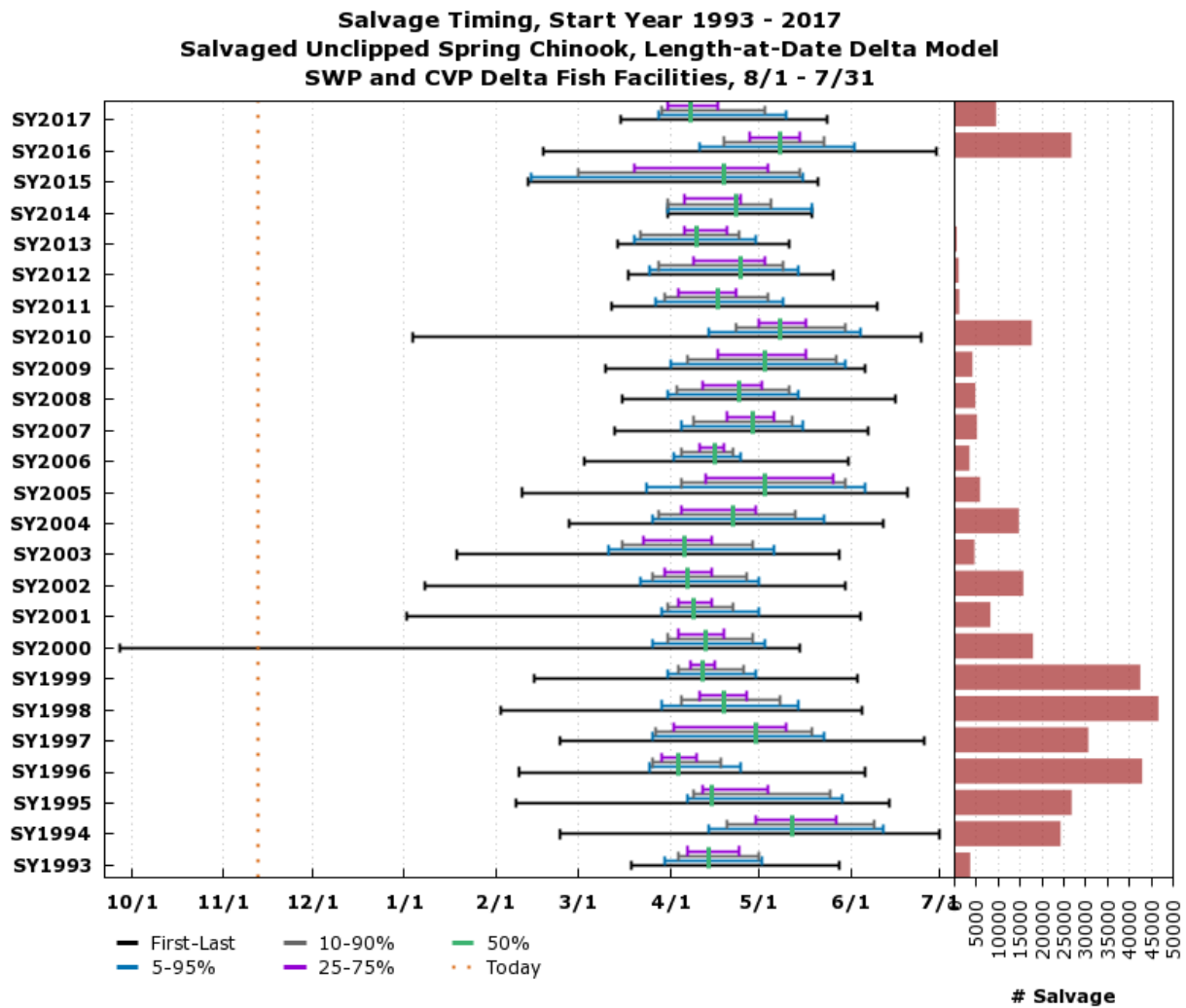


Figure 5.8-43. Conceptual model for far-field effects of water project operations on juvenile salmonids in the Delta. This CM is a simplified version of the information provided by the CAMT SST.

5.8.3.9.1 Entrainment

Among 6.8 million tagged natural origin and 2.8 million tagged hatchery origin Spring-run Chinook Salmon juveniles, entrainment loss averaged less than 0.0005% (Zeug and Cavallo, 2014). As there are no exports under WOA, there is no entrainment risk under WOA. In the December through February, the average total export rate, under the proposed action, is slightly higher difference compared to COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed in March-June are 1,699 cfs higher than COS (Figure H-2 - Appendix H, *Bay-Delta Aquatics Effects Figures*) when juvenile Spring-run Chinook Salmon are most abundant in the Delta.

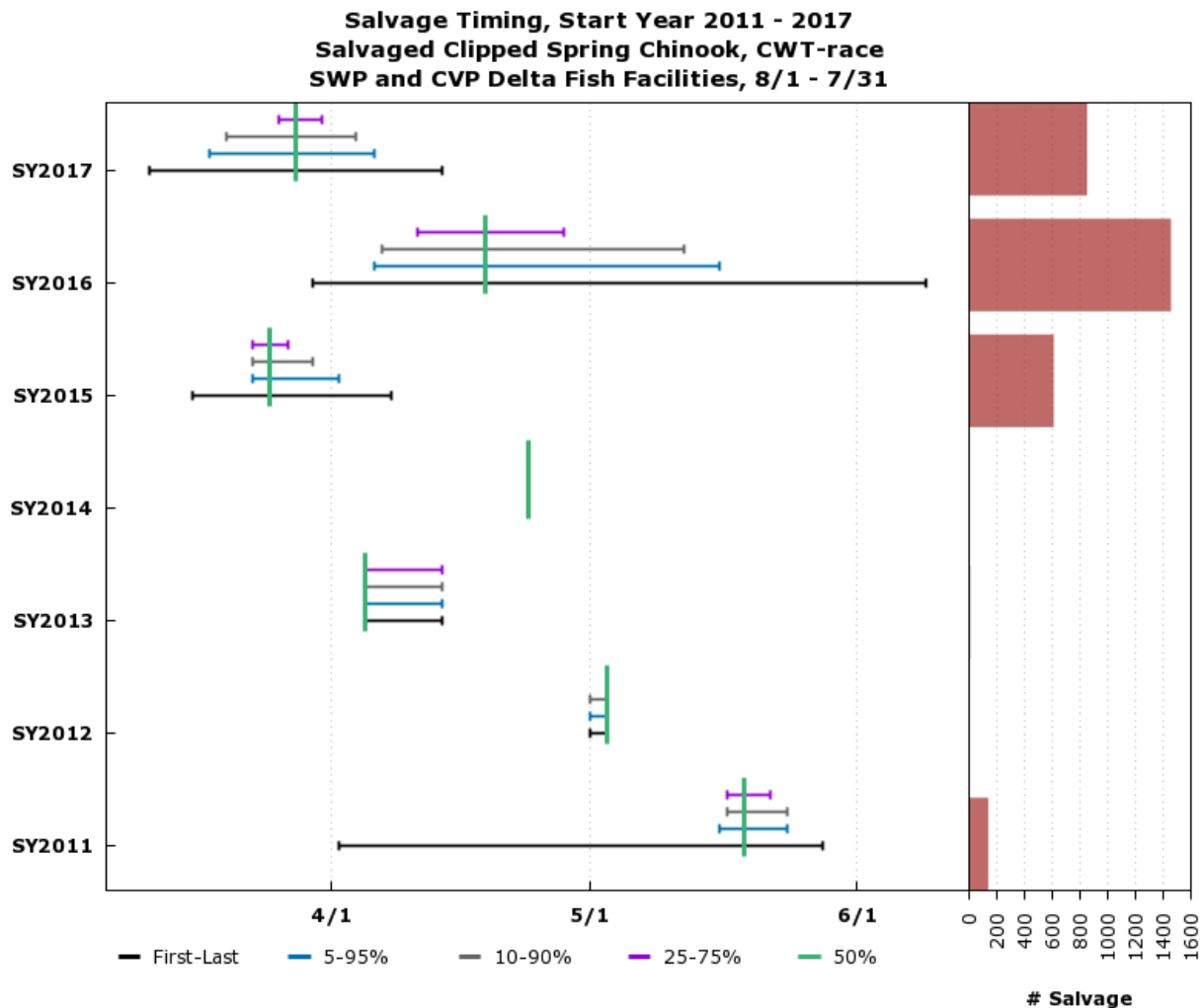
According to SacPAS (Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*), between 0 and 45000 unclipped Spring-run Chinook Salmon are currently salvaged at CVP and SWP fish facilities each year, and between 0 and 9000 clipped Spring-run Chinook Salmon from the Feather River Fish Hatchery. Salvage estimates are made by counting fish for 30 minutes every 2 hours, and multiplying by 4 to obtain the estimate for the number of fish that are entrained into Tracy Pumping Plant or eaten by predators in the canal or fish facility. Entrainment results in harassment and often mortality for juvenile Chinook salmon. Fish that are counted are salvaged and trucked back to the Delta where they are released and may complete their lifecycle.



www.cbr.washington.edu/sacramento/

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Figure 5.8-44. Salvage Data for Unclipped Spring-run Chinook at SWP and CVP Fish Facilities



www.cbr.washington.edu/sacramento/

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Figure 5.8-45. Salvage Data for Clipped Spring-run Chinook at SWP and CVP Fish Facilities

Although data for juvenile Spring-run Chinook Salmon originating from the San Joaquin River are limited, Zeug and Cavallo (2014) analyzed salvage of San Joaquin River-origin fall run juvenile Chinook Salmon that are found in the Delta at a similar time as Spring-run Chinook Salmon. Salvage of Fall-run Chinook Salmon originating from the San Joaquin River averaged 1.4% and increased with export rate at the CVP and SWP (Zeug and Cavallo 2014). However, there were few observations at export rates greater than 3,000 cfs. Average mortality at the facilities represents < 5% total juvenile mortality for San Joaquin River-origin populations but can range as high as 17.5% (Zeug and Cavallo 2014).

Under WOA, there are no exports and therefore no entrainment. In the December through February period, the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H1) and will, therefore, have a similar entrainment risk. Total exports proposed for proposed action in March-June (1,699 cfs higher than COS; Figure H2) when juvenile Spring-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS. Recent acoustic studies of juvenile Fall-run Chinook Salmon in the San Joaquin River revealed that when the Head of Old River

Barrier is out, >60% of fish detected at Chipps Island came through CVP, indicating that salvage is a higher survival route than volitional migration.

5.8.3.9.2 **Routing**

As stated in the Sacramento Winter-run Chinook effects section, routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April (Table 5.8-1). In the December through February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50% in Critical, Dry, Below Normal and Above Normal Years (Figure H-3 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Wet years, velocity overlap in this reach was ≤ 50%. Velocities were higher under proposed action in all water year types indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015). Comparing proposed action to WOA in the Dec-Feb period revealed low velocity overlap in Dry, Above Normal and Wet years with higher velocities in the WOA (Figure H-4 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were more similar in Critical and Below Normal years; however, velocities were still higher in the WOA scenario. This pattern indicates routing into the interior Delta would be lower under WOA relative to proposed action or COS (Perry et al. 2015). In the March to May period, comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H-5 - Appendix H, *Bay-Delta Aquatics Effects Figures*) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento main stem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA indicating routing into the interior Delta under WOA would be lower than proposed action or COS.

Spring-run Chinook Salmon originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can be exposed to hydrodynamic project effects that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April (Table 5.8-1). Early studies using coded wire tags indicated that survival of San Joaquin River-origin juvenile Chinook Salmon was lower in the Old River Route relative to the San Joaquin main stem (Newman 2008). This finding led to strategies designed to keep larger proportions of fish in the San Joaquin River main stem including the Head of Old River rock barrier and non-physical barriers. Recent studies using acoustic technology have indicated that differences in survival among the two routes are not significant (Buchanan et al. 2013; Buchanan et al. 2018). Thus, fish that enter Old River are unlikely to experience reduced survival.

Spring-run Chinook Salmon originating from the San Joaquin River that remain in the San Joaquin River main stem at the Head of Old River are exposed to additional junctions that lead into the interior Delta including; Turner Cut, Columbia Cut, Middle River, Old River, Fisherman's Cut and False River. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the

region of the junctions with San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the December-February period, velocity overlap between proposed action and COS at the Head of Old River was high in Critical water years and moderate in Dry, Below Normal and Wet years (Figure H-7 - Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest overlap occurred in Above Normal years (Figure H-7 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA in the December-February period, velocity overlap was high in critical years and moderate to low in all other water year types (Figure H-8 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March-May period, velocity overlap patterns were similar to comparisons in the December-February period (Figures H-9 and H-10 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

5.8.3.9.3 Through Delta Survival

To examine potential effects of the proposed action, changes in velocity distributions were examined for the Sacramento River at Walnut Grove and Steamboat Slough which are both in this “transitional” region. During the December to February period at Walnut Grove, velocity distributions for proposed action relative to COS were most different in Wet Years (63.4%) with higher velocities in the proposed action. Velocities were also greater for proposed action relative to COS in Dry, Below Normal and Above Normal years although overlap was greater ($\geq 82\%$; Figure H-11 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Critical Years, velocity distributions were almost identical (92.7%; Figure H-11 - Appendix H, *Bay-Delta Aquatics Effects Figures*). A similar pattern was apparent for the comparison between proposed action and WOA (Figure H-12 - Appendix H, *Bay-Delta Aquatics Effects Figures*); however overlap was lower for each water year type (43.9 – 74.1%) with higher velocities under WOA relative to proposed action. At Steamboat Slough in the December to February period, there was a similar pattern where velocities under the proposed action were higher than COS in Wet, Above Normal and Below Normal years and similar in Dry and Critical years (Figure H-13 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA, overlap was moderate to high with values between 45.0 and 76.6 % (Fig H-14 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the March through May period at Walnut Grove, velocity overlap between the proposed action and COS was $\geq 80.9\%$ across all water year types with greater velocities under proposed action (Figure H-15 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA in the March through May period, velocity overlap was variable among water year types from a low of 18.7% in Wet years to 63.5% in Critical years (Figure H-16 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were greater under the WOA relative to the proposed action. At Steamboat Slough in the March through May period, overlap between the proposed action and COS scenarios was high with all values $\geq 84.4\%$ and greater velocities under the proposed action (Figure H-17 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocity overlap was lower when proposed action was compared to WOA (Figure H-18 - Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (23.2%) and highest in Critical years (74.9%).

The small changes in velocity within transitional reaches of the Sacramento River and North Delta between the proposed action and WOA suggest there could be reductions in through Delta survival for Spring-run Chinook Salmon in some water year types under the proposed action.

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. To examine how effects of the proposed project, changes in velocity distributions were examined for the San Joaquin River at Highway 4 and the Head of Middle River which are both in the “transitional” region of the San Joaquin River. During the December to February period at the San Joaquin River at Highway 4, velocity distributions for proposed action relative to COS exhibited high overlap in Critical, Dry and Below Normal water years ($\geq 96.2\%$; Figure H-19 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap values were lower in Above Normal and Wet years with values of 84.4 and 87.2% respectively. In these two water year types, velocities were higher under the proposed action relative to COS (Figure H-19 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA, overlap decreased in all water year types with higher velocities under WOA (Figure H-20 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap values ranged from a low of 58.8% in Wet years to 79.6% in Critical years (Figure H-20 - Appendix H, *Bay-Delta Aquatics Effects Figures*). At the Head of Middle River during the December-February period, overlap was high between the proposed action and COS in Critical, Dry and Below Normal water years ($\geq 90.6\%$; Figure H-21 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Above Normal and Wet years overlap was lower with values of 54.2 and 75.0% respectively. Velocities were higher under the proposed action in these two water year types (Figure H-21 - Appendix H, *Bay-Delta Aquatics Effects Figures*). When the proposed action was compared to WOA, overlap was low in Below Normal, Above Normal and Wet water years ($\leq 25.1\%$) with higher velocities under WOA (Figure H-22 - Appendix I - Appendix H, *Bay-Delta Aquatics Effects Figures*). Overlap was higher in Critical and Dry years and velocities remained higher under WOA (Figure H-22 - Appendix H, *Bay-Delta Aquatics Effects Figures*).

In the March-May period in the San Joaquin River at Highway 4, velocity overlap was high between the proposed action and COS ($\geq 83.3\%$; Figure H-23 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were lower under the proposed action in Dry, Below Normal and Wet year and higher in Above Normal years (Figure H-23 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Comparing the proposed action and WOA in March-May revealed high overlap in Critical years (91.7%). In other water year types, overlap ranged between 54.9% in Wet years to 78.3% in Dry years with higher velocities under the WOA (Figure H-24 - Appendix H, *Bay-Delta Aquatics Effects Figures*). At the Head of Middle River in the March –May period, overlap between the proposed action and COS was moderate in Above Normal Years (57.0%) and high in all other water year types $\geq 72.7\%$ (Figure H-25 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In Above Normal years, velocities were higher under the proposed action and lower in all other water year types (Figure H-25 - Appendix H, *Bay-Delta Aquatics Effects Figures*). Comparison of the proposed action with WOA in March-May at Head of Middle River revealed high overlap in in Critical years and low to moderate overlap in all other water year types (Figure H-26 - Appendix H, *Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were higher under the WOA relative to the proposed action.

5.8.3.10 Delta Cross Channel Operations

The Delta Cross Channel may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. Significant amounts of flow and many juvenile Spring-run Chinook Salmon enter the DCC (when the gates are open) and Georgiana Slough, especially during increased Delta pumping. Mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. Juvenile Chinook Salmon which are entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010) The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes. The peak migration of juvenile Spring-run

Chinook Salmon in the Sacramento River past Knights Landing, which is upstream of the DCC, occurs from March-April (Table 5.8-1). Therefore, the DCC is closed to protect the majority of the juvenile Spring-run migration period in the Sacramento River and reduce the proportion of fish exposed to an open DCC.

5.8.3.11 Agricultural Barriers

The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

The proportion of juvenile Spring-run Chinook Salmon exposed to the agricultural barriers (Temporary Barrier Program, TBP) depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the TBP. The peak relative abundance of juvenile Spring-run Chinook Salmon in the Delta is March and April (Table 5.8-1). If the agricultural barriers are operating as early as April 15 then they have the potential to expose a large proportion of the juvenile Spring-run Chinook Salmon migrating down the San Joaquin River. When the Head of Old River barrier is not in place, acoustically tagged juvenile Chinook salmon have demonstrated a high probability of selecting the Old River route (Buchanan 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). Flap gates tied up on agricultural barriers from May 16 to May 31 would help to reduce the negative effect of the barriers during this period. However, juveniles migrating before or after this period could be exposed to the agricultural barriers with flaps down which apparently decreases passage success and survival (DWR 2018).

Figure 5.8-46 below shows Chinook salmon survival from the Head of Old River between 3 different routes: San Joaquin River to Turner Cut, CVP via the Old River, or SWP via the Old River. As can be shown on the graph below, Chinook Salmon survival is higher through the Old River and the CVP for flows below 3900 cfs at Vernalis than through the San Joaquin River. This figure was generated from a slightly revised meta analysis from route-specific survival estimates from published juvenile Chinook tagging studies completed between 2008 and 2015 (e.g. Buchanan et al. 2016), are generally 100-120 mm parr / smolts. As can also be seen on the figure, flows at Vernalis are less than approximately 3900 cfs nearly 80% of the time. Finally, DWR cannot install the Head of Old River barrier at flows above 5,000 cfs. Therefore, Chinook salmon survival (and, presumably, steelhead, although steelhead data has not shown a difference between the San Joaquin River and Old River) is higher through Old River the majority of the time. Therefore, while agricultural barriers with tidal flap gates down may cause some decline in passage and reach survival, overall survival is expected to increase in the proposed action, which does not include the Head of Old River Barrier, especially with flap gates tied up from May 16 to May 31.

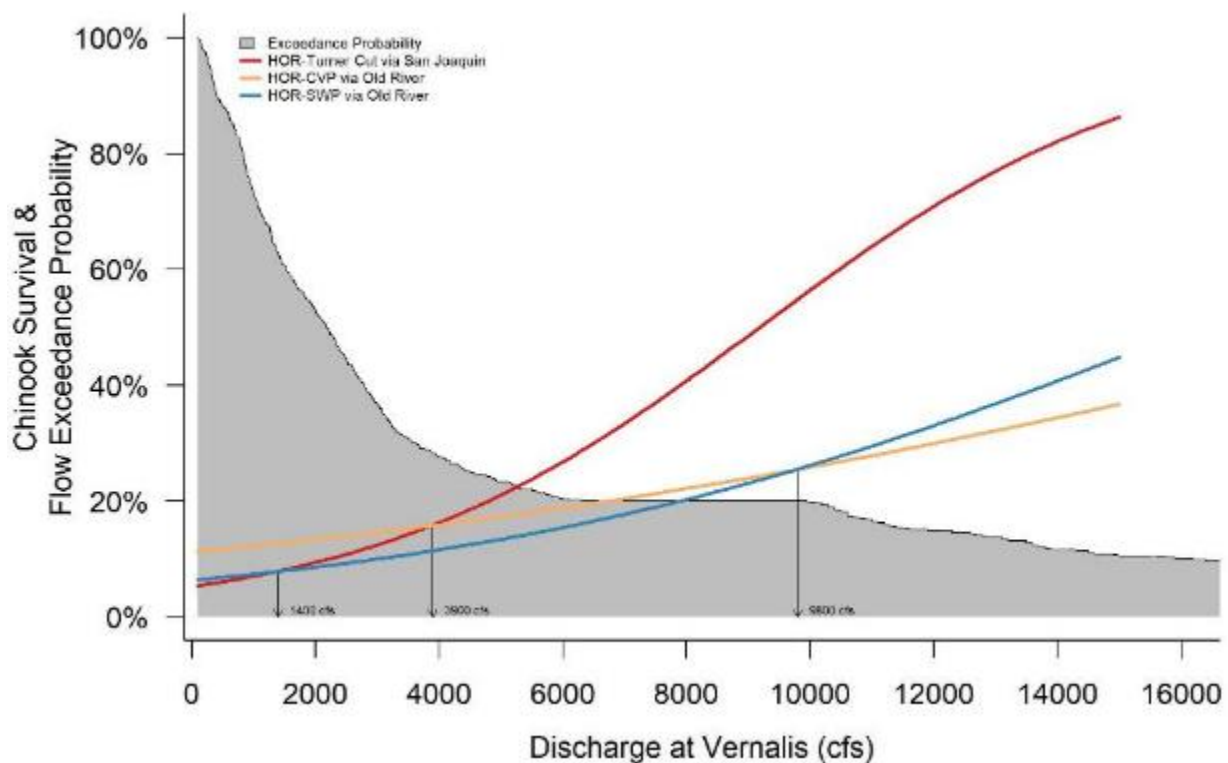


Figure 5.8-46. Chinook Salmon Survival from the Head of Old River

5.8.3.12 Contra Costa Water District Rock Slough Intake

As discussed in Section 4.9.5, CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). Therefore, the operation of the Rock Slough Intake for the proposed action remains unchanged from the current operations.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for CV Chinook Spring-run (NMFS 2017), approximately 18 miles from the Sacramento River and 10 miles from the San Joaquin River via the shortest routes. Designated critical habitat for Spring-run Chinook Salmon does not occur within Rock Slough, but is present further to the north in the Delta (NMFS 2017; NMFS 2014). Salmonids are expected to avoid the area of the Rock Slough Intake during certain times of the year based on historical water temperatures, which range from lows of about 45°F in winter (December and January) to over 70°F beginning in May and continuing to October (Reclamation 2016).

Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of CV Spring-run Chinook Salmon presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD's operations. From 1994 through 1999, CDFW conducted fish

monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over this 6-year period, CDFW captured a total of 108 juvenile CV Spring-run from March through May (CDFG 2002; NMFS 2017). From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected a total of 11 juvenile CV Spring-run from March through May at the Rock Slough Headworks (Reclamation 2016; NMFS 2017). No adult Spring-run were collected in the vicinity of the Rock Slough Intake from 1994 through 2009 (CDFG 2002; Reclamation 2016; NMFS 2017). No juvenile or adult CV Spring-run have been collected in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2008.

Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018, 47 salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a), but none of the captured fish were identified as Spring-run Chinook Salmon (NMFS 2017).

5.8.3.12.1 Rearing to Outmigrating Juveniles in the Bay Delta

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes (i.e., 10 miles from the San Joaquin River and 18 miles from the Sacramento River), juvenile Spring-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile Spring-run can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates.

One indicator of reverse flows is the net flow in OMR. Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect net reverse flow in OMR, and any effect that diversions at Rock Slough Intake would have in the OMR corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants. For juveniles that migrate down the OMR corridor that are not salvaged at TFCF or Skinner Fish Facility, any effect of Rock Slough Intake diversions would be a positive effect on OMR.

For juveniles that migrate down the mainstem of the Sacramento River or the San Joaquin River and for juveniles that were salvaged, trucked, and released in the western Delta, the potential effect of Rock Slough diversions on the net reverse flow in San Joaquin River may be relevant. The effect of water diversions at Rock Slough Intake on the velocity in the San Joaquin River at Jersey Point is presented in the effects analysis for juvenile Winter-run Chinook Salmon. As detailed in that section, the maximum potential effect of water diversions at Rock Slough Intake (assuming diversions at the maximum permitted capacity of 350 cfs and all water diverted by the Rock Slough Intake comes from the San Joaquin River at Jersey Point) is 0.00625 ft/sec in the San Joaquin River at Jersey Point. For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from the Rock Slough diversions.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, we examine the combined effect of all three intakes. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake

have a negligible effect on velocity along the migratory path for juvenile Spring-run Chinook Salmon and are not likely to affect the movement of juvenile salmonids.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. As shown in the Winter-run Chinook Salmon section, the diversions at the Rock Slough Intake could move a neutrally buoyant particle in the San Joaquin River at Jersey Point approximately 540 ft over the course of the day. For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location.

5.8.3.12.2 Adults

As discussed for adult Winter-run Chinook salmon, Rock Slough is poor habitat at a dead-end slough, with relatively high water temperature and a prevalence of aquatic weeds. Therefore, adult CV Spring-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017). The diversion of water at the Rock Slough Intake, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal.

5.8.3.13 *North Bay Aqueduct*

The proposed action includes the North Bay Aqueduct (NBA) intake in the North Delta and operation of the Barker Slough Pumping Plant. Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data is available at [\[link\]](#)). The NBA is located within designated critical habitat for Spring-run Chinook Salmon. There should be no discernable effect to the Spring-run Chinook Salmon due to the operations of the Barker Slough Pumping Facility. This is due to the infrequent presence of Spring-run Chinook Salmon in the monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Facility fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screen.

5.8.3.14 *Water Transfers*

Under WOA, no pumping at Jones and Banks Pumping Plants would occur and therefore no water transfers would occur through them. Under the proposed action, Reclamation is expanding the transfer window to November from the current July to September. Expanding the transfer window could lead to increased pumping at Jones and Banks Pumping Plants, when capacity is available. The Figures below show when capacity is available under the proposed action and the COS, in terms of exceedances, years in the model period of record, and average by water year types. These values are total available, and are not filtered for the pattern on which water might be acquired for transfer. The pattern of acquisition could decrease these values, as well as reoperation of storage that might be required, or the water cost of meeting D-1641. Prior estimates indicate that approximately 50% of the capacity in the figures below would be useful for water transfers given these timing and upstream considerations. In addition, a 20-30% surcharge on acquisition might be necessary to accommodate the salinity related inefficiencies that arise in operations. Based on the figures below and these additional estimates,

expanding the water transfer window could result in an additional approximately 50 TAF of pumping in most yeartypes. As more stored water is available from CVP and SWP reservoirs to pump in wetter yeartypes, most of the available capacity for transfers is in drier yeartypes (Figures 5.8-47 through 5.8-49).

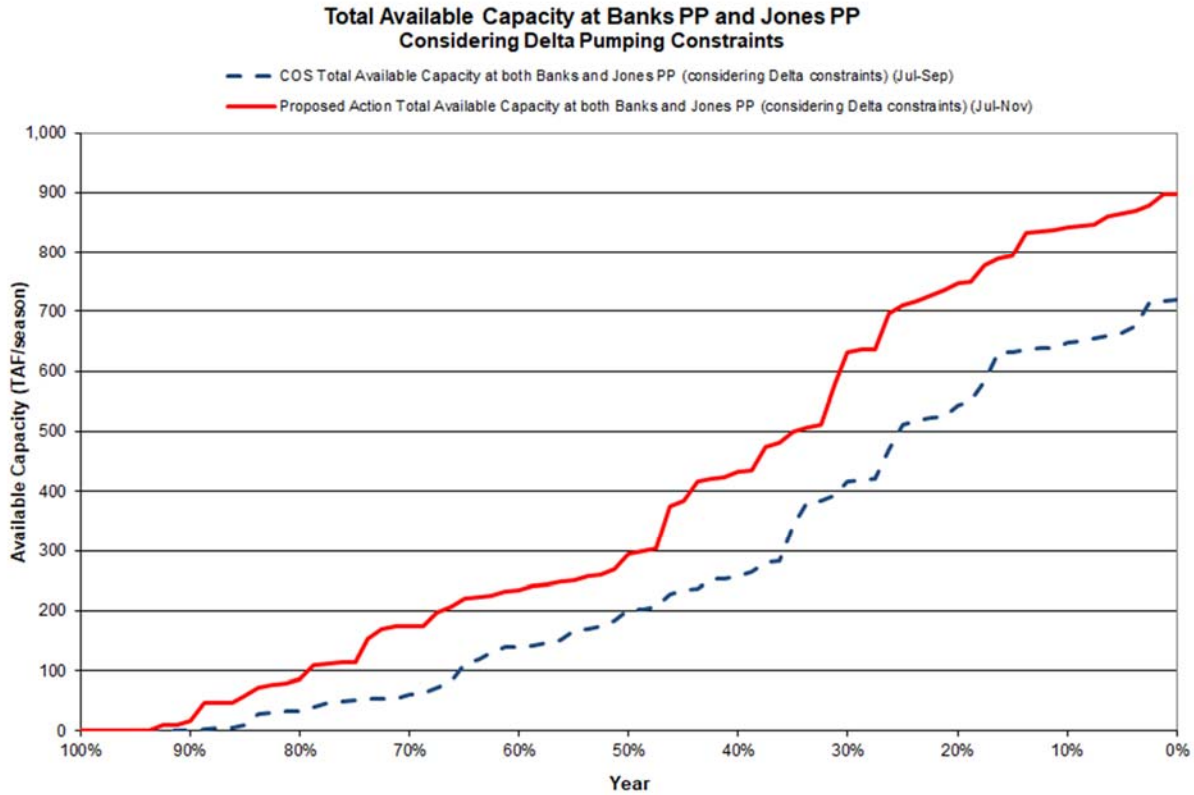


Figure 5.8-47. Exceedance of Available Capacity for Transfers at Jones and Banks under the Proposed Action and COS

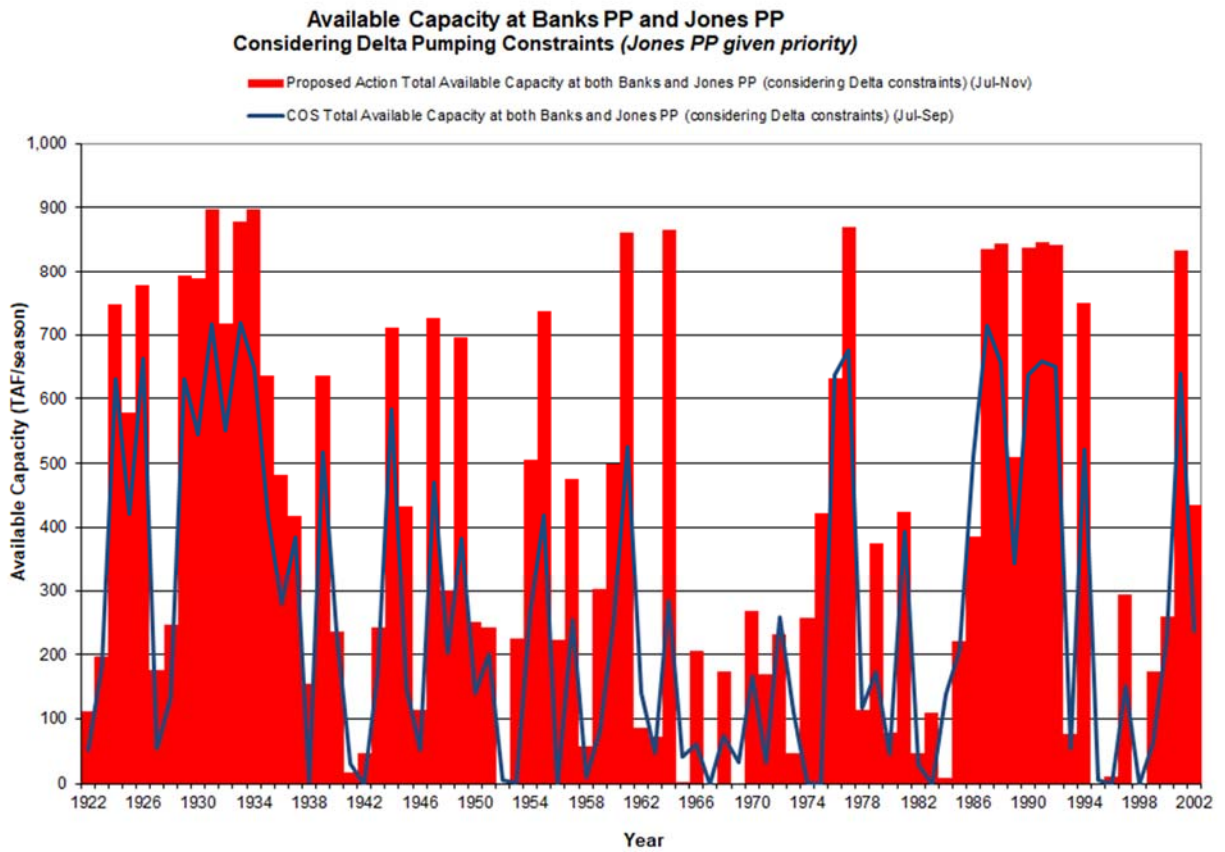


Figure 5.8-48. Modeled annual maximum available capacity for transfers under the proposed action and COS, CalSim period of record (1922-2003)

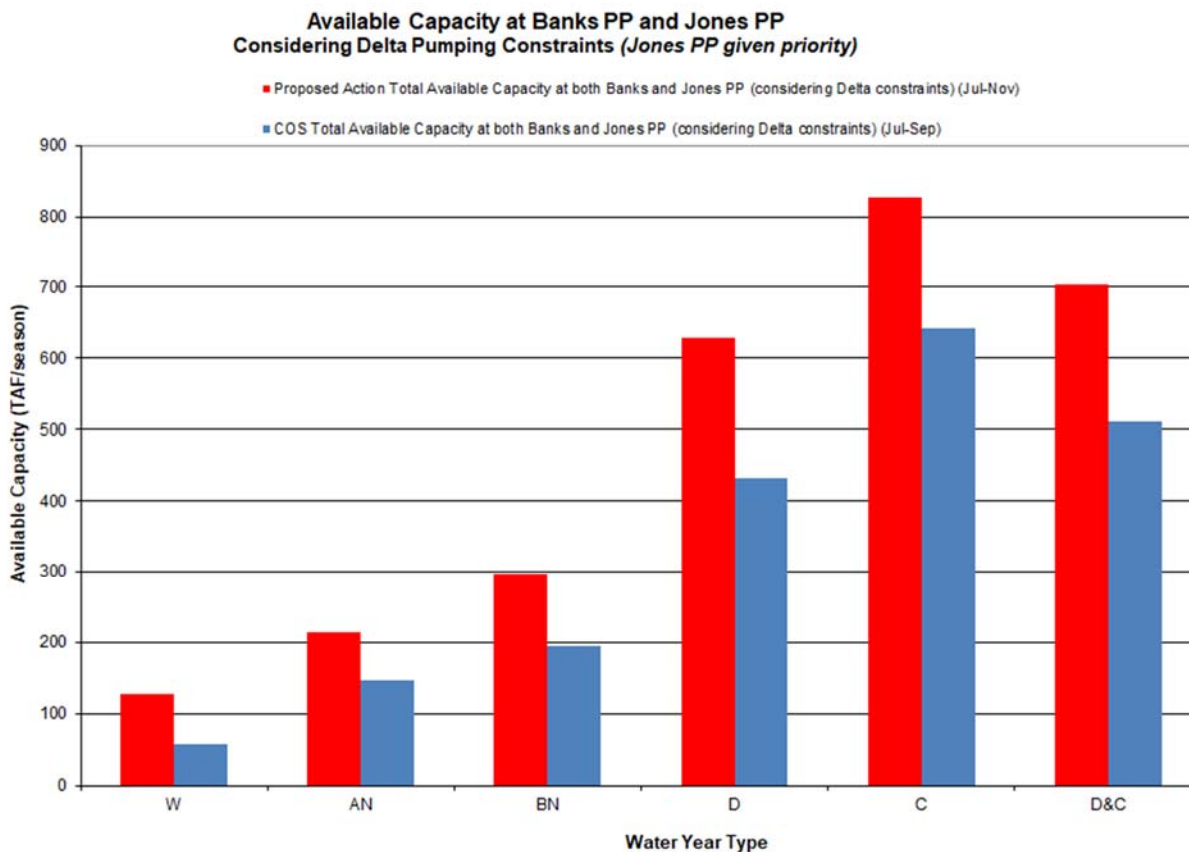


Figure 5.8-49. Water Year Type average available capacity at Jones and Banks Pumping Plants

Egg, aelvin, fry, and adult lifestages of Spring-run Chinook Salmon would not be exposed to the effects of increased water transfers as they do not occur in the Delta during July through November. Juvenile CCV steelhead are detected at Chipps Island between December and July with the highest abundance in March-May (Table 5.8-1). Thus, only the very early or late migrants could potential be exposed to water transfers that occur during this time. These early or late migrant uvenile Spring-run Chinook Salmon could be exposed to increased effects of entrainment, routing, and decreased Delta survival (see OMR management section) as a result of the expanded water transfer window. Increased flows during conveyance in the Sacramento River could provide small survival benefits to migrating juveniles (Perry et al. 2018).

5.8.3.15 Clifton Court Forebay Aquatic Weed Control Program

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program. Juvenile Spring-run are present in the Delta between mid-November and early June with a peak in April (Table 5.6-1). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the probability of exposing Spring-run Chinook Salmon to the herbicide is very low. 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, generally exceeding 70°F by mid-June.

Mechanical harvesting would occur on an as-needed basis and, therefore, listed salmonids could be exposed to this action, if entrained into Clifton Court Forebay. Potential direct and indirect effects to listed fish species from mechanical weed harvesters include mortality or injury from harvester strikes, entanglement in weeds lifted from the water, reduction of aquatic prey species, and temporary disturbances. Increased boat noise and disturbance of the water during harvesting, the slow speed of the harvester (approximately 2 miles per hour), and beginning harvesting closest to the edge should allow fish to escape the area proposed for mowing. However, CV Spring-run Chinook Salmon are unlikely to be present and exposed to the adverse effects due to extreme temperatures.

5.8.3.16 Suisun Marsh Operations

5.8.3.16.1 Rearing to Outmigrating Juveniles in Bay-Delta

5.8.3.16.1.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May to meet salinity standards set by the State Water Resources Control Board and Suisun Marsh Preservation Agreement provides water quality benefits to Spring-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile Spring-run Chinook Salmon (Table 5.8-1). Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. No data are available to estimate the abundance of juvenile Spring-run Chinook Salmon in Montezuma Slough thus, the proportion of the total run utilizing this route is unknown. Spring-run Chinook Salmon typically migrate through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. Spring-run 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 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. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.8.3.16.1.2 Roaring River Distribution System

As described by NMFS (2009: 437-438), the Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.7 ft/s, so that juvenile Spring-run Chinook Salmon would be excluded from entrainment.

5.8.3.16.1.3 Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) diverts water from Goodyear Slough through three 48-inch diameter culverts during high tide. Although the MIDS intakes do not currently have fish screens, it is unlikely juvenile CV Spring-run Chinook Salmon will be entrained into the water distribution system, since Spring-run Chinook have not been caught in past surveys. Also, the large size and better swimming ability of juvenile listed salmonids in the Delta allow these fish to avoid entrainment at MIDS. In addition, the location of the MIDS intake on Goodyear Slough further reduces the risk of entrainment. Goodyear Slough is not a migratory corridor for Spring-run Chinook Salmon.

5.8.3.16.1.4 Goodyear Slough Outfall

Goodyear Slough Outfall improves water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough. Due to its location and design, Spring-run Chinook Salmon are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall likely benefits juvenile Spring-run Chinook Salmon in Suisun Marsh by improving water quality and increasing foraging opportunities.

5.8.3.17 OMR Management

Delta seasonal operations above describe entrainment in more detail. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. Figure 5.8-50 shows historical salvage under the COS. Salvage under the proposed action is anticipated to be similar or less.

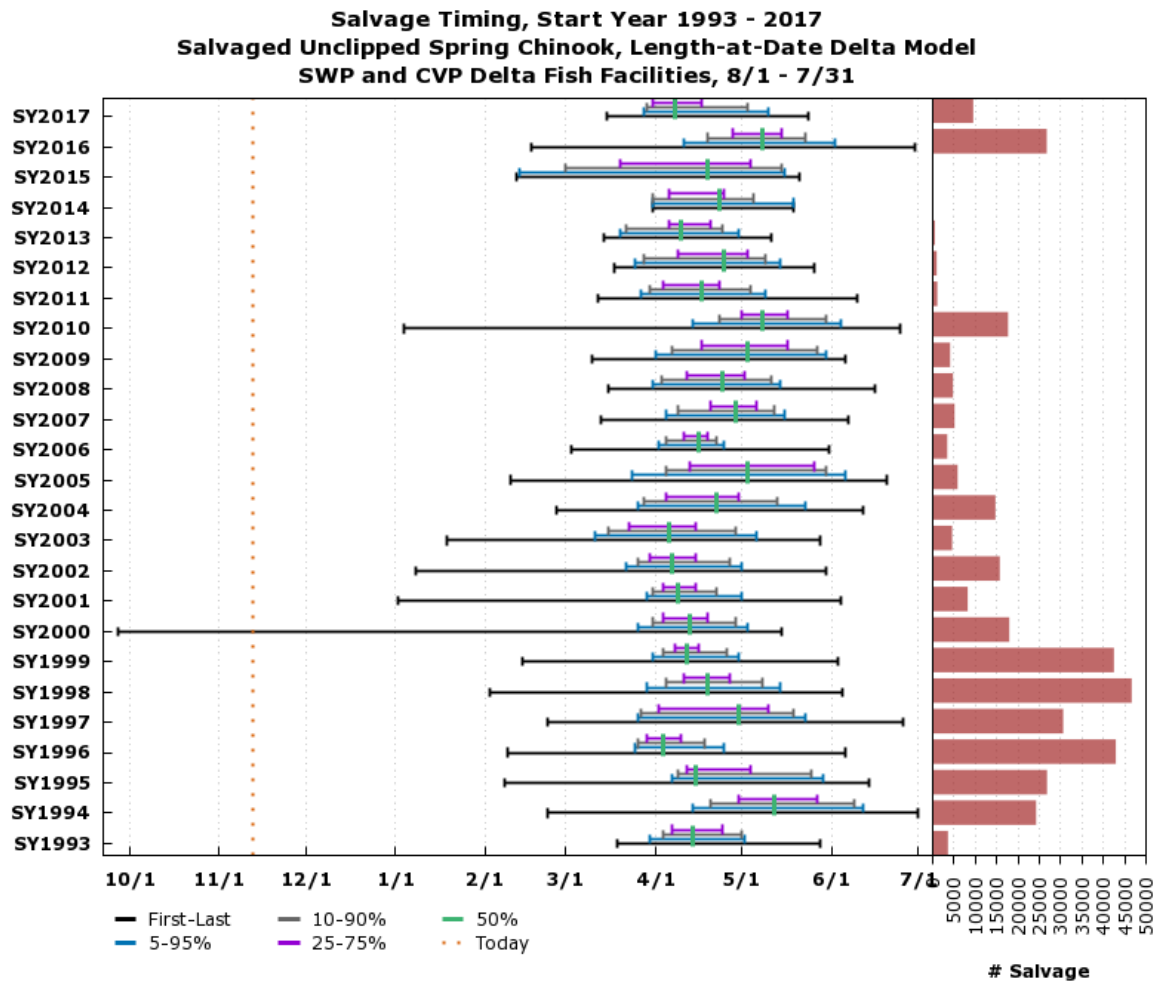


Figure 5.8-50. Salvage of Spring-run Chinook Salmon from 2009 - 2018.

5.8.3.18 Operation of a Shasta Dam Raise

Under the proposed action, Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report. Shasta Dam raise is anticipated to increase the cold water pool in Shasta Reservoir, to the benefit of salmonids holding or spawning downstream in the summer and fall. As shown in the Winter-run Chinook salmon section, the operation of the Shasta Dam raise would result in similar flow releases to the proposed action without the Shasta Dam raise. The operation of a Shasta Dam raise would be anticipated to increase flows in September and November and decrease flows in December to May, as compared to the proposed action without Shasta Dam raise.

The effect of a raised Shasta Dam operating for CVP only on the proposed action may be uncertain, however all scenarios provide the same or greater flows compared to the WOA between June-November (Figure 5.6-40), an important period for Spring-run Chinook Salmon adult holding, as well as spawning and egg incubation. Average monthly flows are similar between June-August under the proposed action with and without a raised Shasta Dam.

Flows are increased from October to November and therefore do not present a risk of redd de-watering or reductions in rearing habitat compared to the proposed action without a raised Shasta Dam.

5.8.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis looks at not only at the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under WOA.

5.8.4.1 Battle Creek Restoration

Under the Proposed Action, Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. NMFS and USFWS Biological Opinions were issued in 2005 on this project, and that consultation discusses effects of Battle Creek restoration.

5.8.4.2 Lowering Intakes at Wilkins Slough

5.8.4.2.1 Egg to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Spring-run Chinook Salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows would directly benefit fish of all life stages, as the lower fall flows would improve cold water pool for the subsequent summer, and allow greater flexibility for spring pulse flows in the next year. Specifically, operation of diversions with fish screens near Wilkins Slough would improve subsequent water temperatures and increase dissolved oxygen, and decrease entrainment risk.

The egg and fry lifestage of Spring-run Chinook Salmon, as well as the population, would benefit from this action.

Egg and fry of Spring-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Spring-run Chinook Salmon spawning from mid- to late-August through early October. Spring-run Chinook Salmon spawn in gravel beds that are often located at the tails of holding pools (OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, effects of construction on Spring-run Chinook Salmon eggs and fry are not anticipated.

5.8.4.2.2 Rearing to Outmigrating Juveniles in Rivers

The installation of fish screens near Wilkins Slough would be beneficial to rearing and emigrating Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Outmigrating juvenile Spring-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough under the proposed action, based spring-run juveniles emigrating from November through May with peak emigration occurring from May through (Table 5.8-1). Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 to October 1), avoiding the emigration period; therefore effects of construction on emigrating spring-run is not expected.

Juvenile spring-run rear in natal tributaries, the Sacramento River mainstem, nonnatal tributaries to the Sacramento River, and the Delta (DFG 1998 *as cited in* OCAP BA) and emigration timing is highly variable (OCAP BA 2008). If rearing Spring-run Chinook Salmon are present in Wilkins Slough during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition the noise associated with construction of the cofferdam may temporarily affect juvenile Spring-run Chinook Salmon. Additionally, fish rescue operations may need be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in the Appendix E, *Avoidance and Minimization Measures* would further minimize any effects to rearing and emigrating Spring-run Chinook Salmon.

5.8.4.2.3 Rearing and Outmigrating Juveniles in the Bay-Delta

Rearing and outmigrating juvenile Spring-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and fish screens near Wilkins Slough, based spring-run juveniles emigrating from November through May with peak emigration occurring from March through April (Table 5.8-1). Juvenile fall-run salmon may rear for up to several months within the Delta before ocean entry (Kjelson et al. 1982 *as cited in* OCAP BA). Rearing within the Delta occurs principally in tidal freshwater habitats. Wilkins Slough is located outside of the Bay-Delta; therefore, rearing and outmigrating juveniles located in the Bay-Delta would not be affected by construction activities occurring during the inwater construction window from June 1 through October 1.

5.8.4.2.4 Adult Migration

The installation of fish screens near Wilkins Slough would be beneficial to immigrating Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Adult Sacramento River spring-run Chinook begin to leave the ocean for their upstream migration in late January to early February based on time of entry to natal tributaries (DFG 1998 *as cited in* OCAP BA 2008). Immigrating Spring-run Chinook Salmon are not expected to be affected by the construction of a new diversion and screens near Wilkins Slough, based spring-run adults immigrating into the Sacramento River Basin between March through June, with a peak from May through June (Table 5.8-1). The implementation of an in-water work window (June 1 and October 1) and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize effects on immigrating Spring-run Chinook Salmon.

5.8.4.2.5 Adult Holding

The installation of fish screens near Wilkins Slough would be beneficial to holding Spring-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Spring-run adults may hold in their natal tributaries for up to several months before spawning (DFG 1998 *as cited in* OCAP BA 2008). Pools in the holding areas need to be sufficiently deep, cool (about 64 F or less), and oxygenated to allow over-summer survival. Suitable holding habitat in Wilkins Slough is not present; therefore, holding Spring-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough. Implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further reduced the likelihood of effects on individuals, and populations.

5.8.4.3 Shasta TCD Improvements

5.8.4.3.1 Egg to Fry Emergence

The ability of the proposed action to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable spawning, incubating and rearing temperatures throughout the season in all but the driest years. Therefore, the improved flow management and temperature regime associated with the Shasta TCD improvements is expected to have high-level population benefits on this life stage of Spring-run Chinook Salmon relative to the WOA and the COS.

5.8.4.3.2 Rearing to Outmigrating Juveniles

There is little difference in water temperatures between the COS and proposed action scenarios during the period of spring-run rearing in the upper Sacramento River, with differences in November the greatest, but less than one degree Fahrenheit difference.

Water temperatures during most years in the November through April period are suitable for juvenile spring-run that rear in and emigrate from the middle Sacramento River under the WOA and the COS and proposed action scenarios, so no adverse effects on the spring-run juveniles are expected for these months. Under all three scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances than the COS and proposed action scenarios, especially in warmer years (Figure SRT_L3_CDmay). These results indicate that water temperature conditions would too warm for juvenile spring-run rearing and emigrating in the middle Sacramento River during May under Without Action conditions, Current Operations, and the Proposed Action, and that conditions would be worse under the Without Action conditions than under the other two scenarios.

5.8.4.3.3 Migrating Adults

High May water temperatures in the middle River are expected for many years under the WOA, and the proposed action improves these temperatures compared to the WOA. As temperatures are still high under the proposed action, Shasta TCD improvements could provide benefits to Reclamation’s ability to meet Sacramento River temperature targets and benefit adult spring-run.

5.8.4.3.4 Holding Adults

The improved flow and temperature management associated with the Shasta TCD improvements is expected to have benefits for holding adult Spring-run Chinook Salmon.

5.8.4.4 Sacramento River Spawning and Rearing Habitat

Spring-run Chinook Salmon juveniles in the Sacramento River would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the Sacramento River improving their likelihood of rearing success due to an increase in total rearing habitat area and rearing habitat quality. Reclamation estimates that this additional 50 acres of rearing habitat could support the progeny of 5,600 returning adult salmonids based on the relationship shown in the plot below.

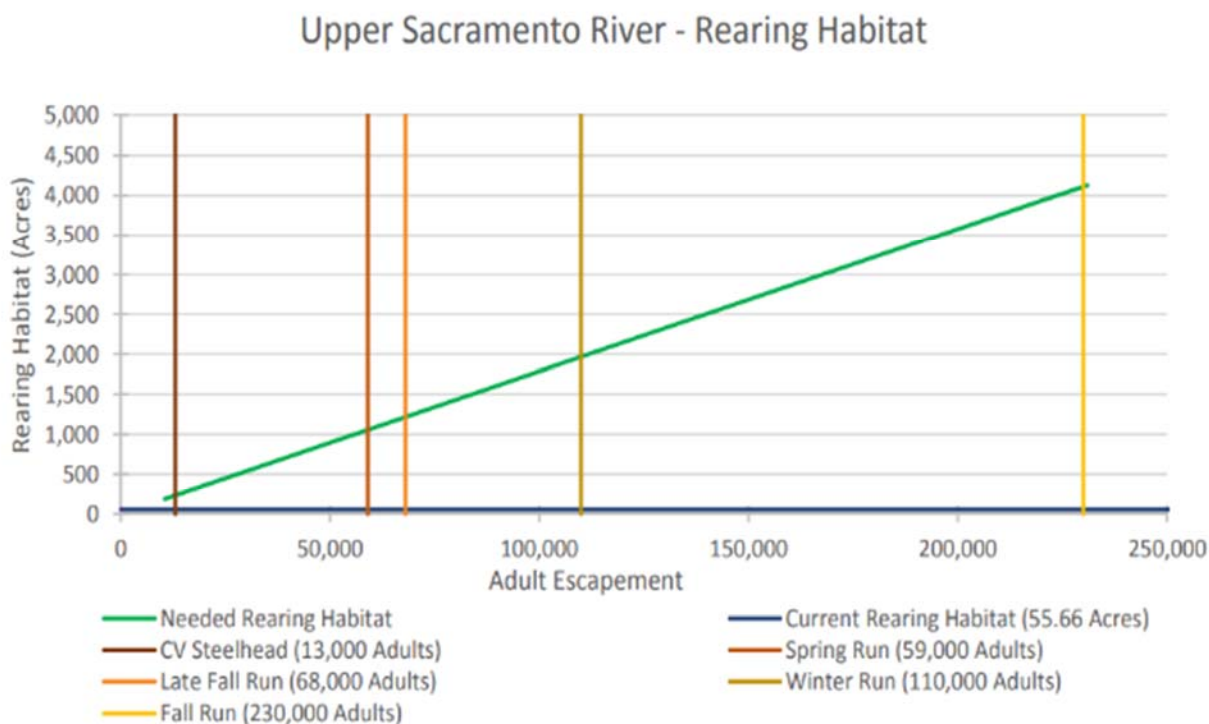


Figure 5.8-51. Adult Escapement and Rearing Habitat on the Upper Sacramento River

Few, if any, rearing and outmigrating juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and peak seasonal occurrence of this life stage in the Sacramento River (November-May; Table 5.8-1). Construction activities in the Sacramento River could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of

gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. Juveniles could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

However, exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. There is no overlap of the peak seasonal occurrence of this life stage and the in-water work window. Therefore this action is not anticipated to have negative effects on rearing and outmigrating juvenile Central Valley Spring-run Chinook Salmon.

5.8.4.5 *Small Screen Program*

A small proportion of the Spring-run Chinook Salmon population would benefit from the Small Screen Program under the proposed action. There may be moderate overlap of the Spring-run Chinook Salmon migration with the main late spring-fall irrigation period for small diversions, and small diversion screening could reduce entrainment of late migrating individuals.

5.8.4.5.1 Egg to Fry Emergence

No egg or fry Spring-run Chinook Salmon would be exposed to fish screens since they remain in the gravel in the rivers. Therefore, there would be no effects from fish screen construction on this life stage.

5.8.4.5.2 Rearing to Outmigrating Juveniles

The operation of fish screens on water diversions under the proposed action would benefit juvenile Spring-run Chinook Salmon by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized under the proposed action since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage.

Juvenile Spring-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes since they will likely be present during the timing of in-water construction (July 15 – October 15). However, the work area for these projects is small, limiting exposure to construction. Spring-run Chinook Salmon exhibit a stream-type life history where juveniles typically spend a year or more in freshwater before emigrating (NMFS 2009). Thus, juveniles may be present in the Sacramento River year-round since they reside in freshwater for 12 to 16 months (Table 5.8-1), but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). Potential short-term adverse effects may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience

increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.8.4.5.3 Rearing to Outmigrating Juveniles in the Delta

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Few if any juvenile Spring-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes. Juvenile Sacramento River Spring-run Chinook Salmon primarily from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.8.4.5.4 Adult Migration

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Adult Spring-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (July 15 – October 15) and the mid-February to October seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). Effects are the same as for juveniles above, and would be minimized through AMMs.

5.8.4.5.5 Adult Holding

Operational benefits of screened diversions are the same as for juveniles in rivers above.

Adult Spring-run Chinook Salmon holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (July 15 – October 15), the mid-February to October seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). However, few fish will potentially be exposed to construction activities due to the localized work areas of these projects and their tendency to remain in deep cold pools in proximity to spawning areas until they are sexually mature and ready to spawn (CDFG 1998; NMFS 2009). Effects are the same as for juveniles above, and would be minimized through AMMs.

5.8.4.6 Adult Rescue

Adult rescue would primarily affect adult Spring-run Chinook Salmon. The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Spring-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the abundance of Spring-run Chinook Salmon of all life stages in the Sacramento River and its tributaries.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Spring-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Spring-run

Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Spring-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 Fish Rescue and Salvage Plan (Appendix E, *Avoidance and Minimization Measures*). As such, it is concluded that the overall population-level negative effects on this life stage of Spring-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of stranded adult Spring-run Chinook Salmon in Yolo and Sutter bypasses).

Juvenile Spring-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, ongoing modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Spring-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Spring-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Spring-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Spring-run Chinook Salmon returning to spawning grounds. As such, it is concluded that the overall population-level negative effects on this life stage of Spring-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of adult Spring-run Chinook Salmon).

Given that this life stage is carried out in the upper Sacramento River and its tributaries and adult rescue activities would occur downstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Spring-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the abundance of Spring-run Chinook Salmon adults holding in the upper Sacramento River and its tributaries.

5.8.4.7 Juvenile Trap and Haul

Juvenile trap and haul would only affect juvenile Spring-run Chinook Salmon. The operation of the juvenile trap and haul is targeted towards juvenile Chinook Salmon, with the goal of increasing the

survival of juveniles and, ultimately, returning adults; therefore, this effort could increase the number of Spring-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries.

The number of juvenile Spring-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.8-1). Individual juvenile Spring-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Spring-run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Spring-run Chinook Salmon. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile Spring-run Chinook Salmon from juvenile trap and haul activities would be low relative to the without action (no trapping and hauling of juvenile Spring-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with unsuitable holding habitat would not be expected to survive or spawn successfully because of the lack of suitable adult holding and/or spawning habitat.

Because juvenile trap and haul would target only wild juveniles during outmigration, adult Spring-run Chinook Salmon holding in rivers would not be directly affected by juvenile trap and haul activities. However, because the purpose of juvenile trap and haul activities is to increase the survival rate of juveniles during drought years, the number of adults holding in rivers potentially would be greater relative to the without action (no trapping and hauling of juvenile Spring-run Chinook Salmon during drought years), as a result of increased juvenile survival and, ultimately, increased adult escapement.

5.8.4.8 Clear Creek Restoration Program

Reclamation proposes to enhance Chinook salmon spawning and rearing habitat within Clear Creek. This action includes placement of large woody debris and gravel augmentation.

This action is expected to enhance habitat complexity, benefiting salmonids that use Clear Creek and improving the habitat conservation value. The benefits from implementation of restoration projects include (1) complex channels and floodplain habitats, and (2) spawning habitat. In some years, over one hundred Spring-run Chinook Salmon have been observed in Clear Creek, so the restoration is anticipated to have beneficial effects to Spring-run Chinook Salmon spawning and rearing habitat over WOA, where no restoration would occur.

Construction-related effects include increased sedimentation and turbidity. As side channel creation and flood plain enhancement projects are implemented as a part of the restoration, construction-related activities have the potential to result in injury or death to listed fish species. Construction-related effects

may include debris falling into the active channel, tools and/or equipment falling into the active channel or noise generated by displaced rock and sediment and the operation of construction machinery.

5.8.4.9 American River Spawning and Rearing Habitat

Spring-run Chinook Salmon juveniles in the American River would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River improving their likelihood of rearing success due to an increase in total rearing habitat area and rearing habitat quality.

Few, if any, rearing and outmigrating juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and peak seasonal occurrence of this life stage in the American River (November-May; Table 5.8-1). Construction activities in the American River could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

However, exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. There is no overlap of the peak seasonal occurrence of this life stage and the in-water work window. Therefore this action is not anticipated to have negative effects on rearing and outmigrating juvenile Central Valley Spring-run Chinook Salmon.

5.8.4.10 American River Drought Temperature Facility Improvements

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Juvenile CV Spring-run Chinook Salmon may be present in the lower American River year-round since they reside in freshwater for 12 to 16 months (Table 5.8-1), but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). Excessively high water temperatures have been identified as one of the factors threatening CV Spring-run Chinook Salmon in the Central Valley and a factor for listing of the species. Juveniles may reside in freshwater for 12 to 16 months, but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage temperatures in the lower American River and improve conditions for this life stage. Therefore, this proposed action may beneficially affect juvenile CV Spring-run Chinook Salmon in the American River by reducing the effects of drought conditions on water temperatures.

5.8.4.11 Stanislaus River Spawning and Rearing Habitat

5.8.4.11.1 Egg to Fry Emergence

Spring running Chinook salmon have the potential to be affected by construction activities associated with the restoration activities in the Stanislaus River. However, benefits from increased habitat complexity due to restoration is expected to offset short-term construction impacts. However, through coordination with the regulatory agencies and implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, effects to the egg to fry emergence life stage of early spawning Chinook salmon would be avoided by construction activities. Through snorkel surveys, Chinook fry were observed in December 2003 in the Stanislaus River (NMFS 2014), which is outside of the July 15 through October 15 in-water work window, although the eggs may have been spawned within the timing window.

5.8.4.11.2 Rearing to Outmigrating Juveniles in Rivers

The creation of side channel and rearing habitat would increase the quality and quantity of off channel rearing (and spawning areas). The habitat restoration activities would improve the riparian habitat available for juvenile Spring-run Chinook Salmon rearing. The benefit of the habitat restoration activities within the Stanislaus River would yield immediate benefits. Existing riparian vegetation would be increased with the creation of side-channel habitat, providing:

- instream object and overhanging object cover;
- new shaded riverine habitat; and
- additional area for food source.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. The habitat restoration would result in increased survival of juvenile spring-running Chinook Salmon in the Stanislaus River.

Reclamation will implement an in-water work window from July 15 through October 15. This is outside of the juvenile outmigration period and juveniles would not be expected to be in the river, therefore there would be no effect of spawning and rearing habitat construction on juvenile spring-running Chinook salmon.

5.8.4.11.3 Adult Migration from Ocean to Rivers

Construction activities associated with the restoration activities in the Stanislaus River may potentially affect immigrating Spring-run Chinook Salmon. However, through implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, immigrating spring-running Chinook Salmon would not be affected by construction activities.

5.8.4.11.4 Adult Holding in Rivers

Additional spawning and rearing habitat is unlikely to benefit Spring-run adults holding in the Stanislaus River as adult holding habitat is generally in the main channel rather than side channels and floodplains.

Construction activities associated with the restoration activities in the Stanislaus River are unlikely to affect adult holding spring-running Chinook salmon in the Stanislaus River. Through implementation of avoidance and minimization measures, including the implementation of an in-water work window from

July 15 through October 15, holding spring-running Chinook Salmon would not be affected by construction activities.

5.8.4.12 Lower San Joaquin River Rearing Habitat

Lower San Joaquin Rearing Habitat restoration is expected to result in similar effects as those described above for Stanislaus River Spawning and Rearing Habitat.

5.8.4.13 Suisun Marsh Salinity Control Gates Operation

No Spring-run Chinook Salmon are detected in the Delta between June and September. Therefore, no effects would occur as a result of the Suisun Marsh Salinity Control Gate operation.

5.8.4.14 Fall Delta Smelt Habitat

No Spring-run Chinook Salmon are detected in the Delta between June and September. Therefore, no effects would occur as a result of the Suisun Marsh Salinity Control Gate operation.

5.8.4.15 Clifton Court Predator Management

Predator control efforts at Clifton Court Forebay under the proposed action could reduce pre-screen loss of juvenile Spring-run Chinook Salmon entrained into Clifton Court Forebay. Spring-run Chinook Salmon are unlikely to be in the area during predator control efforts during the summer in-water work window.

5.8.4.16 Sacramento Deepwater Ship Channel

This action would hydrologically connect the Sacramento River with the Sacramento Deepwater Ship Channel (SDWSC) via the Stone Lock facility from mid-spring to late fall. Juvenile Spring-run Chinook Salmon abundance in the Delta is moderate in March and peaks in April (Table 5.8-1). Juvenile Spring-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be enter into the SDWSC. There are potential benefits to Spring-run Chinook Salmon from this action. Fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar. However, estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. Also, there is potential for decreased migration time to the ocean and exposure to larger food sources of Liberty Island, but this is currently uncertain.

5.8.4.17 North Delta Food Subsidies / Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.8.4.18 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have

limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.8.4.19 Tidal Habitat Restoration

A large proportion of juvenile Spring-run Chinook Salmon are expected to benefit from continuing to construct the 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Benefits include increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta.

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.8-1). There may be some exposure of yearling migrants that enter the Delta in the fall. Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes the following: 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. Many of these are elements highlighted in the SAIL conceptual model (Figure 5.6-4). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.8.4.20 Predator Hot Spot Removal

Predator hot spot removal under the Proposed Action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Spring-run Chinook Salmon. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Spring-run Chinook. All 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. 2017, Sabal et al. 2017).

5.8.4.21 Delta Cross Channel Improvements

Greater operational flexibility and increased gate reliability resulting from improvements to the Delta Cross Channel under the proposed action would reduce the risk of gate failure that could result in higher rates of entrainment of Spring-run Chinook Salmon, if left open. Few Spring-run Chinook Salmon are expected to be exposed to in-water construction related improvements to the Delta Cross Channel due to observance of species protective work windows. Seasonal closure periods would still be in place to protect Spring-run Chinook Salmon. The DCC is an older structure which requires manual operation and increased use could result in locks braking in either open or closed positions. Migrating Spring-run Chinook Salmon would benefit from faster operations that prevent straying into the central Delta and catastrophic failure of the facility. However, improved biological and physical monitoring associated with improvements would likely minimize potentially increased entrainment.

5.8.4.22 Tracy Fish Facility Improvements

A number of programmatic actions are proposed to improve salvage efficiency of TFCF, including installing a carbon dioxide injection device to allow remote controlled anesthetization of predators in the secondary channels of the Tracy Fish Facility. These actions could potentially benefit juvenile Spring-run Chinook Salmon through greater salvage efficiency.

Few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to construction of the CO₂ injection device proposed for the Tracy Fish Facility Improvements, based on lack of observed salvage during the August–October in-water work window (see figures in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS: WR_salvage_unclipped_date, WR_salvage_clipped_date, and WR_salvage_clipped_CWT_race*). Risks to these few individuals would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*), the selected in-water work window, and the small scale of the in-water construction. For juvenile Spring-run Chinook Salmon that arrive at the facility, the proposed improvements are likely to increase survival through the facility.

5.8.4.23 Skinner Fish Facility Improvements

Predator control efforts at Skinner Fish Facility under the Proposed Action to reduce predation on listed fishes following entrainment into Clifton Court Forebay could reduce pre-screen loss of juvenile Spring-run Chinook Salmon entrained into Clifton Court Forebay. Spring-run Chinook Salmon are unlikely to be in the area during predator control efforts.

5.8.4.24 Delta Fishes Conservation Hatchery

As with the other proposed construction activities in the Bay-Delta, few if any juvenile Spring-run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of juvenile Spring-run Chinook Salmon in the Delta (Table 5.8-1). There may be some exposure of yearling migrants to in-water and shoreline construction of the hatchery intake and outfall, as illustrated by timing of occurrence in Sacramento seines and trawls (Figures WR_Seines and WR_Sherwood in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). The relatively few 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 AMMs (Appendix E, *Avoidance and Minimization Measures*). Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. 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 Spring-run Chinook Salmon would be restricted to a small spatial area within the primary migration route.

5.8.4.25 Effects of Monitoring

Less than 2% of the estimated Spring-run Chinook Salmon population, as indexed by the Red Bluff Rotary Screw Trap data, is collectively captured by the salmonid monitoring programs that support CVP operations (Table 5.8-5). Because such a small percentage of the estimated Spring-run Chinook Salmon juvenile production is captured in the monitoring programs, the effects of the monitoring programs are not likely to have effects to the Spring-run population.

Table 5.8-5. Monitoring Programs – Spring-run Chinook Salmon

| Species | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|
| Chipps Island Trawl | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 1229 | 3948 | 889 | 1880 | 2085 | 788 | 163 | 429 | 758 | 593 | 761 | 601 | 1311 | 1108 | 681 | 3882 | 1230 | |
| Sacramento Trawl | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 197 | 1008 | 289 | 558 | 532 | 168 | 67 | 224 | 203 | 316 | 269 | 400 | 774 | 46 | 215 | 2734 | 152 | |
| DJFMP Beach Seine Survey | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 429 | 1238 | 780 | 579 | 766 | 127 | 72 | 60 | 442 | 923 | 463 | 317 | 409 | 352 | 203 | 187 | 208 | 4 |
| CDFW Mossdale Trawl | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 419 | 749 | 320 | 965 | 1042 | 843 | 480 | 385 | 159 | 1271 | 1149 | 644 | 296 | 70 | 124 | 1223 | 529 | |
| EDSM KDTR Trawls | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | na | na | na | na | na | na | na | na | na | na | na | na | na | na | 2 | 51 | na | |
| CDFW Bay Study Trawls | | | | | | | | | | | | | | | | | | |
| Chinook Salmon | 273 | 117 | 327 | 115 | 143 | 115 | 17 | 130 | 157 | 215 | 74 | 134 | 71 | 65 | 62 | 236 | na | |
| CDFW SKT Study | | | | | | | | | | | | | | | | | | |
| Chinook Salmon | 35 | 1624 | 1364 | 348 | 822 | 896 | 603 | 187 | 300 | 244 | 219 | 492 | 632 | 432 | 347 | 565 | 124 | |
| Totals | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 2274 | 6943 | 2278 | 3982 | 4425 | 1926 | 782 | 1098 | 1562 | 3103 | 2642 | 1962 | 2790 | 1576 | 1223 | 8026 | 2119 | |
| RBDD Rotary Trap or Juvenile Production Estimate (JPE) | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon RPE | 277477 | 626915 | 430951 | 615547 | 421436 | 369501 | 164673 | 438405 | 158966 | 184290 | 320897 | | | | | | | |
| Percent of Total | | | | | | | | | | | | | | | | | | |
| Spring-run Chinook Salmon | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02 | 0.01 | | | | | | | |

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5.9 Chinook Salmon, Central Valley Spring-run ESU Critical Habitat

Critical habitat designated for Spring-run Chinook Salmon and potentially affected by the proposed action includes the Feather and Sacramento Rivers, and Clear creek, the as well as portions of the northern Delta. The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are water quantity, floodplain connectivity, water quality, forage, and riparian cover.

5.9.1 Effects of Operations

5.9.1.1 PBF1 – Freshwater Spawning Habitat

The proposed action includes adaptive management actions to improve spawning habitat for Chinook salmon in the upper Sacramento River, and would likely benefit Spring-run Chinook Salmon spawning habitat. Spawning habitat is also affected by changes in flow and water temperature. As indicated in *Eggs to Fry Emergence*, there would be few major differences between the proposed action and cos in flow and no meaningful difference in water temperature in the spawning portion of Spring-run Chinook Salmon critical habitat during the August through January spawning and egg/alevin incubation period. However, differences between the proposed action and the WOA would be large during the first half of the spawning period, August through October. As described in *Eggs to Fry Emergence* Section, effects of these flow differences are uncertain, with some PBFs of habitat benefited and some negatively affected by the higher flows. Flow is much greater under the proposed action than the WOA during August through October, which is expected to substantially benefit most Spring-run Chinook Salmon spawning habitat PBFs. Proposed action and WOA flows are generally similar during November through January. August through October water temperature under the proposed action is much lower than WOA temperature in almost every year. The proposed action water temperature below Keswick Dam during August and September generally ranges from 10 to 18 degrees Fahrenheit lower than the corresponding WOA temperature, and the proposed action temperature is below critical thresholds for incubating eggs and alevins in most years, while the WOA temperature greatly exceeds these thresholds in every year. From November through January, water temperatures are below critical thresholds for incubating eggs and alevins in every year under both the proposed action and WOA scenarios, although the December and January in the coldest years are potentially low enough to retard egg and alevin development. These results indicate that the proposed action scenario would benefit spawning habitat of Spring-run Chinook Salmon in the Sacramento River.

5.9.1.2 PBF2 - Freshwater Rearing Habitat

As described in *Rearing to Outmigrating Juveniles in the Upper and Middle Sacramento River Section*, there would be few differences between the proposed project and COS in flow in rearing habitat of Spring-run Chinook Salmon and no meaningful difference in water temperature in the upper and middle Sacramento River during the November through May rearing period.

Differences in flow and water temperature would be large between the proposed action and the WOA. Proposed action flow is lower than WOA flow during January through April in most years, especially dry years, but is higher than WOA flow during May of dry years. Proposed action water temperature is much higher than WOA temperature from November through February and is much lower in April and May. The reductions in flow under the proposed action, especially in drier years, would likely have adverse

effects on most attributes of spring-run rearing habitat in the Sacramento River. Potential adverse effects include reduced access to riparian and off-channel habitat, greater crowding and competition, and lower prey availability. The temperature differences between the proposed action and the WOA would likely not affect the rearing habitat quality. The temperatures under both the proposed action and WOA would be under critical thresholds for rearing juvenile Spring-run Chinook Salmon in almost all years. Although, the coldest water temperatures under the WOA scenario would potentially cause reduced growth of the juveniles.

5.9.1.3 PBF3 - Freshwater Migration Corridors

As described in *Rearing to Outmigrating Juveniles in the Upper and Middle Sacramento River*, and *Adult Migration from Ocean to Rivers Sections*, proposed action flows during winter and early spring (January through April) would be reduced relative to WOA conditions. Higher, more natural flows under the WOA scenario, including more frequent pulse flows, would have beneficial effects on PBFs of freshwater migratory habitat for juvenile Spring-run Chinook Salmon, including increased migration speeds, access to natural cover and low-velocity refuge habitat, and reduced exposure to predators. However, extremely low flows and higher temperatures under the WOA during May through August in dry and critically dry years would result in severe degradation of migratory habitat for adults. Although the proposed action would have negative effects on migratory habitat for juvenile spring-run in winter and early spring, maintaining 3,250 cfs or more throughout the year would avoid the extremely harsh conditions that would occur in dry and critically dry years under WOA conditions.

5.9.1.4 PBF4 - Estuarine Areas

The Bay/Delta estuarine critical habitat for Spring-run Chinook Salmon is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species (NMFS 2014a). Despite its poor condition, the estuarine habitat is of high value for the conservation of the species because it provides the only migratory corridor and area for transition to the ocean environment for juveniles, as well as adults returning to the Sacramento River. Consequently Bay/Delta food resources, water quality, refuge from predators, migratory cues, and other growth and survival factors are critically important. Potential effects of the proposed action compared to the WOA on the estuarine critical habitat of Spring-run Chinook Salmon includes changes in flow that affect hydrodynamics and routing of juvenile spring-run through Delta channels, habitat diversity, and water quality.

Routing through Delta Channels -Flow from the Sacramento, San Joaquin and other rivers tributary to the Delta, and well as tidal flows, affect the hydrodynamic of Delta channels and influence how juvenile spring-run move through the Delta. As described in the Spring-run chinook routing affects analysis, hydrodynamics and flow velocity effects of the proposed action compared to WOA indicate that routing into the interior Delta would be higher relative to the WOA. However, the differences are concerned discountable and would not substantially affect spring-run juveniles. As described in *Spring-run Chinook Salmon- Through Delta Survival section*, the overall effect of the proposed action on through-Delta survival of juvenile Spring-run Chinook Salmon resulting from differences in Delta channel flow velocities is low.

Adult Spring-run Chinook Salmon are present in the Bay/Delta from January through June, with a peak occurrence in January and February. The adults use olfactory cues to find their way through the Delta to the Sacramento River upstream of the Delta, so higher Sacramento River flow may reduce straying to other rivers (Marston et al. 2012; NMFS 2016 Submitted Ch5 EA Draft BA).

Flow in the Sacramento River at Rio Vista and Freeport during the peak period of adult migration through the Delta, January and February, is slightly lower under the PA and COS relative to the WOA (see Figure 32-11 in the CalSim II Flow section of Appendix D), but is more substantially reduced (\leq half) relative of the remaining months, March through June (e.g., Figure 32-11 in the CalSim II Flow section of Appendix D).

Habitat Diversity- Increased habitat diversity potentially enhances food resources, refuge habitat, flow velocity refuge, and other spring-run juvenile growth and mortality factors. Increased flow in the Bay/Delta likely increases habitat diversity. Higher flow results in greater inundation of marshlands surrounding the Delta, Suisun Bay and San Pablo Bay, which potentially improves: 1) foodweb productivity, 2) access of juvenile spring-run to more abundant and more diverse food resources, 3) refuge of the juveniles from predators, and 4) refuge for resting from high velocity flows. Higher flows may also enhance foodweb productivity by transporting nutrients and plankton from productive habitats, including croplands and the Sutter and Yolo bypasses (DWR and Reclamation 2107 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR).

During the March and April peak period of juvenile spring-run presence in the Delta, Sacramento River flow at Freeport and Rio Vista, as well as Delta outflow, are substantially lower under the PA and COS relative to the WOA (e.g. Figures 32-11 and 41-12 in the CalSim II Flow section of Appendix D). Flow is also lower under the proposed action in Yolo Bypass flow. Therefore, the proposed action is expected to adversely affect estuarine critical habitat relative to the WOA, with respect to habitat diversity and food resources.

5.9.2 Effects of Conservation Measures

The following analysis of designated critical habitat is programmatic, though adaptive management and future ESA consultation, these actions will be refined and any potential adverse effects will minimized or avoided. These actions are beneficial in nature and are expected to improve PBFs in the long-term.

5.9.2.1 Lower American River

Spawning Habitat -The PBFs under proposed action for spawning adult Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; a temporary increase in turbidity to the water quality is anticipated; and a temporary disturbance to substrate is anticipated. Side channel construction, gravel augmentation, and large wood installation may cause temporary adverse effects but could result long-term beneficial effects to PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Rearing Habitat- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the proposed action effects on them are water quantity, floodplain connectivity, water quality, forage, and natural cover. The PBFs under proposed action for rearing Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; a temporary disturbance to floodplain connectivity is anticipated; a temporary increase in turbidity to water quality, no effects to forage are anticipated; and increased natural cover. Restoration including side channel construction, gravel augmentation, and large wood installation is beneficial in nature and expected to improve any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Migration Corridors- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are passage obstructions, water quality, water quantity, and cover. The PBFs under proposed action for migrating Spring-run Chinook Salmon are as follows: no effects to passage obstructions are anticipated; a temporary increase in turbidity

to water quality; no effects to water quantity are anticipated; and a temporary disturbance to cover is anticipated. Side channel construction, gravel augmentation, and large wood installation is not anticipated to result in adverse impacts to any PBFs for Central Valley Spring-run Chinook Salmon critical habitat in the American River.

5.9.2.2 Clear Creek

Spawning Habitat -The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential project effects on them are water quantity and substrate. The PBFs under proposed action for spawning adult Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; and a temporary disturbance to substrate is anticipated. Gravel mobilization is anticipated to result in no negative impacts on any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Rearing Habitat- The PBFs under proposed action for rearing Spring-run Chinook Salmon are as follows: no effects to water quantity are anticipated; potential beneficial effects to floodplain connectivity; temporary increase in turbidity to water quality; no effects on forage are anticipated; and no effects on cover are anticipated. Gravel mobilization is not anticipated to result in impacts to any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

Freshwater Migration Corridors- The PBFs essential to the conservation of the Central Valley Spring-run Chinook Salmon ESU and the potential proposed action effects on them are passage obstructions, water quality, water quantity, and cover. The PBFs under proposed action for migrating Spring-run Chinook Salmon are as follows: no effects to passage obstructions are anticipated; a temporary increase in turbidity to water quality; no effects to water quantity are anticipated; and no effects to cover are anticipated. Gravel mobilization is not anticipated to result in adverse impacts on any PBFs for Central Valley Spring-run Chinook Salmon critical habitat.

5.10 Steelhead, California Central Valley DPS

The increased summer and fall flows of the proposed action compared to the WOA could have benefits for juvenile CV Steelhead rearing, which occurs year-round. However, the reduced spring flows of the proposed action compared to the WOA are likely to affect rearing and migrating CV Steelhead and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows. Operating the temperature control devices on Shasta and Folsom reservoirs has beneficial effects compared to WOA.

The proposed action incorporates information from the Salmonid Scoping Team and the 6-year Steelhead telemetry study to update protections for San Joaquin origin CV Steelhead. Updated science found no difference in survival from routing CV Steelhead into the San Joaquin River mainstem with the installation of HORB to a route through salvage. For Chinook salmon, updated science found a slight benefit in survival to a route through salvage. Similarly, while Vernalis flows improved CV Steelhead survival, improvements were not correlated with exports. Accordingly, the proposed action subsumes protections for CV Steelhead into OMR management. The proposed action continues the telemetry studies to further refine measures for protecting CV Steelhead.

Several conservation measures proposed for Steelhead would also reduce impacts of lower spring flows on CV Steelhead juveniles. These include pulse flows from Shasta Reservoir, spawning and rearing

habitat restoration on the Sacramento and Stanislaus Rivers, cold water pool management on the Sacramento River, predator hot spot removal and the small screen program. Similar to Winter-run Chinook Salmon, OMR management establishes generally protective criteria to avoid entrainment of CV Steelhead, and fish facility improvements can help further reduce the effects of the entrainment from the proposed action.

5.10.1 Lifestage Timing

CV Steelhead express a diverse array of life-history strategies including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life-histories can be adopted by individuals from the same sibling cohort. Although there are general patterns regarding habitat use, migration timing, etc., CV Steelhead can hypothetically be found anywhere within their geographic distribution at all times (NMFS 2009). However, CV Steelhead are a thermally sensitive species like all other salmonids and their distribution and habitat use is generally restricted to waters below 65°F (NMFS 2002); protracted exposure to water temperatures above 75-82°F is likely lethal (Brett et al. 1982; Myrick and Cech 2005). Optimal conditions for CV Steelhead spawning and embryo incubation reportedly occur at water temperatures 52°F (NMFS 2002; SWRCB 2003), temperatures less than 56°F embryo survival has been reported as suitable (NMFS 2009). Water temperatures within the Central Valley and Delta likely control the timing and location of their distribution.

Reservoir releases, combined with other environmental drivers, affect water temperature, DO level, and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds. The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redd (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering. For the purposes of this biological assessment, Reclamation is analyzing effects to CV Steelhead in the Sacramento, Feather, American, and Stanislaus Rivers and the Delta.

General life stage timing and location information for CV Steelhead is provided in Table 5.10-1. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F – Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS. Note that adult abundance timing in the Delta was described by NMFS (2017, p.74) as being high from September to mid-October, medium from mid to late August and mid to late October, and low from mid-June to mid-August and November. This is essentially the same pattern as that suggested for Sacramento River at Fremont Weir in Table 5.10-1, but without the period of low abundance from December to mid-March.

Table 5.10-1. The Temporal Occurrence of Adult (a) and Juvenile (b) CV Steelhead at Locations in the Central Valley (NMFS 2017, Appendix B, p.41).

| (a) Adult Migration | | | | | | | | | | | | |
|-------------------------------------------------------|--------|-----|-----|----------|-----|-----|-----|-------|-----|-----|-----|-----|
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| ¹ Sacramento R. at Fremont Weir | | | | | | | | | | | | |
| ² Sacramento R. at RBDD | | | | | | | | | | | | |
| ³ Mill & Deer Creeks | | | | | | | | | | | | |
| ⁴ Mill Creek at Clough Dam | | | | | | | | | | | | |
| ⁵ San Joaquin River | | | | | | | | | | | | |
| (b) Juvenile Migration | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| ^{1,2} Sacramento R. near Fremont Weir | | | | | | | | | | | | |
| ⁶ Sacramento R. at Knights Landing | | | | | | | | | | | | |
| ⁷ Mill & Deer Creeks (silvery parr/smolts) | | | | | | | | | | | | |
| ⁷ Mill & Deer Creeks (fry/parr) | | | | | | | | | | | | |
| ⁸ Chippis Island (clipped) | | | | | | | | | | | | |
| ⁸ Chippis Island (unclipped) | | | | | | | | | | | | |
| ⁹ San Joaquin R. at Mossdale | | | | | | | | | | | | |
| ¹⁰ Mokelumne R. (silvery parr/smolts) | | | | | | | | | | | | |
| ¹⁰ Mokelumne R. (fry/parr) | | | | | | | | | | | | |
| ¹¹ Stanislaus R. at Caswell | | | | | | | | | | | | |
| ¹² Sacramento R. at Hood | | | | | | | | | | | | |
| Relative Abundance: | = High | | | = Medium | | | | = Low | | | | |

Sources: ¹(Hallock 1957); ²(McEwan 2001); ³(Harvey 1995); ⁴CDFW unpublished data; ⁵CDFG Steelhead Report Card Data 2007; ⁶NMFS analysis of 1998–2011 CDFW data; ⁷(Johnson and Merrick 2012); ⁸NMFS analysis of 1998–2011 USFWS data; ⁹NMFS analysis of 2003–2011 USFWS data; ¹⁰unpublished EBMUD RST data for 2008–2013; ¹¹Oakdale RST data (collected by FishBio LLC) summarized by John Hannon (Reclamation); ¹²(Schaffter 1980).

Adult CV Steelhead immigration into Central Valley streams typically begins in August and continues into March. Immigration generally peaks during January and February (Table 5.10-1), and then CV

Steelhead hold until flows are high enough in tributaries to enter for spawning (Moyle 2002; McEwan 2001; NMFS 2004). Spawning occurs from December through April, with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (McEwan 2001). Eggs usually hatch within four weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another four to six weeks (CDFG 1996). The majority of CV Steelhead spawn only once but are capable of completing multiple return trips to the ocean and spawning migrations. Post-spawning adults returning to the ocean are referred to as kelts. Juvenile CV Steelhead use the middle Sacramento River as a rearing and migration corridor. Rotary screw trap, beach seine, and trawl data collected during 2004 through 2017 indicate that CV Steelhead may be present year-round in the middle Sacramento River but that the majority occur during January through May (Appendix F, Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS). This period encompasses the peak emigration periods of yearling and older juveniles (smolts) from rearing areas in the upper Sacramento River and tributaries upstream of the Delta (Table 5.10-1). Therefore, individuals are present in the proposed action area throughout the year.

Historically adult CV Steelhead maintained several strategies during their migration to natal rivers in preparation for spawning. Some CV Steelhead returned several months prior to spawning to hold over in pools while sexually maturing, others sexually matured in the ocean before returning to freshwater (Williams 2006). Remaining anadromous CV Steelhead predominantly mature in the ocean (McEwan 2001).

5.10.2 Conceptual Model Linkages

CV Steelhead are present in the proposed action area throughout the year. The SAIL conceptual model (Figure 5.6-1) was prepared especially for life stage transitions of Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply well to the CV Steelhead population in Sacramento River. SAIL life stage transitions are the series in changes in form that an organism undergoes throughout its life cycle. SAIL life stage transitions include egg to larval, larvae to juvenile, juvenile to subadult/adult, adult to spawning, and spawning adult to egg and post-spawn adult period. The SAIL conceptual model prepared for Winter-run Chinook will be referenced throughout this section to explain links between the species and the effects of the actions. The primary differences in the habitat requirements between Winter-run and CV Steelhead are the duration and the time of year that the different life stages use their habitats.

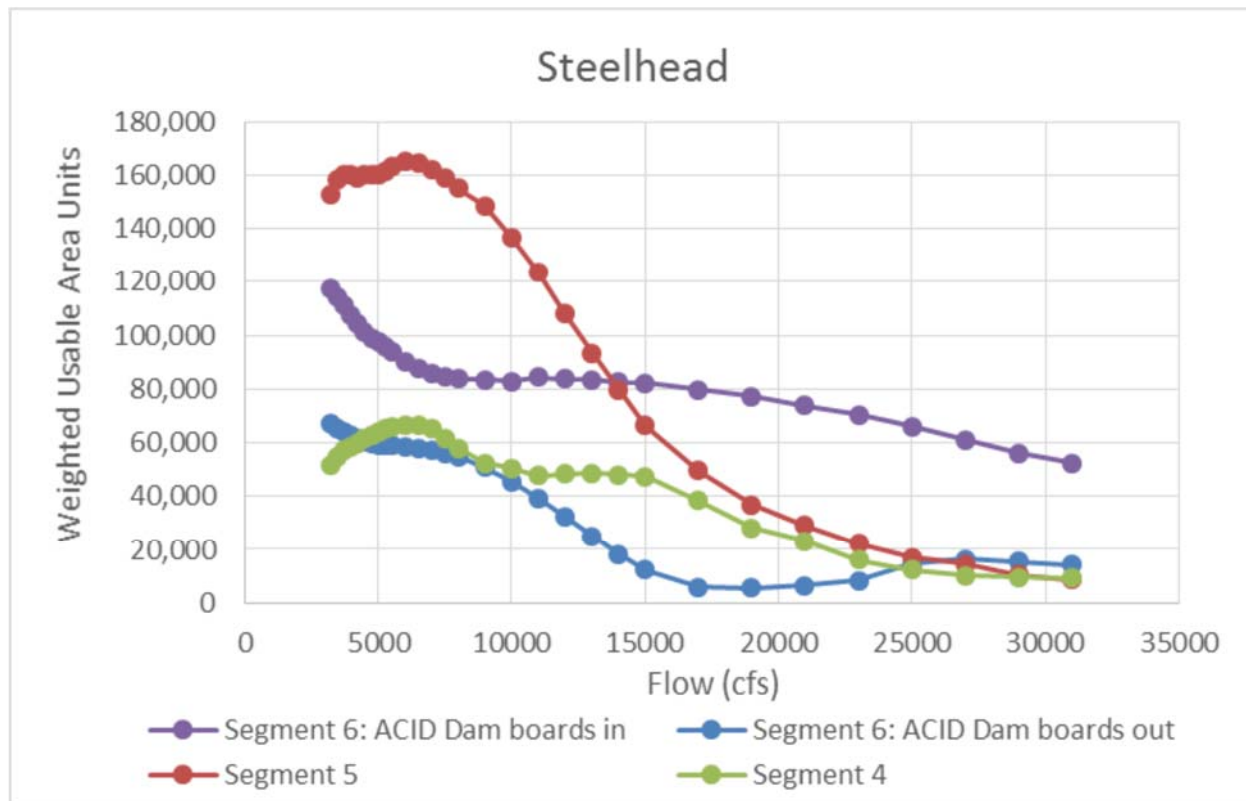
5.10.3 Effects of Operation & Maintenance

5.10.3.1 Sacramento River Seasonal Operations

5.10.3.1.1 Eggs to Fry Emergence

5.10.3.1.1.1 Flow Effects

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin Rivers. On the Sacramento River, steelhead generally spawn where Chinook spawn, between Keswick Dam and Red Bluff Diversion Dam. The effects of flow on available spawning area for CV Steelhead were qualitatively evaluated based on the relationships between flow and weighted usable area (WUA) developed by the USFWS for the Sacramento River between Keswick Dam and Battle Creek (Figure_Steelhead Spawning WUA). These relationships indicate that spawning WUA generally peaks at flows between 3,250 and 7,000 cfs and then declines at higher flows (Figure 5.10-1).



(Source: USFWS 2003)

Figure 5.10-1. Spawning WUA curves for CCV Steelhead in the Sacramento River. Segments 4: Battle Creek to Cow Creek; Segment 5: Cow Creek to the Anderson-Cottonwood Irrigation District (ACID) Dam; Segment 6: ACID to Keswick Dam

The USFWS used Habitat Suitability Criteria (HSC) criteria from the lower American River (USFWS 2000) to model CV Steelhead habitat in the Sacramento River. The USFWS was unable to conduct a transferability test to determine whether the lower American River CV Steelhead HSC are transferable to the Sacramento River, and therefore suggested that the habitat modeling results for CV Steelhead be treated with caution (USFWS 2003).

Under WOA conditions, there would be no Shasta and Keswick reservoir operations to control storage or releases, and no transfer of water from the Trinity River Basin. Under these conditions, flows in the Sacramento River would generally respond to natural seasonal and inter-annual variation in precipitation and runoff. Consequently, flows during the CV Steelhead spawning and incubation period would generally be low initially and then increase with the onset of winter storm events. Under the WOA scenario, CALSIM modeling indicates Keswick releases during November through April would range from 3,250 cfs to 62,650 cfs (Figures 15-8 through 15-13 in the CalSim II Flows section of Appendix D). Based on the CV Steelhead spawning WUA curves for the reaches between Keswick Dam and Battle Creek, flows associated with peak spawning habitat availability (3,250 cfs to 7,000 cfs) would occur most of the time in November (96 percent) and then decline in frequency as flows increase through the winter and spring, occurring about 30 percent of the time in March and April.

Under the proposed action, Keswick releases during the CV Steelhead spawning and incubation period (November through April) would range from 3,250 cfs to 59,000 cfs (Figures 15-8 through 15-13 in the

CalSim II Flows section of Appendix D). Based on the CV Steelhead spawning WUA curves, the largest differences in spawning habitat availability would occur in November when flows within the optimum range (3,250 cfs to 7,000 cfs) are predicted to occur 86 percent of the time under the proposed action scenario and 56 percent of the time under the COS scenario (Figure 15-8 in the CalSim II Flows section of Appendix D). During the peak spawning period (January through March), the frequency of flows associated with peak spawning habitat availability would differ by less than two percent (Figures 15-10 through 15-12 in the CalSim II Flows section of Appendix D). Consequently, the availability of CV Steelhead spawning habitat under the proposed action would be similar except in November when higher flows under the proposed action scenario would reduce the number of years in which flows would be within the optimum range.

Overall, lower winter and spring flows under the proposed action are expected to increase the availability of Steelhead spawning habitat relative to WOA conditions. Compared to the WOA scenario, the proposed action would result in substantially more years in which flows would be within the range of peak spawning habitat availability (3,250 cfs to 7,000 cfs). The largest differences would occur during the peak spawning months (January through March), when flows within the optimum range would occur 63 to 70 percent of the time under and proposed action scenarios versus 29 to 54 percent of the time under the WOA scenario. In addition, lower flows under the proposed action would likely reduce the risk of redd scour and/or dewatering relative to the WOA scenario. If flows are sufficiently high, they can result in excessive depths and flow velocities, resulting in bed scour and loss of existing redds (NMFS 2017). Higher flows may also force adults to build redds in areas that are later dewatered or isolated from the main river channel when flows decline. Therefore, Keswick Dam releases under the proposed action are expected to improve spawning and incubation conditions for CV Steelhead in the upper Sacramento River relative to WOA conditions.

5.10.3.1.1.2 Water Temperature Effects

Proposed action water temperature in the upper Sacramento River apply to the period May 15 to October 31 to provide suitable temperatures for winter-run, spring-run, and fall-run Chinook salmon spawning and incubation life stages. No water temperature requirements have been established for the CV Steelhead spawning and incubation period (November through April) because water temperatures are typically within suitable ranges for these life stages and other species and life stages that are present in the upper Sacramento River during this period. This assumption was evaluated for the WOA and proposed action based on the water temperature modeling results (HEC-5Q) and the recommended criteria developed by USEPA for protection of salmonids (U.S. Environmental Protection Agency 2003) and McCullough et al. (2001). These sources indicate that a water temperature of 53°F provides a reasonable threshold for evaluating the potential for adverse temperature effects based on mean monthly modeling results.

Under the WOA scenario, there would be 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 ability to control water temperatures in the upper Sacramento River. Declining solar radiation and air temperatures in October and November consistently result in suitable water temperatures for CV Steelhead spawning and incubation period through the winter and early spring. Under the WOA scenario, exceedance plots of modeled mean monthly water temperatures between Keswick Dam and Red Bluff from November through April indicate that water temperatures would remain below 53°F in all months except April (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D).

Under WOA scenario, Sacramento River water would flow through Shasta and Keswick reservoirs, similar to uncontrolled flows, resulting in no control of flow releases or water temperature management within the system. Under the proposed action, the highest elevation gates of the TCD would be used to

conserve deeper, colder water for the critical summer months (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D). The largest differences in mean monthly water temperatures between the proposed action and COS would be less than 1°F in November and December. Under both scenarios, water temperatures would frequently exceed the 53°F threshold in November but would decrease in December and remain below this threshold through March.

Compared to WOA conditions, water temperatures in the upper Sacramento River under the proposed action would be higher from November through February, similar in March, and lower in April (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D). Based on the frequency of years in which water temperatures are predicted to exceed the 53°F threshold, potential adverse effects on CV Steelhead spawning and incubation under the proposed action would occur in November when mean water temperatures below Keswick Dam are predicted to range from 52°F to 58°F between Keswick Dam and Red Bluff (Figure 5-8 in the HEC5Q Temperatures section of Appendix D). However, with higher reservoir storage and water temperature management actions under these scenarios, suitable water temperatures would be maintained through the primary Steelhead spawning and incubation period (January through April). Furthermore, in contrast to the WOA scenario, lower water temperatures under the proposed action would extend the period of suitable incubation temperatures into April (Figure 5-13 in the HEC5Q Temperatures section of Appendix D).

5.10.3.1.2 Rearing to Outmigrating Juveniles

5.10.3.1.2.1 Flow Effects

The effect of flow on available rearing area for CV Steelhead was qualitatively evaluated based on the relationships between flow and weighted usable area (WUA) developed by the USFWS for the Sacramento River between Keswick Dam and Battle Creek (Figure 5.10-2). Rearing habitat WUA for CV Steelhead was not estimated directly by the USFWS but was modeled using the rearing WUA curves for late Fall-run Chinook Salmon because the juvenile rearing period is similar to that of CV Steelhead, and this substitution follows previous practice (e.g., SacEFT model, ESSA 2011). However, the validity of using the late Fall-run Chinook Salmon WUA curves to characterize CV Steelhead rearing habitat is uncertain.

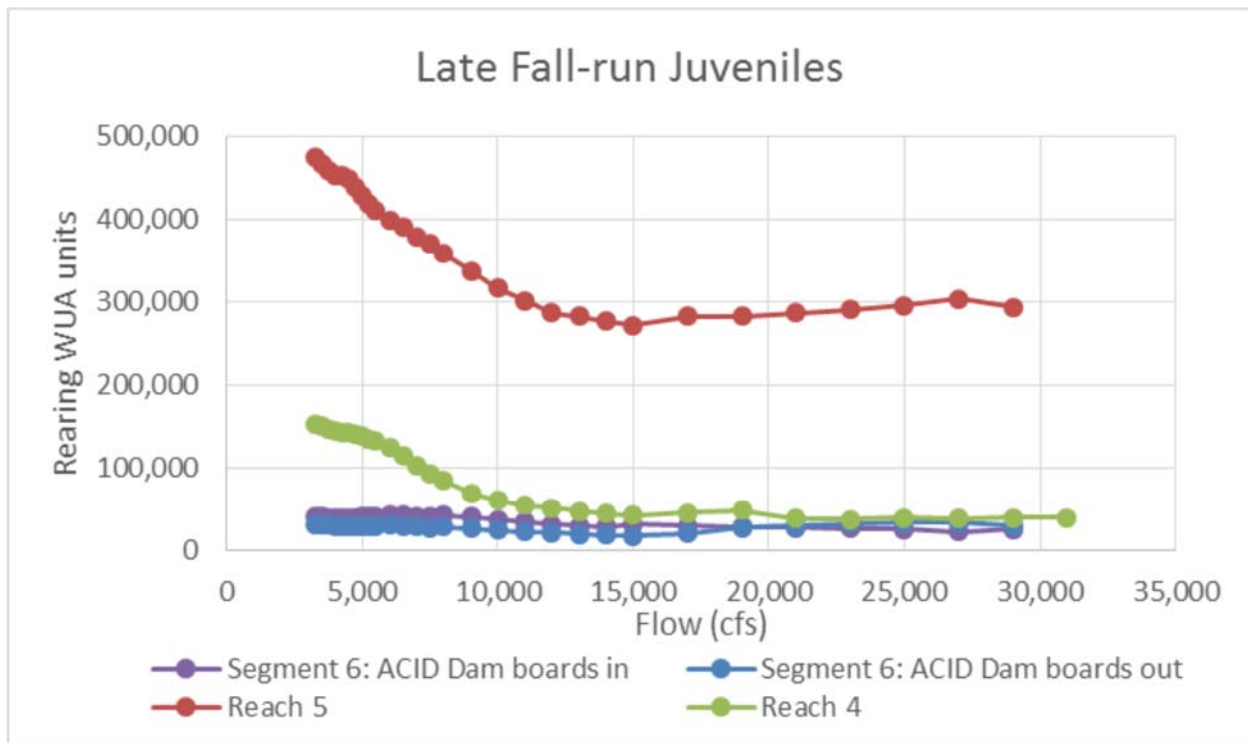


Figure 5.10-2. Rearing WUA curves for late Fall-run Chinook Salmon in the Sacramento River. Segment 4: Battle Creek to Cow Creek; Segment 5: Cow Creek to the Anderson-Cottonwood Irrigation District (ACID) Dam; Segment 6: ACID to Keswick Dam (Source: USFWS 2005).

The relationships indicate that rearing WUA in the upper Sacramento River generally peaks at or below the lowest flow studied (3,250 cfs). Similar to the effects described for Winter-run Chinook Salmon, these low flows would also reduce the quality of rearing habitat through changes in other physical and biological attributes, including high water temperatures, reduced habitat complexity (e.g., reduced side channel and floodplain connectivity), increased crowding and competition, and reduced availability and quality of prey organisms (Windell et al. 2017). Summer water temperatures would be further exacerbated by increased release temperatures due to the lack of cold water storage in Shasta Reservoir under the WOA scenario.

CALSIM modeling indicates that monthly flows in the upper Sacramento River during May through October would frequently drop below 3,250 cfs, especially during the summer of dry and critically dry years. During June through September, Keswick releases under the WOA scenario would be lower than 3,250 cfs in up to 55 percent of the years (Sac R flow below Keswick dam_aug).

Under the proposed action scenario, Shasta and Keswick reservoir operations during summer target flow and water temperature requirements for Winter-run Chinook Salmon and other anadromous fishes. CALSIM modeling indicates that flows of 3,250 cfs or more would be maintained through the spring and summer months. Compared to the COS scenario, modeled flows under the proposed action are higher in June and lower in September (Figures 15-15 through 15-18 in the CalSim II Flows section of Appendix D), but these differences would occur over a range of flows (6,000 to 17,000 cfs) that is not expected to substantially affect rearing habitat for juvenile CV Steelhead. Surrogate WUA for CV Steelhead rearing is reduced at higher flows but remains relatively stable between flows of 6,000 and 17,000 cfs (Figure_Late Fall-run Chinook WUA_Juv).

5.10.3.1.2.2 Water Temperature Effects

CV Steelhead need suitable rearing temperatures throughout the year. The USEPA-recommended 7DADM water temperature for juvenile salmonids in core rearing areas (upper reaches of natal rivers) is 61°F, although this is based on Pacific Northwest fish and hydrology and does not consider the feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures during May through October in the Sacramento River below Keswick Dam would range from about 53°F to 73°F, exceeding the 61°F threshold in 7 percent of years in May and 100 percent of years during June through September (Figures 5-1 through 5-6 in the HEC5Q Temperatures section of Appendix D). Water temperatures during these months would be even higher at downstream locations in the upper Sacramento River. For example, monthly mean temperatures at Bend Bridge are predicted to exceed 70°F in July in all years (Figure 5.10-3). These water temperatures would have sublethal and lethal effects on juvenile CV Steelhead throughout the upper Sacramento River, including reduced growth, delayed smoltification, desmoltification, and physiological stress which can lead to disease and increased predation mortality.

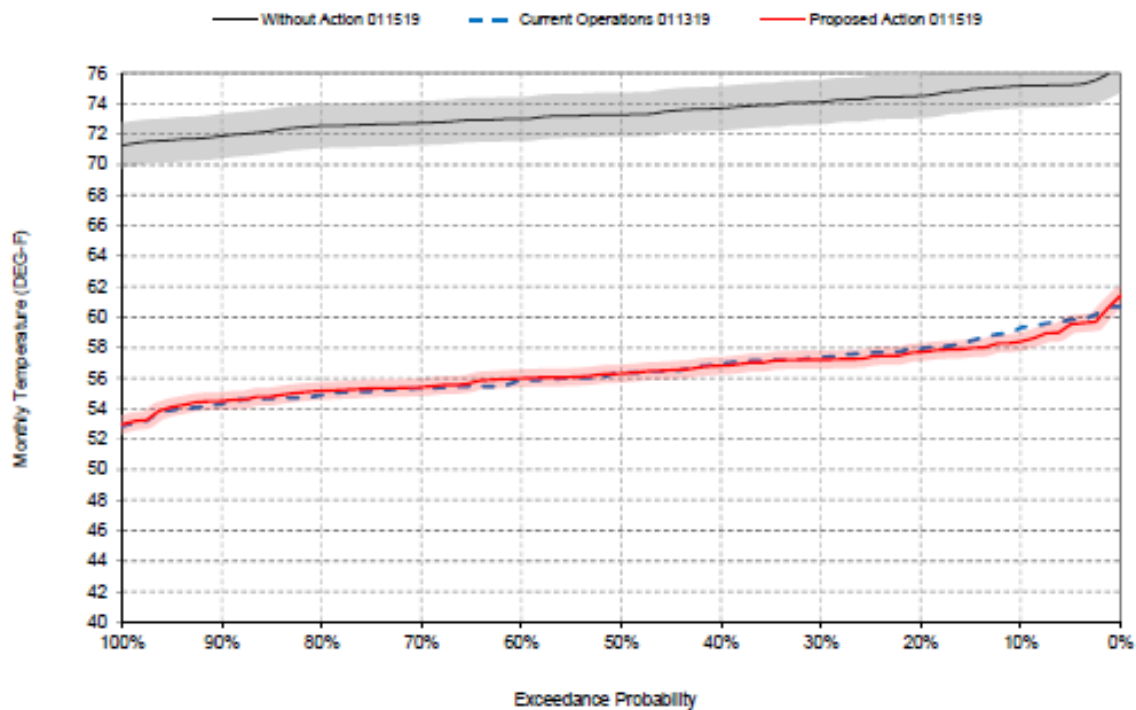


Figure 5.10-3. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the proposed action, WOA, COS, scenarios, July

Water temperatures under the proposed action would be substantially lower than those under the WOA scenario. Monthly mean water temperatures would range from about 46°F to 66°F, exceeding the 61°F threshold in less than 10% of the years in August, September and October. The proposed action would avoid or minimize exposure of juvenile CV Steelhead to sublethal and lethal temperatures, and maintain suitable water temperatures throughout their residence in the upper Sacramento River.

Under the proposed action, summer rearing conditions for juvenile CV Steelhead would be substantially improved relative to WOA conditions. Although Steelhead are adapted to low summer base flows that occurred naturally in their historical spawning and rearing habitat above impassable dams, existing populations in the upper Sacramento River and other tailwater reaches below mainstem dams are

dependent on the higher, colder releases from these dams for maintenance of suitable summer rearing conditions.

5.10.3.1.3 Adult Migration from Ocean to Rivers

5.10.3.1.3.1 Flow Effects

Changes in flow potentially affect passage conditions for upstream migration of adults, including the creation of physical barriers and changes in water temperature, dissolved oxygen, and straying, stranding, and disease risk. Very low flows can affect passage by creating physical barriers or poor water quality conditions (e.g., high temperatures and/or low DO) that can block or delay adult migration. Flow thresholds for evaluating passage conditions and related problems for migrating CV Steelhead adults have not been determined for the Sacramento River. A threshold of 3,250 cfs is used in this analysis to evaluate the potential for adverse effects. Flows in the Sacramento River rarely drop below this level, and adults have not been observed experiencing migration difficulties at this flow. As such, it represents a conservative minimum flow above which fish do not experience migration difficulties.

Under WOA conditions, flows during the CV Steelhead immigration period (August through March) would generally be low until the first storm events increase flows in the fall or early winter. Under the WOA scenario, CALSIM modeling indicates that flows in the middle Sacramento River would be very low in August, especially in dry and critically dry years, resulting in poor passage conditions in most years (Figure 19-17 in the CalSim II Flows section of Appendix D). Based on a flow threshold of 3,250 cfs, flows providing suitable passage would occur about half the time in September and October, 90 percent of the time in November, and 100 percent of the time during January through March (Figures 19-12 through 19-18 in the CalSim II Flows section of Appendix D).

Under the proposed action, flows of 3,250 cfs or more would be maintained through the CV Steelhead immigration period in nearly all years (Figures 19-12 through 19-17 in the CalSim II Flows section of Appendix D). In contrast, suitable passage conditions under the WOA scenario would not occur until later in the fall, resulting in potential delays in migration and adverse impacts on migrating adults (e.g., increased exposure to high temperatures resulting in elevated pre-spawning mortality). In dry and critically dry years, suitable passage conditions may not occur until November. Consequently, the proposed action would have beneficial effects on adult CV Steelhead immigration relative to the WOA conditions.

5.10.3.1.3.2 Water Temperature Effects

The USEPA-recommended 7DADM water temperature for adult salmonids during their upstream migration is 68°F, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures in the Sacramento River at Knights Landing in August and September would range from about 74°F to 83°F, creating a thermal barrier for upstream migration in all years (Figures 14-17 and 14-18 in the HEC5Q Temperatures section of Appendix D). Based on a threshold of 68°F, suitable water temperature for upstream migration would occur about 95 percent of the time in October, and 100 percent of the time during November through March (Figures 14-7 through 14-12 in the HEC5Q Temperatures section of Appendix D). Consequently, water temperatures under the WOA scenario would be too warm for CV Steelhead upstream migration through September, and suitable water temperatures for upstream migration would be delayed until October or November. In combination with higher flows, the proposed action would be expected to improve immigration conditions for adult CV Steelhead during the early immigration period (August through October) relative to WOA conditions.

5.10.3.1.4 Adult Holding

5.10.3.1.4.1 Flow Effects

Changes in flow potentially affect conditions for holding CV Steelhead adults, including availability of holding habitat (e.g., pools), access to cover, and suitable water temperatures prior to spawning. Flow thresholds for evaluating holding conditions for CV Steelhead adults have not been determined for the Sacramento River. In general, higher flows are likely to benefit holding adults by providing better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk to anglers or poachers (Windell et al. 2017).

Under WOA conditions, flows during the CV Steelhead holding period (September through November) would generally be low until the first storm events increase flows in the fall or early winter. Under the WOA scenario, CALSIM modeling indicates that median flows in the upper Sacramento River would be 3,350 cfs in September, 3,700 cfs in October, and 4,800 cfs in November. Under the proposed action, flows in the upper Sacramento River in September and October would be substantially higher than those under the WOA scenario in most years (Figures 15-6 and 15-18 in the CalSim II Flows section of Appendix D). Consequently, the proposed action would likely improve holding conditions for adult CV Steelhead relative to WOA conditions, especially in dry and critically dry years.

5.10.3.1.4.2 Water Temperature Effects

The USEPA-recommended 7DADM water temperature for holding adults is 61°F, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. Under WOA conditions, monthly mean water temperatures in the Sacramento River below Keswick Dam would consistently exceed the 61°F threshold in September (Figure 15-18 in the CalSim II Flows section of Appendix D). Declining water temperatures beginning in September would result in suitable holding temperatures in the upper Sacramento River in October and November (Figures 15-7 and 15-8 in the CalSim II Flows section of Appendix D).

Under the proposed action, water temperatures exceeding the 61°F threshold in the Sacramento River below Keswick Dam during the CV Steelhead holding period would occur about 5 percent of the time in September and October (Figures 15-6 and 15-18 in the CalSim II Flows section of Appendix D). Compared to the COS, water temperatures under the proposed action would be up to 4°F higher in some years in August and September and up to 4°F lower in most years in October, but these differences would be limited to years in which water temperatures are well below the 61°F threshold. Compared to the WOA scenario, the proposed action would substantially improve water temperatures for adult Steelhead during their holding period in the upper Sacramento River. The benefits would occur primarily in September when Keswick Dam releases would consistently be 12°F to 13°F cooler in most years. In combination with higher flows, lower water temperatures under the proposed action would have beneficial effects on holding adults relative to WOA conditions.

5.10.3.2 *Whiskeytown Reservoir Operations and Clear Creek Flows*

5.10.3.2.1 Eggs to Fry Emergence

Under the proposed action, eggs and emerging fry in Clear Creek are not anticipated to be impacted as they would not be exposed to the effects of Whiskeytown water temperature controls in Clear Creek based on the timing of these controls (60°F at IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.10-1).

Under the proposed action, eggs and emerging fry would be exposed to the effects of Clear Creek geomorphic flows, and potentially spring attraction flows based on the proposed timing of these releases (after January 1 for geomorphic flows; April-June for spring attraction flows [Clear Creek Technical Team 2018]), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.10-1). Potential effects of these flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment “cap” that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989).

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3,000–3,500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50 percent (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3,000 cfs occur on 0.2 percent of days since WY 1965 (37 days total). Proposed geomorphic and attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30 percent of the flow needed to transport sediment in the absence of flows from downstream tributaries. If geomorphic flows were to achieve their intended effect (gravel mobilization) there may be short-term adverse impacts to incubating Steelhead eggs via redd scour or sediment deposition. However, the total area and overall quality of egg incubation habitat would be increased post gravel mobilization.

5.10.3.2.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating juveniles would be exposed to the effects of geomorphic and spring attraction flows given the likely timing of spring attraction flows (May-June [Clear Creek Technical Team 2018]), geomorphic flows (contemporaneous with peak storm flows after January 1), and the peak timing of this life stage in Clear Creek (year-round; Table 5.10-1). Under the proposed action, some rearing and outmigrating CV Steelhead juveniles would be exposed to the effects of Whiskeytown temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (year-round; Table 5.10-1).

5.10.3.3 *Feather River Flows*

The DWR proposes flows from Oroville Dam that would affect conditions downstream of the Oroville Complex FERC boundary. These downstream effects are discussed in this section.

5.10.3.3.1 Eggs to Fry Emergence

5.10.3.3.1.1 **Flow Effects**

Eggs and emerging fry of CV Steelhead would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (December-May; Table 5.10-1 & NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5-SHCV-1), and compliance with D-1641.

Table 5.10-2. Feather River High Flow Channel Minimum Instream Flow Requirements

| Preceding April – July Unimpaired runoff (Percent of Normal) | High Flow Channel Minimum Instream Flow | | |
|--------------------------------------------------------------------|-----------------------------------------|-----------|---------------|
| | OCT-FEB (cfs) | MAR (cfs) | APR-SEP (cfs) |
| 55% or greater | 1,700 | 1,700 | 1,000 |
| Less than 55% | 1,200 | 1,000 | 1,000 |

Under the WOA scenario, Oroville Dam would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.10-4). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the WOA scenario would approximate uncontrolled flows, with generally lower summer and fall flows and higher winter and spring flows compared to the proposed action and COS (Figures 5.10-5 and 5.10-6).

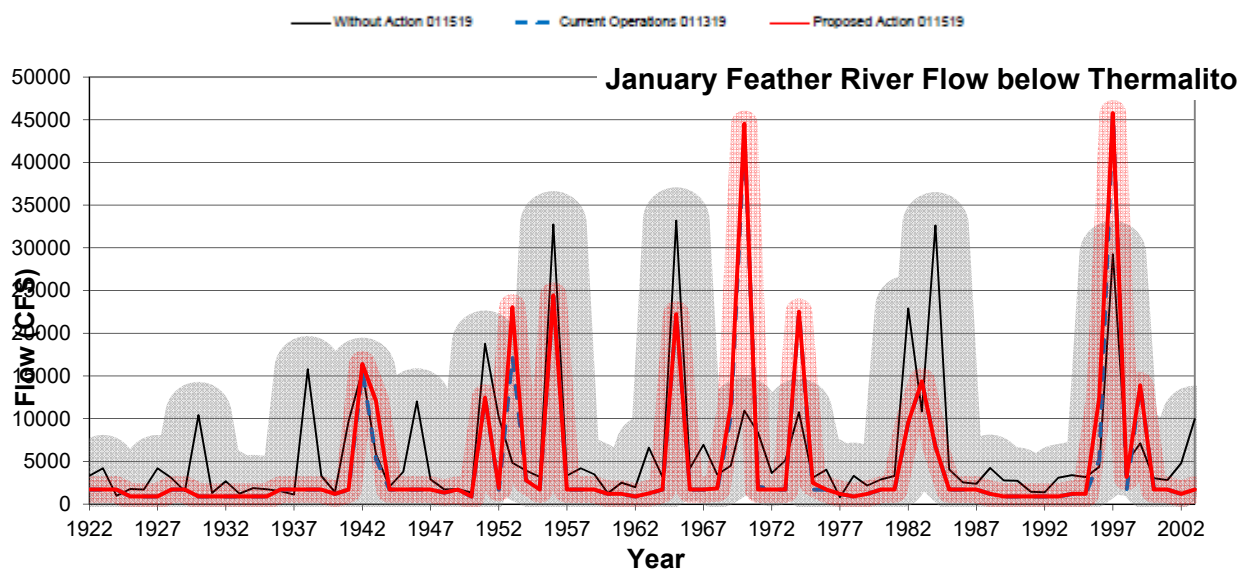


Figure 5.10-4. CalSimII estimates of mean Oroville storage (TAF) for the period 1923–2002 under WOA, COS, and proposed action.

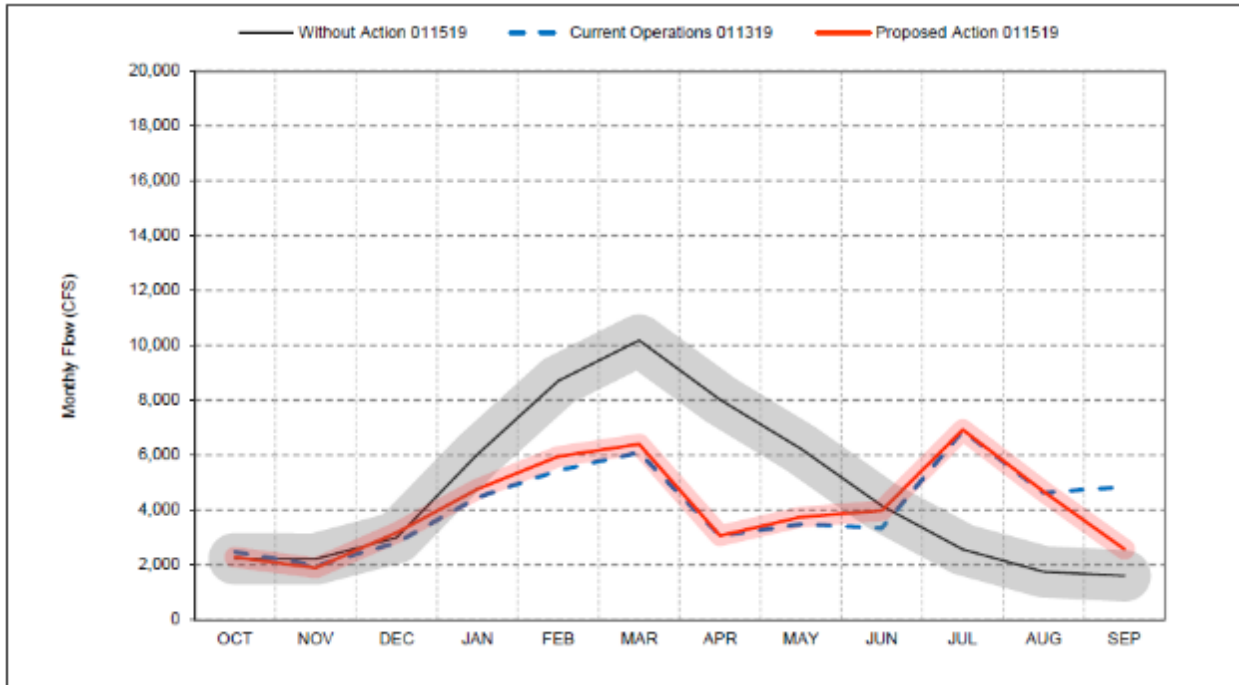


Figure 5.10-5. CalSimII estimates of Feather River long-term average flow below Thermalito Afterbay under the WOA, COS, and proposed action.

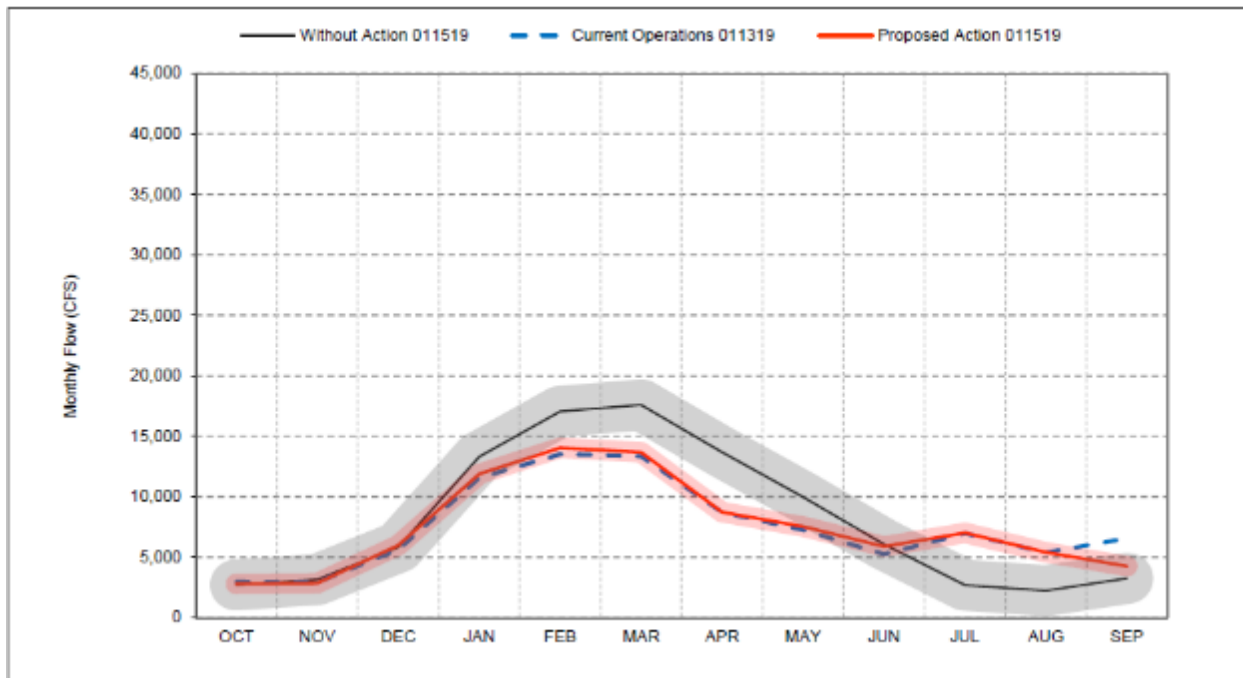


Figure 5.10-6. CalSimII estimates of Feather River mouth long-term average flow under the WOA, COS, and proposed action.

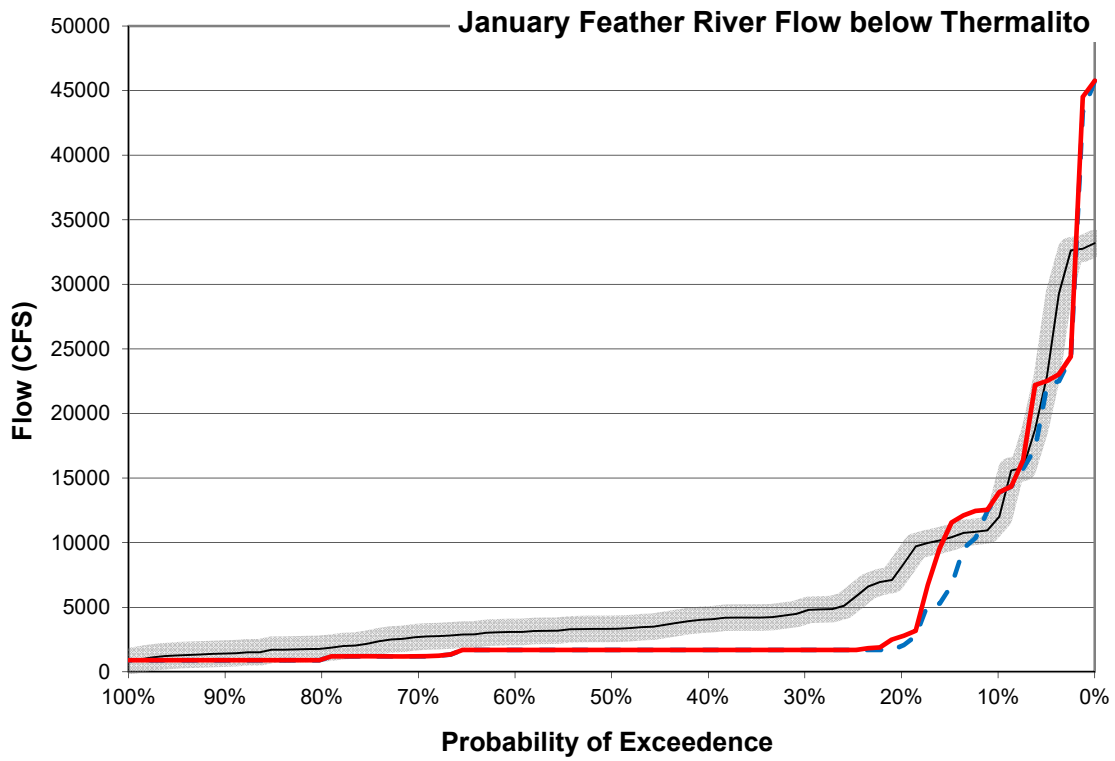


Figure 5.10-7. CalSimII estimates of Feather River flow below the Thermalito Afterbay in December-February under the WOA, COS, and proposed action.

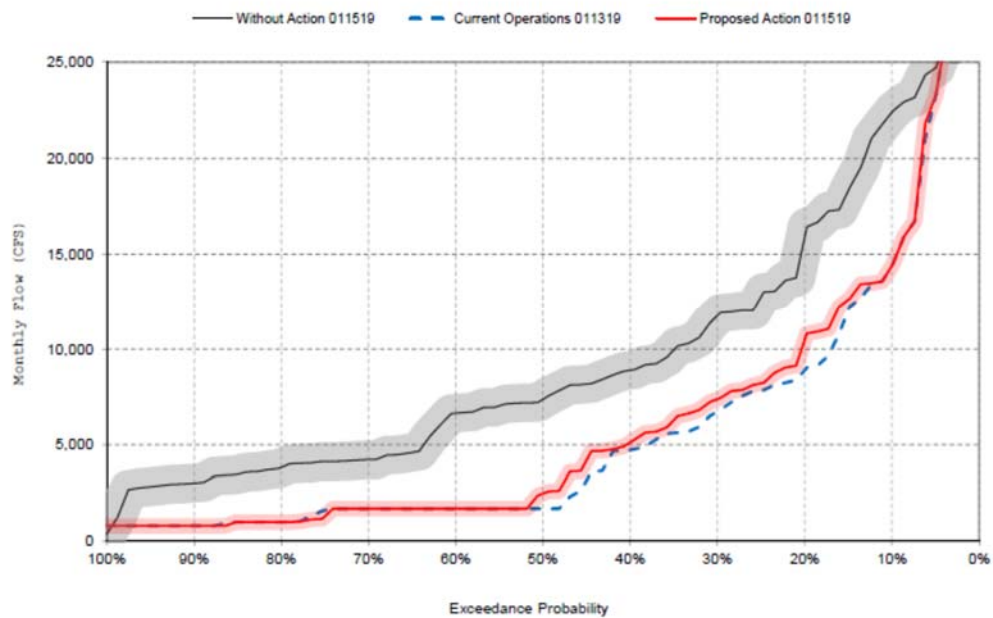


Figure 5.10-8. CalSimII estimates of Feather River flow below the Thermalito Afterbay in March, under the WOA, COS, and proposed action.

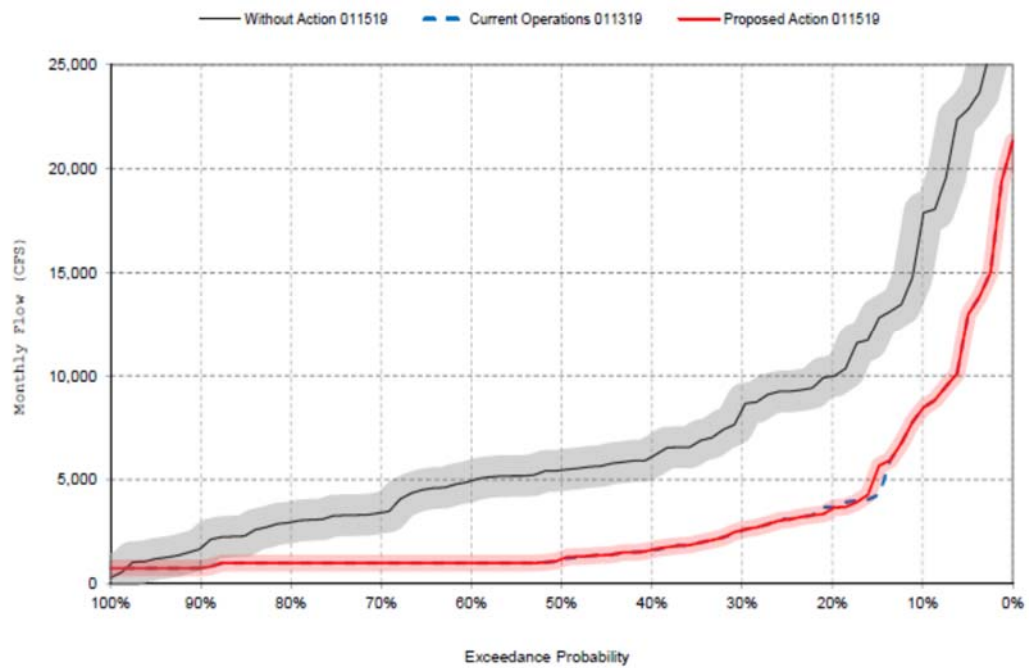


Figure 5.10-9. CalSimII estimates of Feather River flow below the Thermalito Afterbay in April under the WOA, COS, and proposed action.

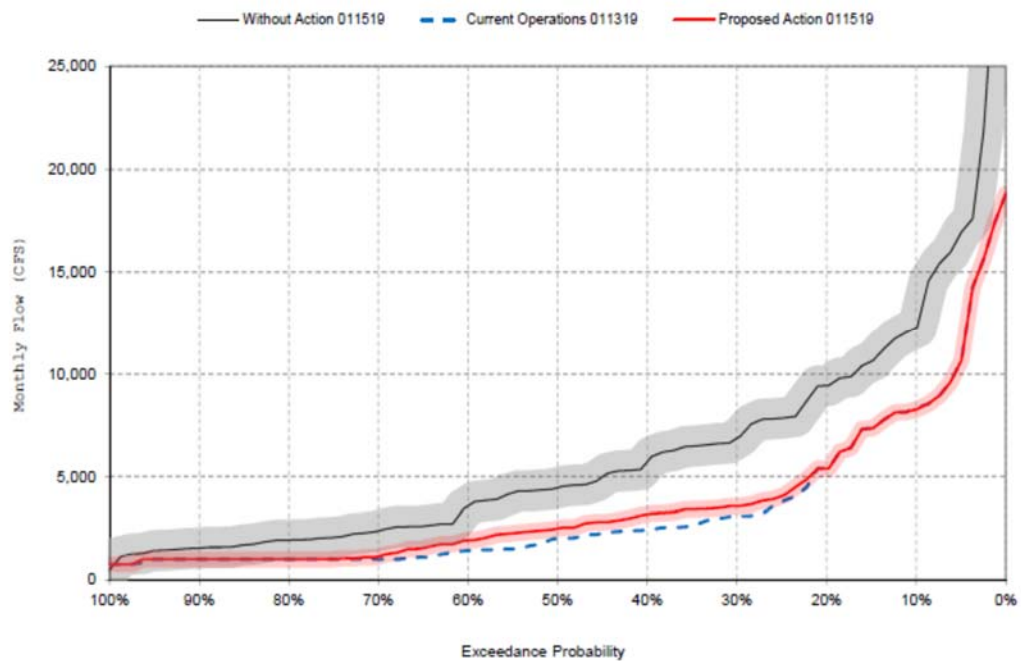


Figure 5.10-10. CalSimII estimates of Feather River flow below the Thermalito Afterbay in May under the WOA, COS, and proposed action.

Feather River flows below Thermalito Afterbay under the WOA are similar or substantially higher than flows under the proposed action during the peak seasonal timing of CV Steelhead egg incubation (December-May) (Figures 5.10-7 through 5.10-10). Differences in flows between the proposed action and COS are minimal during the December to May period. Flows below the minimum threshold would have a number of negative effects on this life stage, including higher water temperatures, lower DO in redds, and potential for redd dewatering, all of which may lead to elevated egg mortality. Insufficient flow may also limit the extent of river bed available for redd construction, thereby limiting available habitat for this life stage. Conversely, the higher, uncontrolled flows projected to occur during this incubation and emergence period under the WOA could result in redd scouring.

Flows in the Feather River HFC under the proposed action and during the egg incubation period are lower than WOA flows, and in below normal, dry and critical water year types, proposed action flows are substantially lower than WOA flows during December-May (Figures 5.10-11 through 13). CalSimII model output indicates flows projected under the proposed action will likely meet the minimum instream flow criteria during in below normal, dry and critical water year types. In addition, proposed action flows are anticipated to result in reliably higher flows than the COS during the months of April and May, a critical period for CV Steelhead egg incubation. As a result, potential negative effects of low flows on this life stage are anticipated to be reduced under the proposed action compared to the COS. In addition, proposed action flows, although lower than WOA flows during this life stage, are projected to meet or exceed minimum instream flow requirements in the HFC while at the same time minimizing the potential negative effects of high flows.

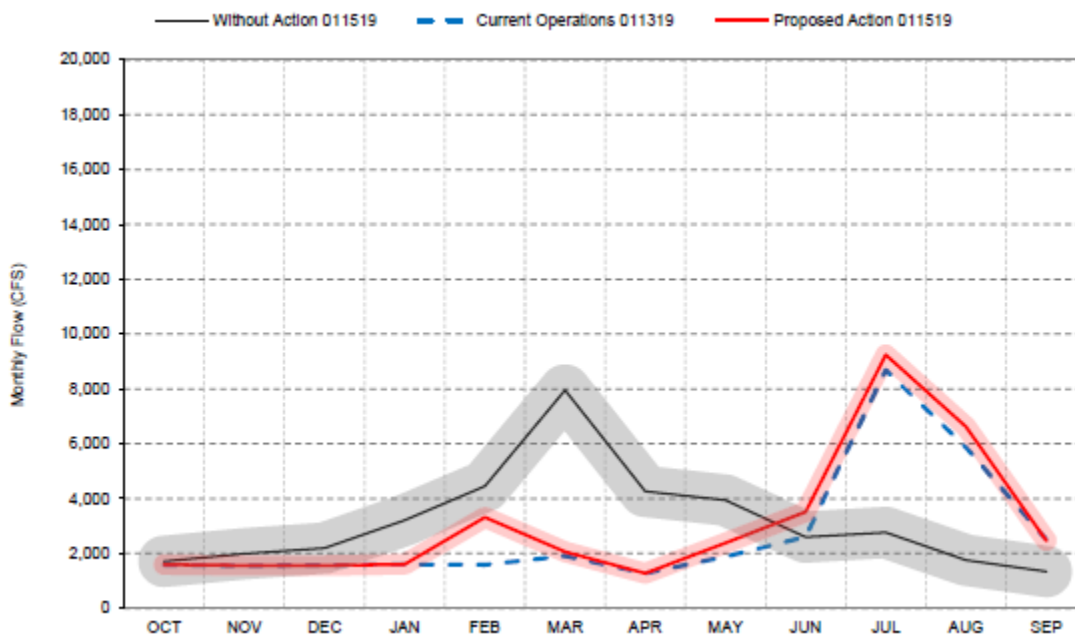


Figure 5.10-11. CalSimII Estimates of Feather River Flow below Thermalito Afterbay for below Normal Water Years under the WOA, COS, and Proposed Action

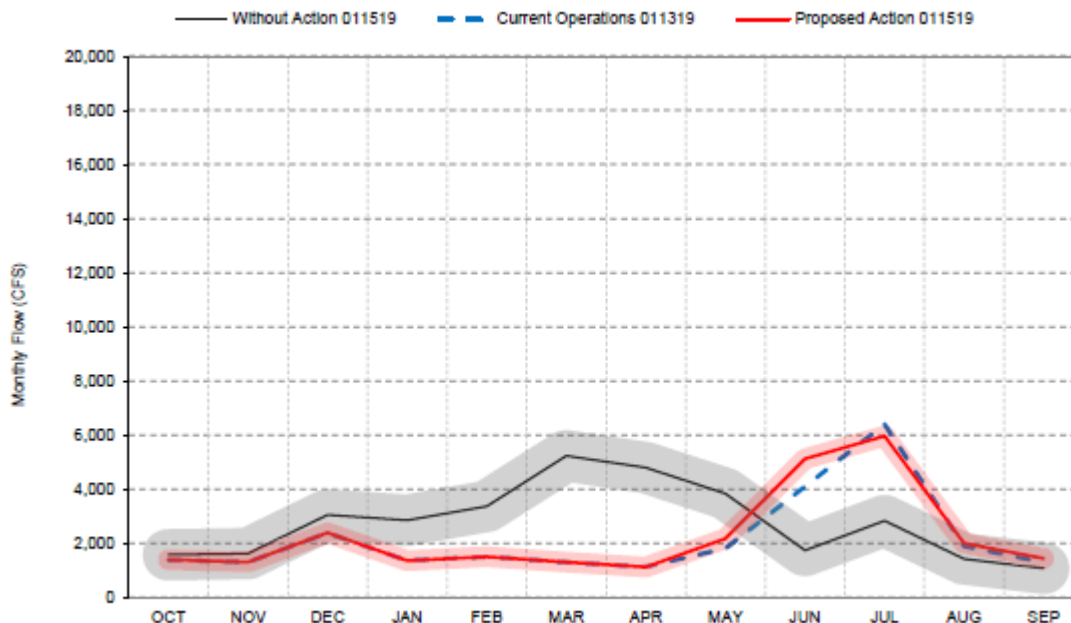


Figure 5.10-12. CalSimII Estimates of Feather River Flow below Thermalito Afterbay for Dry Water Years under the WOA, COS, and Proposed Action

N

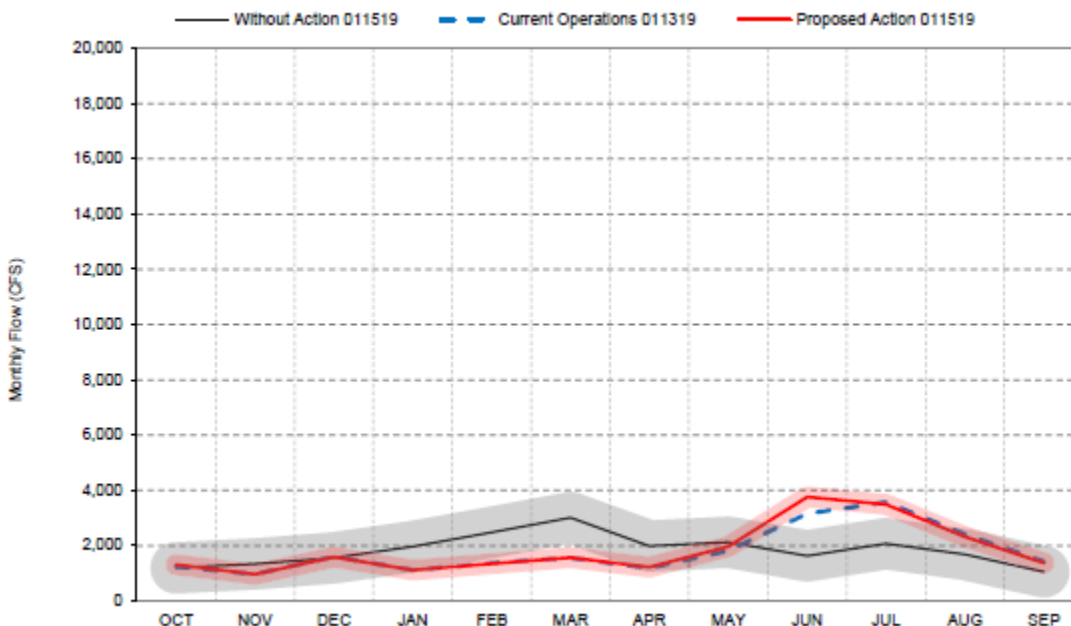


Figure 5.10-13. CalSimII Estimates of Feather River Flow below Thermalito Afterbay for critically Dry Water Years under the WOA, COS, and Proposed Action

5.10.3.3.1.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of CV Steelhead eggs. Exposure to the effects of elevated water temperatures include an inability to satisfy metabolic demand, and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). CV Steelhead eggs require water temperatures 46-52°F for optimal development and survival, 52-55°F for suboptimal, with temperatures above 55°F causing chronic to acute stress (Stillwater Sciences 2006; U. S. Bureau of Reclamation 2008).

Under the WOA scenario, there would be limited control of flow or water temperature in the Feather River HFC where CV Steelhead egg incubation occurs. Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78 °F occurring in July and August (Figure 5.10-14).

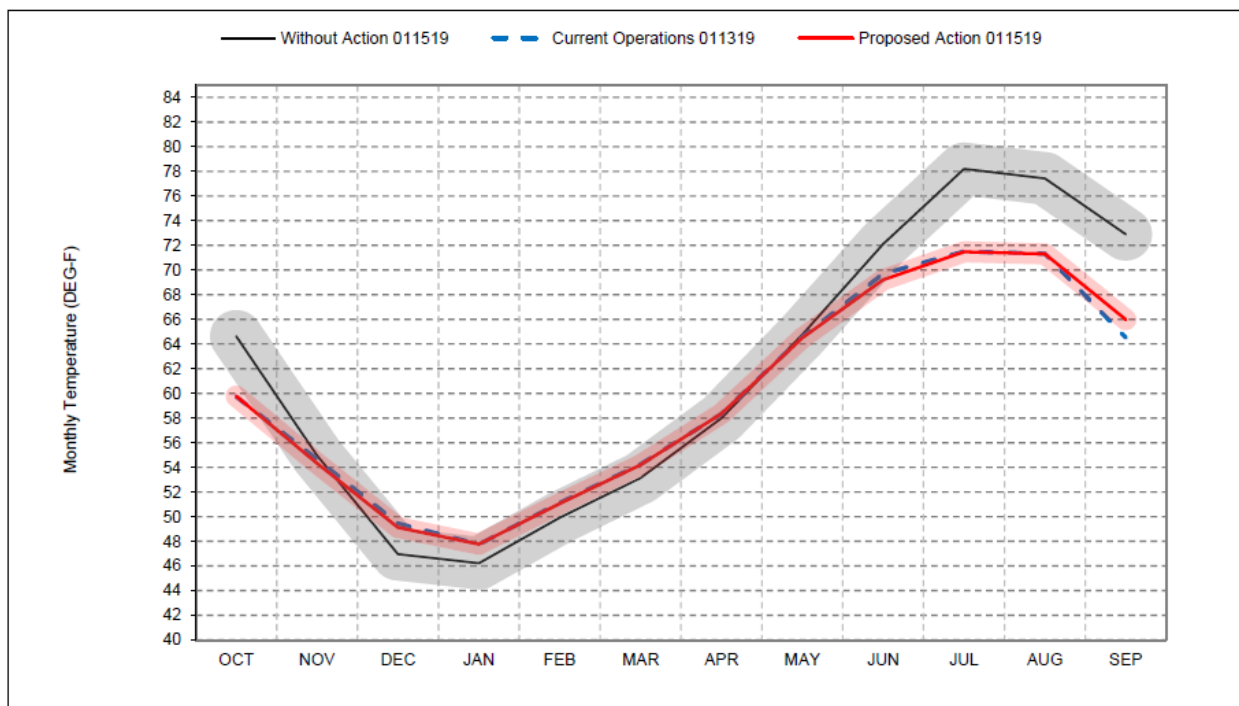


Figure 5.10-14. Long-term Average RecTemp Estimates of Feather River Water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.10-14). Water temperatures at Gridley Bridge under the WOA scenario are slightly higher than the proposed action during April and May, which coincides with the later part of the seasonal timing of CV Steelhead egg incubation and are slightly lower during the months of December to March when the risk of temperature-related stress and mortality are substantially reduced (Figures 5.10-15 through 18). Under most conditions near or above the 55°F threshold, the proposed action scenario would decrease the

likelihood of temperature-related stress and mortality occurring during the period of egg incubation. In addition, modeled water temperatures at Gridley Bridge under the proposed action indicate better likelihood of water temperature compliance at the compliance point (lower FERC project boundary).

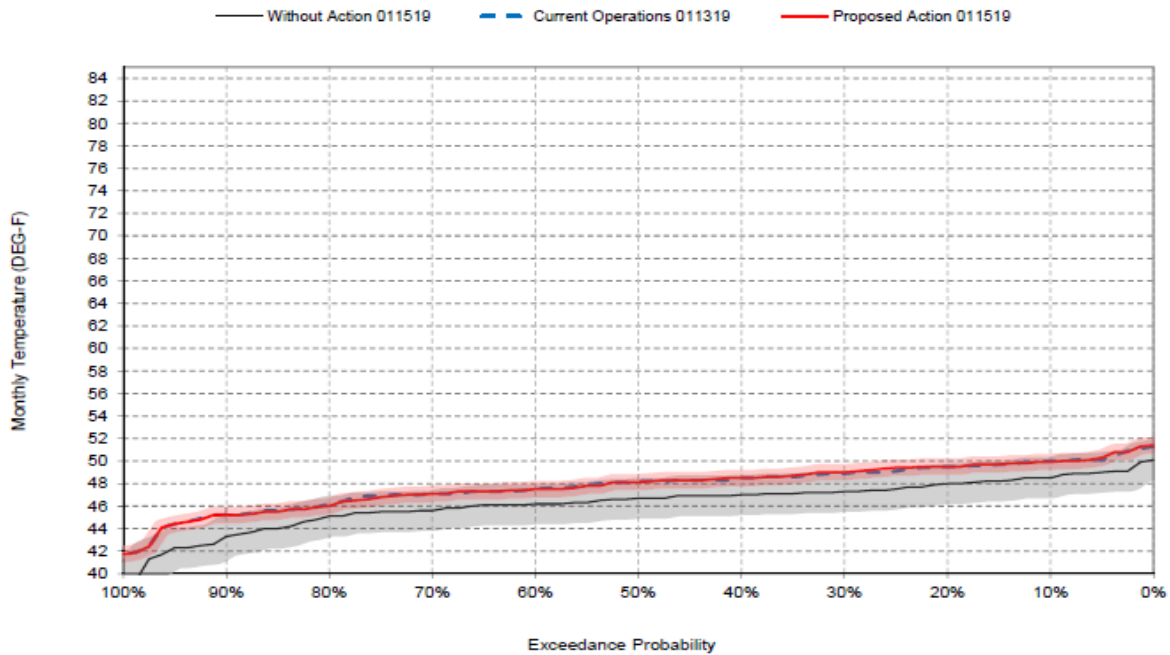


Figure 5.10-15. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for January

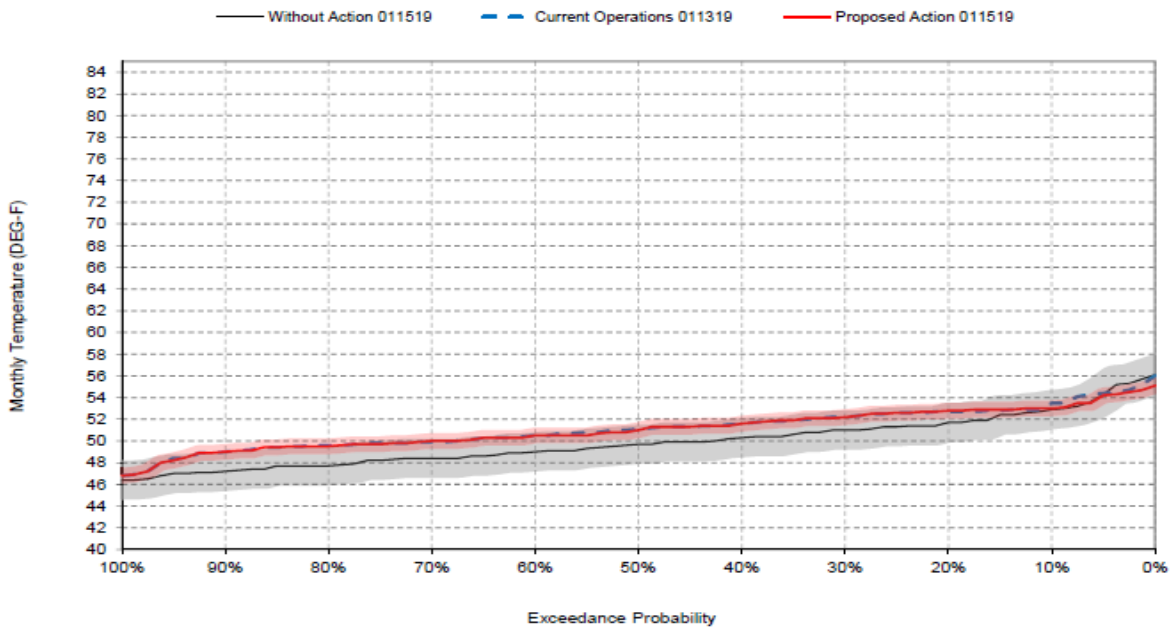


Figure 5.10-16. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for February

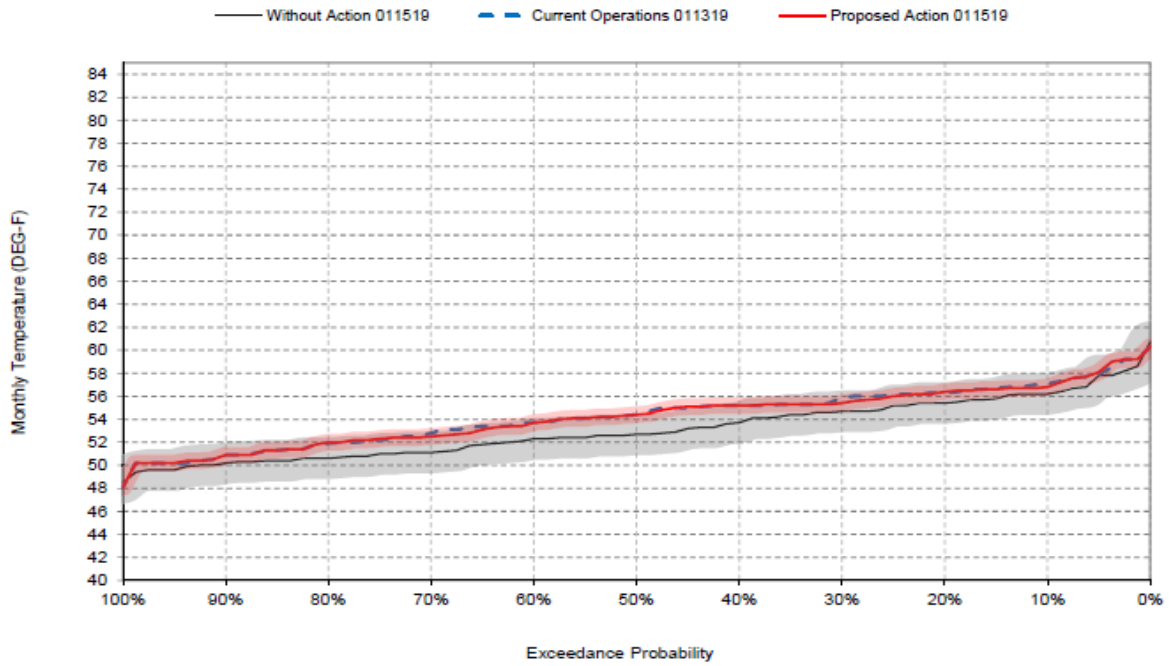


Figure 5.10-17. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for March

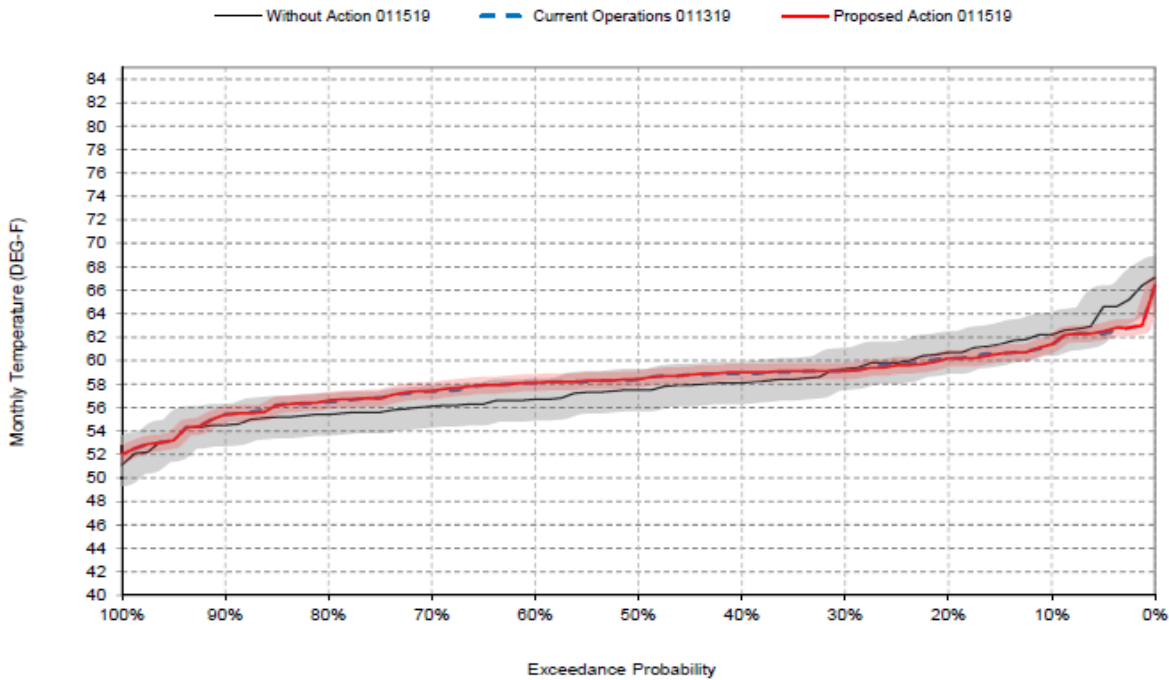


Figure 5.10-18. RecTemp Estimates of Feather River water Temperature at Gridley Bridge under the WOA, COS, and Proposed Action for April

Water temperatures exceeding the objectives and biological thresholds for this life stage of CV Steelhead would have a number of negative impacts on individuals, including acute to chronic physiological stress, potentially leading to egg mortality. Water temperatures in the Feather River HFC under the proposed action during the egg incubation period are similar to or lower than WOA water temperatures. Importantly, RecTemp model output indicates water temperatures projected under the proposed action will increase the likelihood that December to May temperature objectives are met. As a result, potential negative effects on this life stage are anticipated to be minimized under the proposed action.

5.10.3.3.2 Rearing to Outmigrating Juveniles

5.10.3.3.2.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA generally approximate or are significantly higher than flows under the proposed action during the peak seasonal timing of CV Steelhead juvenile rearing (January-May; Figure 5.10-7 through 10). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios. Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the January to May period, with relatively equal differences across the range of exceedance probabilities.

Higher WOA flows in winter and spring could have both positive and negative effects on rearing juvenile CV Steelhead. Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002). These adverse effects of low flow are generally mitigated by flow increases, but there can be adverse effects of high flows including higher stranding risk resulting from increased use of floodplain habitat and greater flow fluctuations, and higher contaminant loading from stormwater runoff.

The differences in flows between the WOA scenario and the proposed action are likely to suggest negative impacts to rearing individuals and their habitat. Higher WOA flows from January to May could result in both positive and negative effects on rearing CV Steelhead. Beneficial effects include an increase in floodplain and side-channel habitat, improved foraging conditions, reduced competition and predation, lower water temperatures and higher DO, and enhanced emigration flows. Negative effects are anticipated to be an elevated stranding risk resulting from increased use of floodplain habitat and larger flow fluctuations, and contaminant loading from stormwater runoff. The comparative magnitude of positive and negative effects of higher flows under the WOA compared to the proposed action are difficult to quantify; however, potential adverse effects of lower flows from January to May are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.10.3.3.2.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of rearing individuals. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, reduction in growth due to increased metabolic demands, decreased productivity, and eventual mortality. Rearing juvenile CV Steelhead require temperatures < 65°F for optimal development and survival, and 65-68°F for suboptimal, with temperatures above 68°F causing chronic to acute stress (Stillwater Sciences 2006). Water temperatures in the Feather River from

November to May are relatively less influenced by flow releases from Lake Oroville than in summer and fall, given the larger flow volumes, and colder air temperatures during these months.

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figures 5.10-11 through 13). Water temperatures at Gridley Bridge under the WOA are the same or lower than water temperatures under the proposed action from January to May, which coincides with the peak seasonal timing of rearing CV Steelhead. However, the risk of temperature-related stress and mortality are substantially reduced or not present during this period as water temperatures remain well within the optimal range (< 65°F) for this life stage and under the Feather River HFC temperature objectives for these months. Additionally, summer water temperatures under the proposed action, are lower than the WOA during a period at moderate risk of water temperature-related stress and mortality, decreasing the likelihood of water temperature-related stress and mortality occurring during juvenile rearing under some conditions of the WOA. As a result, potential negative effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.10-14).

5.10.3.3.3 Adult Migration from Oceans to Rivers

5.10.3.3.3.1 Flow Effects

As indicated by the SAIL Bay-Delta to Upper River (CM6) conceptual model these flows, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of migrating adult CV Steelhead (Johnson et. al., 2016, Windell et. al., 2017). Instream flow from Oroville Dam releases may also heavily influence the strength of navigational cues utilized by migrating adults and the propensity of these fish to stray from migratory pathways leading to high quality spawning habitat.

Feather River flows below Thermalito Afterbay under the WOA generally approximate or are significantly lower than flows under the proposed action during the peak seasonal timing of CV Steelhead adult migration (September and October; Table 5.10-1 & NMFS 2016). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is low under all scenarios, although some risk exists under the WOA in September and October of critically dry years, when flows are lower under the WOA than the proposed action. (Figure 5.10-7 through 10).

Modeled flows under the proposed action during this period are higher than WOA flows, and are not anticipated to decline below minimum instream flow standards, or to a level that results in increased passage or barrier issues in the Feather River HFC. Lower WOA flows from September to October could result in both positive and negative effects on migrating adult CV Steelhead. Negative effects include a decrease in floodplain and side-channel habitat, increased competition and predation, higher water temperatures and lower DO, and diminished immigration flows. Positive effects are anticipated to be a reduced stranding risk resulting from reduced floodplain access. Because the proposed action produces only modest flow increases compared to the WOA, the proposed action is anticipated to result in the benefits listed above without dramatically increasing stranding risk.

5.10.3.3.3.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can

include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult CV Steelhead require temperatures < 52°F for optimal survival, and 52-70°F for suboptimal, with temperatures above 70°F causing chronic to acute stress (Stillwater Sciences 2006).

Under the proposed action, operations and flow releases would be managed to achieve Feather River HFC temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from September to October, and water temperatures that are roughly equivalent from November to March. Water temperatures at Gridley Bridge under the proposed action are substantially lower than temperatures under the WOA from September to October, which coincides with the peak seasonal timing of migrating adult CV Steelhead. The risk of water temperature-related stress and mortality are present during this period as water temperatures are projected to be in or near the suboptimal range (52-70°F) for this life stage in October and potentially above the chronic to acute stress threshold (> 70°F) under the WOA in September (Figure 5.10-14). Water temperatures under the proposed action are slightly higher than the WOA during November to March, a period at a moderate risk of water temperature-related stress and mortality, according to RecTemp model results. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be reduced under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5-SHCV-6).

5.10.3.3.4 Adult Holding

5.10.3.3.4.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA equal or exceed flows under the proposed action during the peak seasonal timing of CV Steelhead holding (December-March; Table 5.10-1 & NMFS 2016). In particular, WOA flows are reliably higher than the proposed action in January through March. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, and all water year types. Differences in flows between the proposed action and COS are minimal during the December to March period.

Exposure to the effects of differences in flow during this life stage could include variation in water temperature and DO, and the amount and quality of holding habitat used to shelter from predators, and rest during the gamete maturation phase. Proposed action flows are lower than WOA flows in January through March; however, proposed action flows are not anticipated to decline below minimum instream flow standards or to a level that is anticipated to result in substantial loss of suitable holding habitat in the Feather River HFC. As a result, conditions for holding adult CV Steelhead will be minimally impacted during the majority of the peak seasonal timing of this life stage.

5.10.3.3.4.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of holding adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and delayed or poor gamete maturation. Holding adult CV Steelhead require water temperatures < 52°F for optimal survival, and 52-70°F for suboptimal, with temperatures above 70°F causing chronic to acute stress (Stillwater Sciences 2006).

Water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are slightly lower than those projected under the proposed action during

December to March (Figure 5-SHCV-4). Under the proposed action, water temperatures are slightly higher but within the optimal range during the peak seasonal timing of holding adult CV Steelhead. The risk of temperature-related stress and mortality is negligible during this period, as water temperatures are projected to be at or near the suboptimal range (<60.8-66.2°F) for this life stage only during March, the end of the peak seasonal timing of holding adult CV Steelhead. As a result, potential negative effects of water temperature on this life stage are not anticipated under the proposed action, even during below normal, dry, and critically dry water year types (Figure 5.10-11 through 13).

5.10.3.4 American River Seasonal Operations

5.10.3.4.1 Eggs to Fry Emergence

Under the proposed action, Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in the 2017 Flow Management Standard (FMS). Under the WOA, the 2017 FMS would not be implemented. The 2017 FMS includes a Minimum Release Requirement (MRR) with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. The objective of the planning minimum is to preserve storage to protect against future drought conditions, and to facilitate the development of the cold water pool when possible to improve habitat conditions for CV Steelhead and Fall-run Chinook Salmon.

Cool water temperatures are important for embryo survival. Water temperatures reportedly must be between 41°F and 55.4°F for maximum survival (Moyle 2002). In addition, redd dewatering protective adjustments were included in the 2017 FMS to limit potential redd dewatering due to reductions in the MRR during the January through May period coincident with the embryo incubation period. The embryo incubation and alevin development period for CV Steelhead follows the December through April spawning period. Eggs usually hatch within four weeks, depending on stream temperature, and the yolk sac fry remain in the gravel after hatching for another four to six weeks (CDFG 1996). Under the proposed action, the implementation of the proposed 2017 FMS measures would provide habitat conditions in the lower American River tailored for salmonids, particularly during drought conditions and improve conditions for this life stage relative to WOA.

5.10.3.4.2 Rearing to Outmigrating Juveniles

Under the proposed action, the planning minimum would preserve storage when compared to WOA and COS. In addition to the MRR flows, the 2017 FMS under the proposed action includes the following water temperature objectives to provide suitable water temperatures for salmonids:

- 65°F from mid-May to mid-October to provide suitable conditions for juvenile CV Steelhead rearing in the lower American River
- 60°F or less by October 1 to provide suitable conditions for Fall-run Chinook Salmon holding and early spawning (also benefits CV Steelhead)
- 56°F or less by November 1 to provide suitable conditions for Fall-run Chinook Salmon spawning and embryo incubation (also benefits CV Steelhead)

The 2017 FMS also includes the provision for spring pulse flows, with the purpose to provide a juvenile salmonid emigration cue before potentially lower flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River.

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. The proposed action would likely beneficially affect this life stage of CV Steelhead in the American River when compared to the WOA and COS scenarios.

5.10.3.5 Delta Seasonal Operations

5.10.3.5.1 Entrainment

ICF (2018) analyzed salvage of CV Steelhead at the CVP and SWP between 2003 and 2017 and found that salvage increased with export rate and decreased with San Joaquin River flow. Salvage also decreased with OMR flow. However, OMR is comprised of both exports and San Joaquin River flow which complicates attempts to understand individual effects.

Average total exports for months when juvenile CV Steelhead are present in the Delta indicate zero entrainment risk under the WOA. In the December through February period, proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H1 – Appendix H – Bay-Delta Aquatics Effects Figures) and will therefore have a similar entrainment risk. Total exports proposed for proposed action in March-June (1,699 cfs higher than COS; Figure H2 – Appendix H – Bay-Delta Aquatics Effects Figures) when juvenile CV Steelhead are most abundant in the Delta at Chipps Island (Table 5.10-1), will increase entrainment risk relative to COS.

5.10.3.5.2 Routing

Routing of juvenile CV Steelhead into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2. Juvenile CV Steelhead are present in the Sacramento River at Hood upstream of the first distributary junctions between November and early June with peak abundance from February to early June (Table 5.10-1). In the December through February period, velocity overlap between proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50 percent in Critical, Dry, Below Normal and Above Normal Years (Figure H3 – Appendix H – Bay-Delta Aquatics Effects Figures). In Wet years, velocity overlap in this reach was \leq 50 percent.

Comparing proposed action to WOA in the December-February period revealed low velocity overlap in Dry, Above Normal and Wet years with higher velocities in the WOA (Figure H4 – Appendix H – Bay-Delta Aquatics Effects Figures). Velocities were more similar in Critical and Below Normal years; however, velocities were still higher in the WOA scenario. This pattern indicates routing into the interior Delta would be lower under WOA relative to proposed action or COS (Perry et al. 2015). In the March to May period Comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H5 – Appendix H – Bay-Delta Aquatics Effects Figures) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento River mainstem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H6 – Appendix H – Bay-Delta Aquatics Effects Figures).

5.10.3.5.3 Through Delta Survival

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. To examine potential effects of the proposed action, changes in velocity distributions were examined assuming a positive correlation between

discharge and mean water column velocity for the Sacramento River at Walnut Grove and Steamboat Slough, which are both in this “transitional” region. During the December-February period at Walnut Grove, velocity distributions for proposed action relative to COS were most different in Wet Years (63.4%) with higher velocities in the proposed action. Velocities were also greater for proposed action relative to COS in Dry, Below Normal and Above Normal years although overlap was greater ($\geq 82\%$; Figure H11 – Appendix H – Bay-Delta Aquatics Effects Figures). In Critical Years, velocity distributions were almost identical (92.7%; Figure H11 – Appendix H – Bay-Delta Aquatics Effects Figures). A similar pattern was apparent for the comparison between proposed action and WOA (Figure H12 – Appendix H – Bay-Delta Aquatics Effects Figures); however, overlap was lower for each water year type (43.9 – 74.1%) with higher velocities under WOA relative to proposed action. At Steamboat Slough in the December-February period, there was a similar pattern where velocities under the proposed action were higher than COS in Wet, Above Normal and Below Normal years and similar in Dry and Critical years (Figure H13 – Appendix H – Bay-Delta Aquatics Effects Figures).

When the proposed action was compared to WOA, overlap was moderate to high with values between 45.0 and 76.6 percent (Figure X14 – Appendix H – Bay-Delta Aquatics Effects Figures). Velocities were higher under the WOA in all water year types (Figure H14 – Appendix H – Bay-Delta Aquatics Effects Figures). Results of this analysis indicate that through delta survival between December-February would be higher under the proposed action relative to COS, but potentially reduced survival relative to WOA.

When comparing the proposed action to WOA in the March through May period, velocity overlap was variable among water year types from a low of 18.7 percent in Wet years to 63.5 percent in Critical years (Figure H16 – Appendix H – Bay-Delta Aquatics Effects Figures). In all water year types, velocities were less under the proposed action relative to the WOA. Velocity overlap was lower in March through May at Steamboat Slough when proposed action was compared to WOA (Figure H18 – Appendix H – Bay-Delta Aquatics Effects Figures). The lowest value occurred in Wet years (23.2%) and highest in Critical years (74.9%). These results indicate that survival under the proposed action may be reduced due to lower water velocity compared to WOA assuming water velocity scales positively and linearly with discharge.

In the March through May period at Walnut Grove, velocity overlap between the proposed action and COS was ≥ 80 percent across all water year types with greater velocities under proposed action (Figure H15 – Appendix H – Bay-Delta Aquatics Effects Figures). At Steamboat Slough in the March through May period, overlap between the proposed action and COS scenarios was high with all values ≥ 84 percent (Figure H17 – Appendix H – Bay-Delta Aquatics Effects Figures). The small changes in velocity within transitional reaches of the Sacramento River and North Delta between the proposed action and COS suggest there could be small improvements associated with the proposed action in through Delta survival in some water year types. There would potentially be a reduction in survival under the proposed action when compared to the WOA.

5.10.3.6 Delta Cross Channel Operations

Under WOA, the Delta Cross Channel would be closed, and fish would not be entrained into the central Delta. Significant flow and many juvenile CV Steelhead enter the central Delta when the DCC gates are open. Mortality of juvenile CV Steelhead entering the central Delta is higher than for those continuing downstream in the Sacramento River. The peak migration of juvenile CV Steelhead in the Sacramento River past Knights Landing, which is upstream of the DCC, occurs from January-February (Table 5.10-1). Therefore under the proposed action, the continued operation of the DCC to protect the majority of the juvenile CV Steelhead during their migration period in the Sacramento River would reduce the proportion of fish exposed to an open DCC and result in beneficial impacts to this life stage when compared to the COS. Under WOA conditions, the DCC would remain closed, which is more protective of this life stage;

however, DCC operations under the proposed action attempt to minimize the potentially negative effects compared to WOA by closing the DCC gates during peak migration periods.

5.10.3.7 Agricultural Barriers

The Temporary Barriers Project (TBP) consists of three rock barriers across south Delta channels to improve water levels for agricultural diversions and one rock barrier to improve San Joaquin River salmonid migration in the south Delta. The temporary rock barriers are installed and removed at Middle River near Victoria Canal, Old River near Tracy, Grant Line Canal near Tracy Boulevard Bridge, and the head of Old River. The TBP is operated based on San Joaquin River flow conditions. The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30. The Head of Old River Barrier is only installed from September 16 to November 30 to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook Salmon.

5.10.3.7.1 Rearing to Outmigrating Juveniles

The proportion of juvenile CV Steelhead exposed to the TBP depends on their annual timing of installation and removal. Due to their location, primarily juvenile CV Steelhead migrants originating from the San Joaquin River would be exposed to the TBP. The peak relative abundance of juvenile CV Steelhead in the San Joaquin River in the vicinity of the TBP (Mossdale) occurs in April and May (Table 5.10-1). If the agricultural barriers are operating as early as April 15, there is potential exposure to a large proportion of the juvenile CV Steelhead migrating down the San Joaquin River.

When the Head of Old River barrier is not in place, acoustically tagged juvenile CV Steelhead have demonstrated a high probability of selecting the Old River route (Buchanan 2018[PC1]), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile CV Steelhead migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, CV Steelhead passage past the agricultural barrier was improved (DWR 2018). Therefore, although the proposed action does not include HORB, which could result in negative impacts to CV Steelhead juvenile migration, the improvements to the agricultural barriers (including flap gates tied up from May 16 to May 31) would help to reduce the negative effect of the barriers on migrating juvenile CV Steelhead during this period relative to COS. However, juvenile CV Steelhead migrating before or after this period could be exposed to the agricultural barriers with flaps down, which apparently decreases passage success and survival (DWR 2018). Therefore, the potential negative effects of the agricultural barriers under the proposed action on juvenile CV Steelhead depends on when they are installed and whether or not the flap gates are down.

Figure 5.10-19 below shows Chinook salmon survival from the Head of Old River between 3 different routes: San Joaquin River to Turner Cut, CVP via the Old River, or SWP via the Old River. Chinook Salmon survival is higher through the Old River and the CVP for flows below 3,900 cfs at Vernalis than through the San Joaquin River. This figure was generated from a slightly revised meta analysis from route-specific survival estimates from published juvenile Chinook tagging studies completed between 2008 and 2015 (e.g., Buchanan et al. 2016). Flows at Vernalis are less than approximately 3,900 cfs nearly 80 percent of the time. Finally, DWR cannot install the Head of Old River barrier at flows above 5,000 cfs; therefore, Chinook salmon survival (and, presumably, CV Steelhead) is higher through Old River the majority of the time.

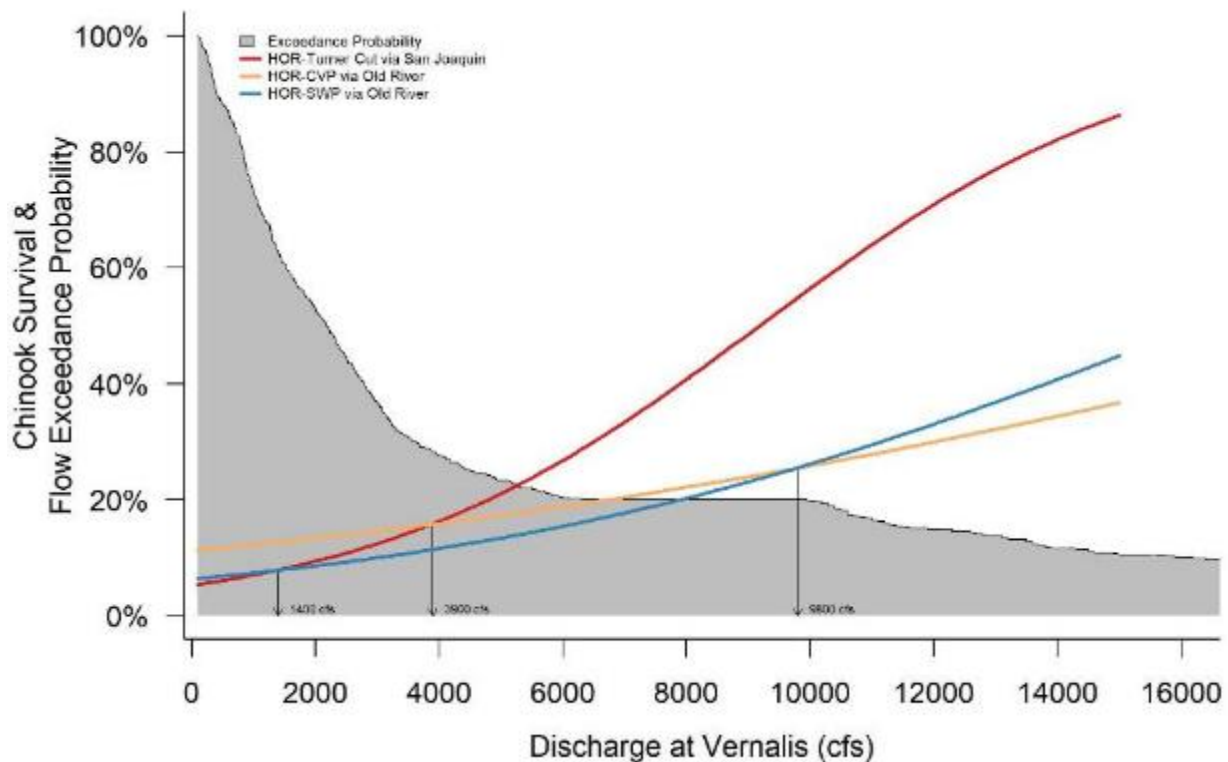


Figure 5.10-19. Chinook Salmon Survival from Head of Old River

5.10.3.8 Contra Costa Water District Rock Slough Intake

CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The subject of this consultation is the actual diversion of water through the Rock Slough Intake, covered under the NMFS 2009 biological opinion on the long-term coordinated operations of the CVP and SWP. However, since the 2009 biological opinion, the Rock Slough Fish Screen has been built, and entrainment of salmonids resulting from diverting water into the Rock Slough intake has been fully avoided. Adverse effects of fish screen operation are covered under the NMFS 2017 biological opinion.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for CV Steelhead (NMFS 2017), approximately 18 miles from the Sacramento River via the shortest route. Fish monitoring prior to the construction of the Rock Slough Fish Screen (RSFS) indicates the timing and magnitude of CV Steelhead presence near the Rock Slough Intake. Since 1994, fish monitoring has been conducted by CDFW and CCWD consistent with the separate biological opinions and permits that govern CCWD's operations. From 1994 through 1996, CDFW conducted fish monitoring at the Rock Slough Intake and in the Contra Costa Canal up to the first pumping plant. Over this period, CDFW captured a total of 36 juvenile CV Steelhead from February to May (CDFG 2002;

NMFS 2017). In the 11 years prior to construction of the RSFS (1999-2009), CCWD's Fish Monitoring Program collected a total of 15 juvenile CV Steelhead at the Rock Slough Headwords (Reclamation 2016; NMFS 2017). In addition, one adult CV Steelhead (622 mm FL, adipose fin intact) was collected and released during fish rescue efforts in November 2009, for the construction of the RSFS (Reclamation 2016). Since construction of the RSFS, one ad-clipped CV Steelhead was collected at the RSFS facility (April 24, 2012) by operation of the hydraulic rake cleaning system (Reclamation 2016; Tenera 2018a). Based on the size, the CV Steelhead was likely a hatchery released smolt (Reclamation 2016, Appendix A).

On July 3, 2017, NMFS issued a biological opinion (NMFS 2017) that considered improvements to the RSFS facility including the hydraulic rake cleaning system, operations and maintenance (O&M) of the RSFS and associated appurtenances, and administrative actions such as the transfer of O&M activities from Reclamation to CCWD. NMFS determined that the O&M of RSFS may result in the incidental take of juvenile CV Steelhead and provided an incidental take limit based upon the number of listed fish collected in the pre and post-construction RSFS monitoring (NMFS 2017). The incidental take provided in NMFS 2017 is 10 juvenile and 10 adult CV Steelhead per year.

5.10.3.8.1 Rearing to Outmigrating Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile CV Steelhead are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmonids can be "drawn" into the south Delta under reverse flows and high CVP and SWP pumping rates. One indicator of reverse flows is the net flow in OMR. Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect OMR, and any effect that diversions at Rock Slough Intake under the proposed action would have in the OMR corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants. For juveniles that migrate down the Old and Middle River corridor that are not salvaged at TFCF or Skinner Fish Facility, any effect of Rock Slough Intake diversions would be a positive effect on OMR.

For juveniles that migrate down the mainstems of the Sacramento or San Joaquin Rivers and for juveniles that were salvaged, trucked, and released in the western Delta, the potential effect of Rock Slough diversions on the net reverse flow in San Joaquin River may be relevant. The effect of water diversions at Rock Slough Intake on the velocity in the San Joaquin River at Jersey Point is presented in the effects analysis for juvenile Winter-run. As detailed in that section, the maximum potential effect of water diversions at Rock Slough Intake (assuming diversions at the maximum permitted capacity of 350 cfs and all water diverted by the Rock Slough Intake comes from the San Joaquin River at Jersey Point) is 0.00625 ft/sec in the San Joaquin River at Jersey Point. For comparison, the velocity threshold for design of fish screens to prevent impingement of salmonids is 0.33 ft/sec, which is 50 times the maximum possible contribution from the Rock Slough diversions.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, the combined effect of all three intakes was examined. CCWD's Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect salmonids from diversions in the vicinity of fish screens (0.33 ft/sec) is over 21 times greater than the maximum possible contribution from CCWD's combined physical capacity. The water diversions at the Rock

Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile CV Steelhead.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. As shown in the Winter-run section, the diversions at the Rock Slough Intake could move a neutrally buoyant particle in the San Joaquin River at Jersey Point approximately 540 ft over the course of the day. For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location. Although the diversions at Rock Slough Intake are not likely to impact juvenile CV Steelhead, the aggregate effect of all water diversions in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.10.3.8.2 Adult Holding

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult CV Steelhead are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult CV Steelhead that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). As illustrated in NMFS 2017 (Figure 10), water diversions at the Rock Slough Intake reduce the ebb tidal flows through the RSFS. Thus, the diversion of water at the Rock Slough Intake under the proposed action, which is the subject of this consultation, reduces the false attraction created by the ebb tides existing the Contra Costa Canal. Furthermore, it is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs. Although the likelihood that adult CV Steelhead will be present near the Rock Slough Intake is low, a small number of fish could stray into Rock Slough, or be attracted by the flows exiting the Contra Costa Canal on ebb tides.

5.10.3.9 *North Bay Aqueduct*

Under the proposed action, there would be no changes to operational criteria at the NBA's BSPP relative to current operations and WOA. Juvenile CV Steelhead could occur in the vicinity of the BSPP; however, the fish screens used at the facility are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment and greatly minimize impingement of fish against the screen itself (NMFS 2009). In addition, the location of the facility is well off the typical migration corridor of juvenile CV Steelhead (NMFS 2009: 417). No juvenile CV Steelhead have been captured during CDFW monitoring surveys from 1996 to 2004 (<http://www.delta.dfg.ca.gov/data/nba>).

5.10.3.10 Water Transfers

CV Steelhead juveniles could be exposed to increased entrainment, predation, and decreased through-Delta survival as a result of the expanded transfer window under the proposed action, but as the peak of the juvenile outmigration is in the spring, effects are anticipated to be minimal. No other lifestages of CV Steelhead would co-occur in time and space with water transfers from the Delta.

5.10.3.11 Clifton Court Forebay Aquatic Weed Program

Under the proposed action, the application of aquatic herbicide to the waters of CCF will occur during the summer months of July and August. Juvenile CV Steelhead abundance in the Delta peaks between March and May (Table 5.10-1). Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70°F by mid-June. As such, it is unlikely that juvenile CV Steelhead would be rearing near this location after mid-June and the potential application of aquatic herbicide would only occur well after the peak outmigration period (Table 5.10-1) and therefore CV Steelhead are not expected to be exposed to herbicide application activities.

Mechanical harvesting would occur on an as-needed basis and therefore listed salmonids could be exposed to this action, if entrained into the CCF. Potential direct and indirect effects to listed fish species from mechanical weed harvesters include mortality or injury from harvester strikes, entanglement in weeds lifted from the water, reduction of aquatic prey species, and temporary disturbances. Increased boat noise and disturbance of the water during harvesting, the slow speed of the harvester (approximately 2 miles per hour), and beginning harvesting closest to the edge should allow fish to escape the area proposed for mowing. However, CV Steelhead are unlikely to be present and exposed to the adverse effects due to extreme temperatures.

5.10.3.12 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May under the proposed action coincides with downstream migration of juvenile CV Steelhead (Table 5.10-1). Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. No data are available to estimate the abundance of juvenile CV Steelhead thus, the proportion of the total run utilizing this route is unknown. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.10.3.12.1 Roaring River Distribution System

Under the proposed action, the Roaring River Distribution System water diversion intake is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s (for Delta Smelt protection), excluding juvenile CV Steelhead from entrainment (NMFS 2009: 437).

5.10.3.12.2 Morrow Island Distribution System

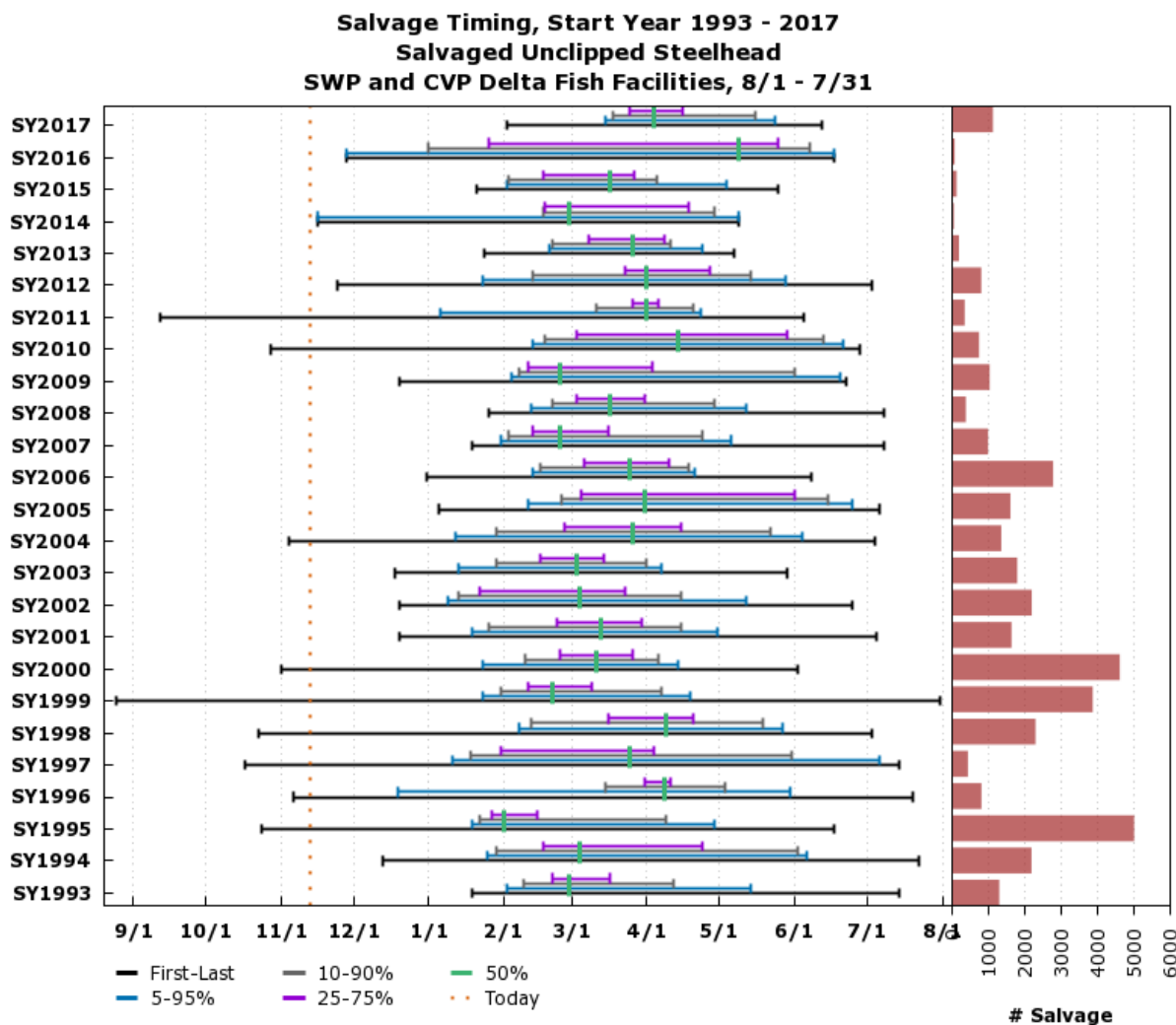
The MIDS diverts water from Goodyear Slough through three 48-inch diameter culverts during high tide. Although the MIDS intakes do not currently have fish screens, it is unlikely juvenile CV Steelhead will be entrained into the water distribution system because CV Steelhead have not been caught in past surveys. Also, the large size and better swimming ability of juvenile listed salmonids in the Delta allow these fish to avoid entrainment at MIDS. In addition, the location of the MIDS intake on Goodyear Slough further reduces the risk of entrainment. Goodyear Slough is not a migratory corridor for CV Steelhead. The operation of the MIDS under the proposed action would not impact CV Steelhead.

5.10.3.12.3 Goodyear Slough Outfall

Goodyear Slough Outfall improves water circulation in the Suisun Marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough. Due to its location and design, CV Steelhead are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall likely benefits CV Steelhead in Suisun Marsh by improving water quality and increasing foraging opportunities.

5.10.3.13 *OMR Management*

As shown in Figure 5.10-20 below, at CVP and SWP fish facilities in the Delta, between 0 and approximately 5000 juvenile CV Steelhead are currently caught each year. Exports are expected to increase slightly under the proposed action, and therefore salvage of CV Steelhead is also expected to increase under the proposed action. Restricting OMR flows to -5,000 cfs will reduce or avoid entrainment. Triggers based on salvage that further restrict OMR will further reduce entrainment. Enhanced monitoring and predictive tools will further reduce entrainment while increasing operational flexibility. OMR management under the proposed action will reduce the entrainment effects of the proposed action on CV Steelhead.



www.cbr.washington.edu/sacramento/

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Figure 5.10-20. Sac PAS Salvage Unclipped Steelhead

5.10.3.14 Stanislaus River Operations - Stepped Release Plan

CV Steelhead in the Stanislaus River are found mostly in the reach from Goodwin Dam downstream to Oakdale (Kennedy 2008). Under the WOA, CV Steelhead distribution would be similar to the proposed action and COS as Goodwin Dam would still represent a complete physical barrier to further upstream migration. Steelhead on the Stanislaus River generally move upstream to spawn between July and March, and juvenile steelhead outmigrate between January and June (NMFS, 2014).

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries.

5.10.3.14.1 River Flow

Modeled flows below Goodwin Dam are depicted below in Figure 5.10-21. Stanislaus Modeled Flows. Under WOA conditions, flows are highest in February and July. Flows drop below 500 cfs from August to October. August and September flows are often 0 cfs (see Figure below). April and May flows range from 0 cfs in the driest years to over 1,400 cfs in the wettest.

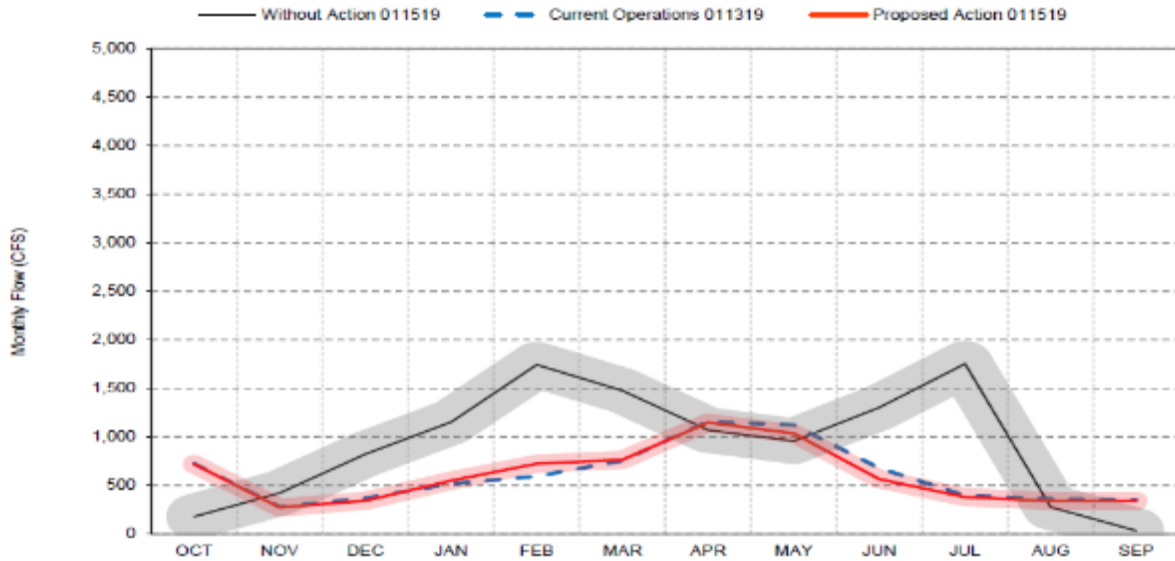


Figure 5.10-21. Stanislaus River Flow below Goodwin Dam under WOA, Current Operations Scenario (COS) and Proposed Action Scenario

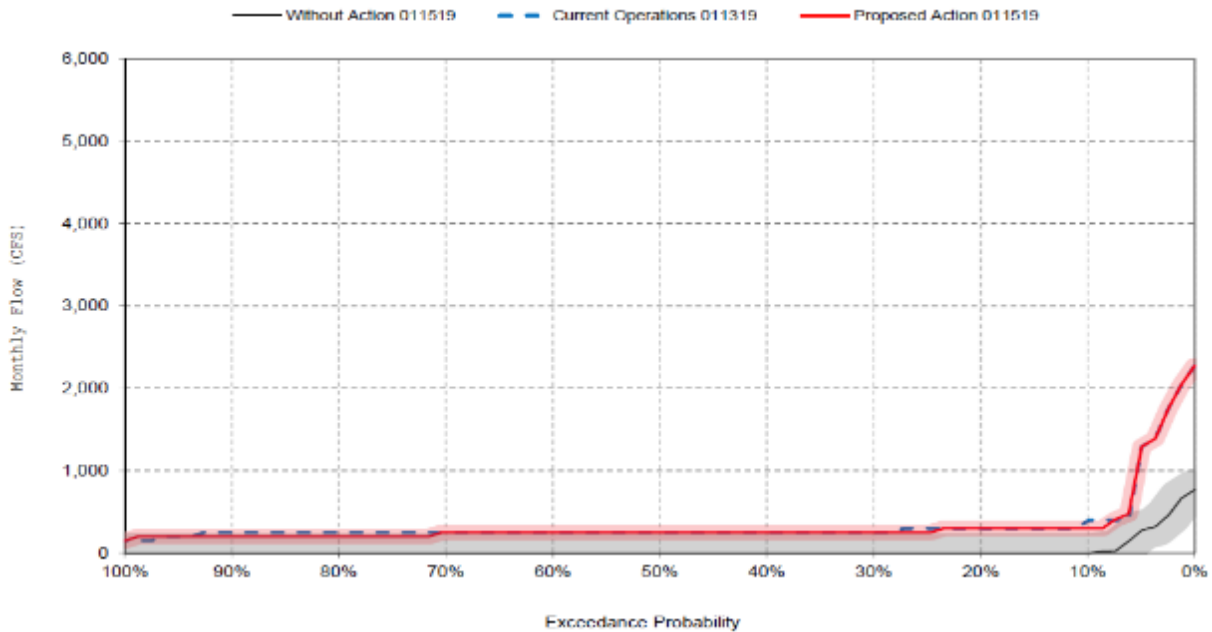


Figure 5.10-22: Stanislaus River Flows below Goodwin Dam, September Exceedance

Under the proposed action, flows are at least 200 cfs year-round in all water year types. As compared to WOA, the proposed action has lower flows in November to March and some wet June and July's (late snowmelt runoff). The proposed action has higher flows than WOA in April through October of most years.

5.10.3.14.2 Water Temperature

The Stepped Release Plan promotes increased storage at New Melones Reservoir. Over time, increased total storage would promote the development of a larger cold water pool. Recognizing that there is no ability for Reclamation to release water from different depths at New Melones, increased water depth above the static intake structure would function like a thermal cap, keeping the water below cooler. More cold water in New Melones Reservoir may lower water temperatures downstream of Goodwin Dam, which would benefit CV Steelhead in all life stages in the lower Stanislaus River.

As can be seen in Figure 5.10-23 below, the proposed action greatly decreases water temperatures in May through October as compared to WOA, and the proposed action increases temperatures between December and March as compared to WOA.

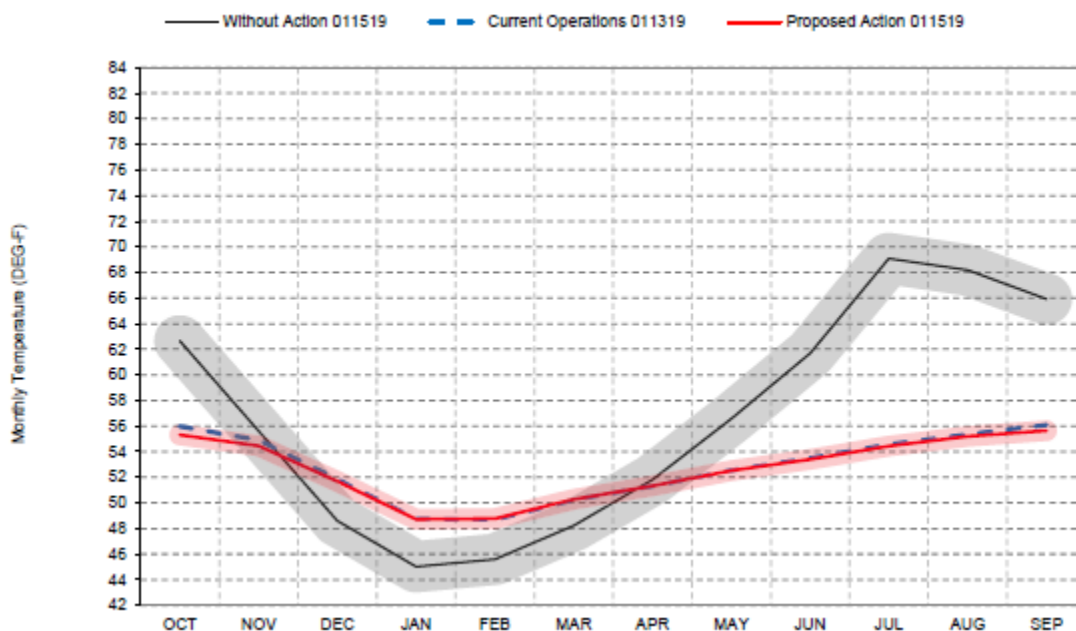


Figure 5.10-23: Stanislaus River below Goodwin Dam, Long-term Average Temperatures by Month

5.10.3.14.3 Egg to Fry Emergence (January – March)

A water temperature of 53°F provides a reasonable threshold for evaluating the potential for adverse temperature effects to spawning and egg incubation (USEPA, 2003). This reference, however, is based on Pacific Northwest fish.

Under the WOA, temperatures in the Stanislaus River below Goodwin Dam are below 53 degrees Fahrenheit between January and March in all years. Under the proposed action, temperatures are also below 53 degrees in all years, although temperatures are a few degrees higher than WOA. Therefore, proposed action is not anticipated to have impacts on the egg to fry emergence lifestage.

5.10.3.14.4 Juveniles (January – June)

Under WOA, flows in March, the peak of juvenile outmigration, range from 121 cfs to 2,380 cfs. Under the proposed action, flows during this period range from 200 cfs to 1,528 cfs. Higher flows in March under the proposed action would benefit rearing and outmigrating juvenile CV Steelhead by increasing the inundated area of rearing habitat, stimulating food production and primary productivity, increasing cover and habitat complexity, and increasing ability to avoid predators.

For juvenile rearing and outmigrating temperatures, the USEPA recommends 61 degrees Fahrenheit, although this is based on Pacific Northwest fish. Under WOA, approximately 50% of June months would exceed this threshold. Under the proposed action, all months between January and June are modeled to have Stanislaus River water temperatures below 61 degrees Fahrenheit. This would be a slight benefit of the proposed action to outmigrating juvenile CV Steelhead, avoiding temperature stress for the last outmigrats.

5.10.3.14.5 Migrating Adults (July – March)

During July through March, the WOA has flows ranging from 0 cfs in most Augusts and Septembers to approximately 6,800 cfs in occasional wetter July months. Under WOA, CV Steelhead adults would not be able to migrate up to spawning habitat below Goodwin Dam in August or September, or approximately half of July months. The proposed action flows during the CV Steelhead adult migration window range from a minimum of 200 cfs during the summer to approximately 1,500 cfs in some March months. Under the proposed action, CV Steelhead adults would be able to reach the spawning grounds in all months due to minimum 200 cfs flows. The proposed action benefits CV Steelhead by allowing adult migration during their entire window.

The USEPA-recommended 7DADM water temperature for holding adults is 68°F. Although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM, it is appropriate for comparison to monthly averaged temperature model results. Under the WOA, temperatures during the adult migration window for CV Steelhead on the Stanislaus River below Goodwin Dam range from 43.6 degrees in January in some years to 72 degrees in some July months. In the without action, temperatures would be above 68 degree Fahrenheit migrating adult threshold in 70% of July months, 60% of August months, 30% of September months, and then is below 68 degrees for the rest of the adult migration window. Temperatures would be below the 61 degrees Fahrenheit adult holding threshold in the without action in November through March in all years under the Without Action. Under the proposed action, temperatures would be below 68 degrees and below 61 degrees from July through March in all water years. The largest differences between the WOA and the proposed action are in January, where the proposed action is up to 4 degrees Fahrenheit warmer than WOA but still below CV Steelhead temperature thresholds, and in September, where the WOA is 12 degrees Fahrenheit warmer than the proposed action and exceeds adult migration as well as adult holding temperatures. Therefore, the proposed action also provides a temperature benefit to CV Steelhead, by providing optimal temperatures during their entire adult migration window.

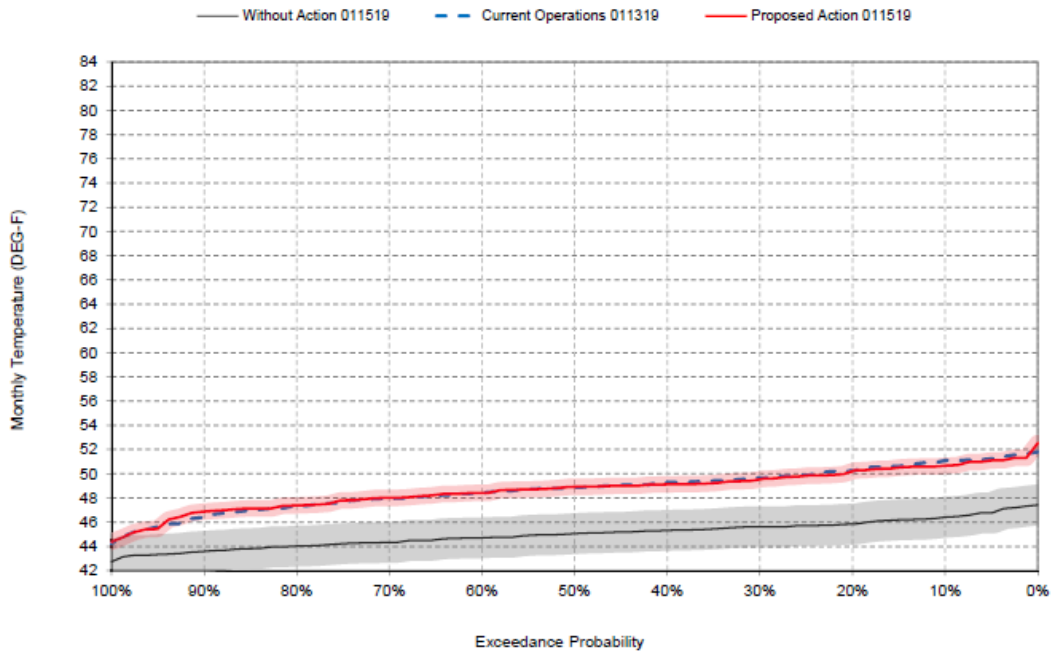


Figure 5.10-24: Exceedance Probability of January Temperatures below Goodwin Dam

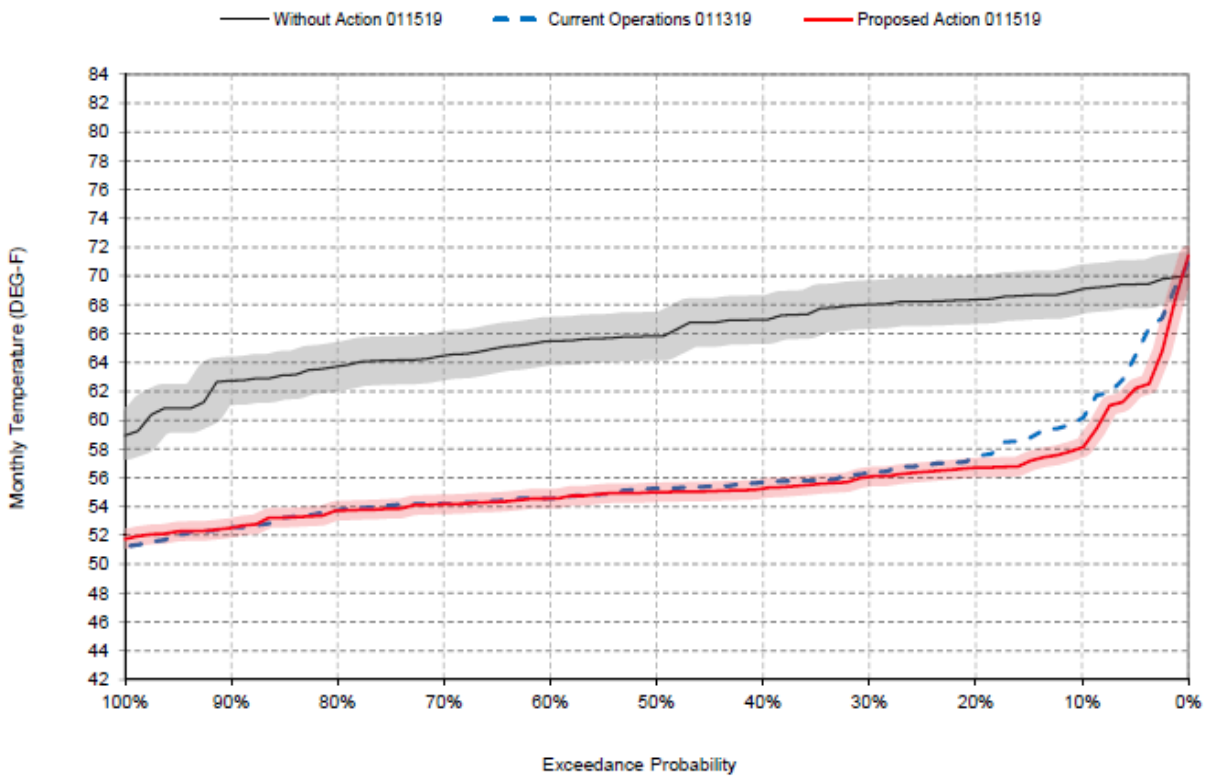


Figure 5.10-25: Exceedance Probability of September temperatures in the Stanislaus River below Goodwin Dam

5.10.3.15 Stanislaus River Dissolved Oxygen

Reclamation currently operates to meet a DO requirement on the lower Stanislaus River of 7.0 mg/L at Ripon from June 1 to September 30. Under the proposed action, Reclamation would operate to meet the same DO requirement at Orange Blossom Bridge, approximately 31 miles upstream from Ripon, where salmonids are primarily located at that time of year.

5.10.3.15.1 Rearing to Outmigrating Juveniles

Based on multi-year observations of salmonid abundance in the Stanislaus River, Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that DO concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Because the fish are generally located at least twice this distance upstream, the DO concentration there is likely to be higher than at the Stanislaus River Weir. The majority of juvenile CV Steelhead are found at locations where summer DO levels would meet or exceed 7 mg/L.

5.10.3.15.2 Adult Migration from Ocean to Rivers

Based on the typical seasonal occurrence of this life stage in the Stanislaus River (mid-January to late June), adult migrating CV Steelhead would not be expected to be exposed to the effects of altering the DO requirements at Ripon.

5.10.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the proposed action and are beneficial in nature. The following analysis looks not only at the construction related effects of the measures, but also the benefits to the population once completed. Conservation measures would not occur under WOA conditions.

5.10.4.1 *Lowering Intakes Near Wilkins Slough*

5.10.4.1.1 Eggs to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to CV Steelhead. The installation of new diversions and screens that would operate at lower flows would indirectly benefit fish of all life stages. Specifically, operation of diversions near Wilkins Slough at lower flows could increase Shasta and Trinity water storage and cold-water pool. As a result, additional water may be available for Keswick releases to:

- Improve water temperatures and dissolved oxygen during egg incubation;
- Improve water quality, and subsequently increase redd quality and decrease the risks of pathogens and disease; and
- Reduce the risks of redd dewatering and stranding.

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter. Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (OCAP BA 2008). In the upper

Sacramento River spawning occurs between November 15 through April, peaking in November through December and during April. Fry are present for another four to six weeks within the gravel (OCAP BA 2008) prior to moving into shallow protected areas associated with the stream margin (OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, CV Steelhead are not likely to spawn there and subsequently there is a very low potential for eggs and fry to be present. The lack of suitable habitat, implementation of an in-water work window (June 1 through October 1), and other AMM's identified in Appendix E minimizes the potential for CV Steelhead egg and fry to be affected by the action.

5.10.4.1.2 Rearing to Outmigrating Juveniles

The fish screens would directly benefit rearing and outmigrating juvenile Steelhead by reducing mortality risks from entrainment, thus increasing the survival of rearing and outmigrating juveniles, and in turn potentially increasing successful CV Steelhead recruitment. The installation of new diversions and screens that operate at lower flows would indirectly benefit rearing and outmigrating juvenile CV Steelhead. Specifically, this action could increase Shasta and Trinity water storage. As a result, additional water may potentially be available for Keswick releases and spring pulse flows that would:

- Provide access to floodplains, side channels, and refuge habitat;
- Decrease predation risks to outmigrating juveniles; and
- Increase emigration cues.

CV Steelhead rear year-round in the upper Sacramento River basin (OCAP BA 2008). Construction activities have the potential to affect rearing CV Steelhead that move downstream and through Wilkins Slough. Rearing CV Steelhead have the potential to be exposed to temporary increases to turbidity and associated decrease in DO, underwater noise associated with construction of a cofferdam for in-water work. Additionally, the installation of a cofferdam (if needed) increase the risk of mortality of Steelhead through fish rescue operations required to remove fish from the dewatered work area. Implementation of an in-water work window (June 1 through October 1), and other AMM's identified in Appendix E, aim to minimize the duration and likelihood of these potentially adverse effects to rearing CV Steelhead.

CV Steelhead emigrate downstream from the Upper Sacramento River basin between November and July, with peak emigration occurring January through March. Construction activities would not affect emigrating Steelhead as an in-water work window (June 1 through October 1) would be implemented, in addition to other standard AMM's.

5.10.4.1.3 Adult Migration from Ocean to Rivers

The installation of new diversions and screens near Wilkins Slough that would operate at lower flows would indirectly benefit migrating adult CV Steelhead. Specifically, this action could increase Shasta and Trinity water storage and cold-water pool. As a result, additional water may potentially be available for Keswick releases that would:

- Decrease water temperatures and increase DO during adult migration;
- Decrease the risks of disease and pathogens;
- Decrease concentrations of contaminants; and
- Increase migration cues and decrease straying.

Adult CV Steelhead migrate from the ocean to spawning grounds during much of the year, with peak migration occurring in the fall or early winter. Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (OCAP BA 2008). Implementation of an in-water work window (June 1 through October 1) would reduce the effects on migrating Steelhead; however, the onset of in-water work would occur prior to the peak of migration (end of September). Any CV Steelhead that may be present in Wilkins Slough during the onset of in-water construction activities may be exposed to temporary increases in turbidity and associated DO, and underwater noise associated with the construction of a cofferdam. Additionally, fish rescue activities may need to occur, thus increasing the risk of survival associated with moving fish within the coffered area to the mainstem of the slough. Reclamation will coordinate with the resource agencies prior to the onset of construction activities to determine if any other AMM's are required.

5.10.4.1.4 Adult Holding

Historically adult CV Steelhead maintained several strategies during their migration to natal rivers in preparation for spawning. Some CV Steelhead return several months prior to spawning and hold over in pools while sexually maturing, others sexually matured in the ocean before returning to freshwater (Williams 2006). The former life-history strategy required suitable cold-water habitat for holding. However, anadromous CV Steelhead predominantly mature in the ocean (McEwan 2001) and do not hold prior to maturation and spawning. Wilkins Slough does not contain suitable habitat (cold water) for holding nor is this a common life-history strategy expressed in CV Steelhead. Therefore, construction activities are not anticipated to affect holding CV Steelhead due to implementation of an in-water work window (June 1 through October 1) and other AMM's identified in Appendix E.

5.10.4.2 *Shasta TCD Improvements*

5.10.4.2.1 Eggs to Fry Emergence

Water temperature has a major influence on CV Steelhead, directly affecting survival, growth rates, distribution, and developmental rates (NMFS 2009). Steelhead embryo incubation period (i.e., January through May) occurs in the winter and spring following spawning. The implementation of the proposed Shasta TCD would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage. Therefore, this action would have high-level population benefits on this life stage of CV Steelhead.

5.10.4.2.2 Rearing to Outmigrating Juveniles

Water temperature can affect juvenile rearing and outmigration and adult immigration and holding within the Sacramento River. CV Steelhead can be found where daytime water temperatures range from nearly 32°F to 81°F in the summer, although mortality may result at extremely high (i.e., > ~73°F) water temperatures if the fish have not been gradually acclimated (Moyle 2002). Juvenile CV Steelhead in northern California rivers reportedly exhibited increased physiological stress, increased agonistic activity, and a decrease in forage activity after ambient stream temperatures exceeded 72°F (Nielsen et al. 1994). Since juvenile CV Steelhead rear in streams for 1-3 years and are present year round (Table 5.10-1), they would be affected by the effects of drought related excessively high water temperatures. The implementation of the proposed Shasta TCD would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead.

5.10.4.2.3 Adult Migration from Ocean to Rivers

Adult CV Steelhead are affected by excessively high water temperatures due to their presence within the Sacramento River in the summer and fall. The implementation of this action would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage.

5.10.4.2.4 Adult Holding

As discussed above, the implementation of the proposed Shasta TCD would improve Reclamation's ability to manage temperatures in the Sacramento River and meet water temperature requirements for CV Steelhead, improving conditions for this life stage.

5.10.4.3 *Sacramento River Spawning and Rearing Habitat*

The creation of side channel and rearing habitat under the proposed action would increase the quality and quantity of off channel rearing and spawning areas in the Sacramento River. These habitat restoration activities would improve the riparian habitat available for emerging CV Steelhead fry, providing an overall benefit to the species.

Based on the proposed in-water work windows for the upper Sacramento River (AMM2), CV Steelhead adults, eggs, and alevins would be subject to potential adverse effects from proposed spawning (e.g., gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants.

Although these potential effects may be unavoidable, exposure of the CV Steelhead population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3-5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.10.4.4 *Small Screen Program*

5.10.4.4.1 Egg to Fry Emergence

CV Steelhead in the egg-to-emergence life stage would not be expected to be exposed to the effects of operation or construction of screens on water diversion intakes based on the seasonal occurrence of this life stage in the Sacramento River, and the geographic location of redds away from diversions. This life stage occurs over a 2-2.5 month period from mid-February through June following the December to April Steelhead spawning period (NMFS 2009), which is outside of the timing of the in-water construction (August–October).

5.10.4.4.2 Rearing to Outmigrating Juveniles in the Rivers

The operation of fish screens on water diversions under the proposed action would benefit juvenile CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for negative impacts to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage.

Juvenile CV Steelhead rearing and outmigrating in the Sacramento River may be exposed to the effects of construction of screens under the proposed action since juvenile CV Steelhead spend one to three years in freshwater prior to migration to the ocean (CDFG 1996). Juvenile CV Steelhead may be found in the work area of these projects. Potential short-term negative impacts may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. CV Steelhead juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.10.4.4.3 Rearing to Outmigrating Juveniles in the Bay Delta

Fish screens under the proposed action would also benefit this lifestage in the same ways described above. Juvenile CV Steelhead outmigrating in the Bay-Delta may be exposed to the effects of construction of screens since they migrate downstream during most months of the year, with a peak emigration period in the spring and a smaller peak in the fall (Hallock et al. 1961). Juvenile CV Steelhead may be found in the work area of these projects; however, AMMs would minimize impacts.

5.10.4.4.4 Adult Migration

The operation of fish screens on water diversions under the proposed action would benefit adult migrating CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. Adult CV Steelhead may be exposed to the effects of construction of screens on water diversion intakes associated with the proposed action based on the overlap of timing of in-water construction (July 15 – October 15) and the timing this life stage in the Sacramento River. AMMs would minimize effects.

5.10.4.4.5 Adult Holding

The operation of fish screens on water diversions under the proposed action would benefit CV Steelhead by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. Adult CV Steelhead holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes associated with the proposed action due the overlap of the timing of in-water construction (August–October), and the seasonal occurrence of this life stage in the Sacramento River. AMMs would minimize effects.

5.10.4.5 *Adult Rescue*

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult CV Steelhead, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of CV Steelhead of all lifestages in the Sacramento River and its tributaries.

5.10.4.5.1 Egg to Fry Emergence

Given that this life stage is carried out in gravel substrates and adult rescue activities would occur downstream of CV Steelhead spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.5.2 Rearing to Outmigrating Juveniles in Rivers

Although CV Steelhead are less likely to use floodplain habitat, including the Yolo and Sutter bypasses, than Chinook salmon, there is a potential for juveniles to occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities.

The number of juvenile CV Steelhead that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile CV Steelhead exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on the timing of collection, as fish collected later in the season when water quality conditions (e.g., water temperature) generally are more stressful for fish may make juveniles more susceptible to injury and stress-related effects. The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with increased numbers of adult CV Steelhead returning to spawning grounds. As such, the overall population-level negative effects on this life stage of CV Steelhead from adult rescue activities would be low relative to WOA conditions (i.e., no rescue of adult CV Steelhead in Yolo and Sutter bypasses).

5.10.4.5.3 Rearing to Outmigrating Juveniles

Given that this life stage is carried out in the Bay-Delta and adult rescue activities would occur upstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.5.4 Adult Migration from Ocean to Rivers

Exposure of this life stage to adult rescue effects would be restricted only to those adult CV Steelhead that become stranded in the Yolo and Sutter bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter

bypasses would be unaffected by adult rescue activities. The number of adult CV Steelhead that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult CV Steelhead exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8. As such, it is concluded that the overall population-level negative effects on this life stage of CV Steelhead from adult rescue activities would be low relative to WOA conditions (i.e., no rescue of stranded adult CV Steelhead in Yolo and Sutter bypasses).

5.10.4.5.5 Adult Holding

Given that this life stage is carried out in the upper Sacramento River and its tributaries and adult rescue activities would occur downstream in the Yolo and Sutter bypasses, there would be no direct effects on this life stage from implementing adult rescue activities.

5.10.4.6 Juvenile Trap and Haul

The operation of juvenile trap and haul is targeted towards juvenile CV Steelhead, with the goal of increasing the survival of juveniles and, ultimately, returning adults. This effort could increase the number of CV Steelhead of all lifestages in the Sacramento River and its tributaries.

5.10.4.6.1 Egg to Fry Emergence

Given that this life stage is carried out in gravel substrates and temporary juvenile collection weirs would be placed downstream of CV Steelhead spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing juvenile trap and haul activities.

5.10.4.6.2 Rearing to Outmigrating Juveniles in Rivers

The number of juvenile CV Steelhead that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.10-1). Individual juvenile CV Steelhead exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release.

Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of CV Steelhead. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions (i.e., no trapping and hauling of juvenile CV Steelhead during drought years) and would be potentially offset by benefits (i.e., increased juvenile

survival and ultimately increased adults returning to spawn) associated with the juvenile trap and haul program.

5.10.4.6.3 Rearing to Outmigrating Juveniles in Bay-Delta

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile CV Steelhead trapped in the Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta. Wild juveniles that migrate in-river to the Bay-Delta (either before December 1 or that avoid capture by the temporary juvenile collection weirs after December 1) would not be affected by juvenile trap and haul activities. Potential effects associated with juvenile trap and haul on this life stage would be same as those described for Winter-run Chinook Salmon juveniles. The risk from these potential effects would be minimized through application of AMM8, and any potential adverse effects on individual juvenile CV Steelhead would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of CV Steelhead. As such, the overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions.

5.10.4.6.4 Ocean Juvenile to Ocean Adult

Exposure of this life stage to trap and haul effects would be restricted only to those juvenile CV Steelhead trapped in the Sacramento River and subsequently released to the lower Sacramento River and/or Bay-Delta, and that enter the ocean. Wild juveniles that migrate in-river to the ocean would not be affected by juvenile trap and haul activities. The overall population-level negative effects on this life stage of juvenile CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions.

5.10.4.6.5 Adult Migration from Ocean to Rivers

Exposure of this life stage to trap and haul effects would be restricted only to those adult CV Steelhead that were trapped in the Sacramento River as juveniles and subsequently released to the lower Sacramento River and/or Bay-Delta as part of the juvenile trap and haul program. Ocean adults that had out-migrated in-river as juveniles would not be affected by juvenile trap and haul activities. Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with suitable habitat may compete with native-run adults for spawning space, excavate or superimpose their redds on the redds of native-run fish, or spawn with native-run fish, thereby introducing genes from neighboring populations that have strayed into the river. However, it is concluded that the overall population-level negative effects on this life stage of adult CV Steelhead from juvenile trap and haul activities would be low relative to WOA conditions and would be potentially offset by benefits (i.e., increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

5.10.4.6.6 Adult Holding

Because juvenile trap and haul would target only wild juveniles during outmigration, adult CV Steelhead holding in rivers would not be directly affected by juvenile trap and haul activities. However, because the purpose of juvenile trap and haul activities is to increase the survival rate of juveniles during drought years, the number of adults holding in rivers potentially would be greater relative to the WOA conditions as a result of increased juvenile survival and, ultimately, increased adult spawners.

5.10.4.7 *Spawning and Rearing Habitat (American River)*

5.10.4.7.1 Eggs to Fry Emergence

Eggs and emerging fry would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River. Effects include an increase in total spawning habitat area, improved intragravel incubation conditions and reduced likelihood of redd superimposition. Therefore, this action would benefit this life stage of CV Steelhead.

No eggs and emerging fry would be exposed to construction of side channel habitat, gravel, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the American River (December-April; Table 5.10-1). CV Steelhead spawn as early as December and as late as early April with the peak in February. All fry are out of the gravel before July when construction could begin. There would be no impact from construction to this lifestage in the American River.

5.10.4.7.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating individuals would benefit from increased side channel habitat, gravel, and large wood resulting from habitat restoration in the American River. Effects include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality.

Rearing and outmigrating juveniles could be exposed to construction of side channel habitat, gravel augmentation, and large wood installation. Juvenile CV Steelhead grow quickly in the American River and young of the year are 100 mm or larger by the time construction activity starts in the summer. These fish are often attracted by the disturbance from construction activity and are able to swim quickly to desirable locations when in close proximity to construction activities. Construction activities in the American River could result in mortality of this life stage if crushed by heavy equipment, if individuals were stranded or isolated during dewatering. This life stage could be negatively affected by degraded water quality from contaminant discharge by heavy equipment and discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., reduced ability to take in oxygen, increasing metabolic cost), and reduced foraging ability caused by decreased visibility. Outmigration timing does not overlap with construction activities so there would be no effect on outmigrating juvenile CV Steelhead.

Construction activities are temporary and exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would be minimized.

5.10.4.7.3 Adult Migration from Ocean to Rivers

Completion of restoration activities would increase the number of CV Steelhead of all life stages within the CVP watershed. Early migrating CV Steelhead adults may be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the American River. Adult CV Steelhead are strong swimmers and able to avoid construction activities in the American River. Migrating adults could be negatively affected by degraded water quality from contaminant discharge by heavy equipment, and increased discharges of suspended solids and turbidity, leading to direct

physiological or physiological impacts on fish health/performance (e.g., reduced ability to take in oxygen, increasing metabolic cost), loss of aquatic vegetation providing physical shelter, and delay in migration caused by elevated noise levels from machinery.

Construction activities are temporary and exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would be minimized.

5.10.4.7.4 Adult Holding

Generally CV Steelhead do not hold over during the summer months though if present, holding adults could be exposed to construction of side channel habitat, gravel augmentation, and large wood installation based on the timing of the in-water work window (July 1-September 30). Holding pools are typically in deep water near mid-channel and away from shallower riffles, pool tails, and channel margins where most gravel augmentation and side channel construction would occur. When construction activities in the American River occur near holding pools, holding adults could be displaced, injured, or killed by heavy equipment strikes or disturbance of suitable habitat during manipulation of gravel or creation of side channels. Adult CV Steelhead are strong swimmers and able to avoid construction activities. Holding adults could be negatively affected by degraded water quality from contaminant discharge by heavy equipment and increased discharges of suspended solids and turbidity, leading to direct toxicological or physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost).

Exposure to effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5 the temporary, negative effects that may result from construction of side channel habitat, gravel augmentation, and large wood installation would affect few if any holding adult CV Steelhead. Completion of restoration activities would increase the number of CV Steelhead of all life stages within the CVP watershed.

5.10.4.8 *Drought Temperature Facility Improvements (American River)*

Under the proposed action, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Water temperature is perhaps the physical factor with the greatest influence on CV Steelhead, directly affecting survival, growth rates, distribution, and developmental rates (NMFS 2009). Warm water temperatures have been identified as a key stressor for CV Steelhead in the American River, particularly below dams, affecting juvenile rearing and outmigration and adult immigration and holding. Since juvenile CV Steelhead rear in streams for one to three years and are present year round (Table 5.10-1), they would be affected by drought related excessively high water temperatures. The implementation of the proposed drought temperature management measures would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for CV Steelhead during drought conditions and improve conditions for all life stages.

5.10.4.9 Spawning and Rearing Habitat (Stanislaus River)

5.10.4.9.1 Eggs to Fry Emergence

Juvenile CV Steelhead occur in the Stanislaus River, but those individuals may assume a resident life history that is not ESA protected like the anadromous life history of CV Steelhead. *O. mykiss* only become CV Steelhead upon outmigrating to the ocean. The weir on the Stanislaus River has counted only 82 CV Steelhead (i.e., *O. mykiss* longer than 16 inches) during escapement monitoring from 2003 to 2017 (no spring monitoring occurred in 2006 and 2008; Figure 5.10-26) (FishBio2012). These fish were categorized based on length, which is a standard practice. *O. mykiss* that have reared in the ocean and become CV Steelhead are generally much larger than their resident counterpart that reared only in freshwater. The individuals detected on the Stanislaus River did not receive additional testing to determine if the individuals completed an anadromous life history or not. While less common, larger resident *O. mykiss* can occur; so, there remains a degree of uncertainty as to determining resident or CV Steelhead origins.

Habitat restoration activities would directly benefit CV Steelhead, increasing the quantity and quality of spawning habitat in the Stanislaus River. Additionally, the created side channel and floodplain habitat would provide additional refuge for outmigrating juvenile CV Steelhead.

Construction activities associated with spawning and rearing habitat restoration under the proposed action are not expected to result in any direct effects to CV Steelhead eggs or emerging fry, based on timing of in-water construction (July 15 through October 15), typical seasonal occurrence of this life stage in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures.

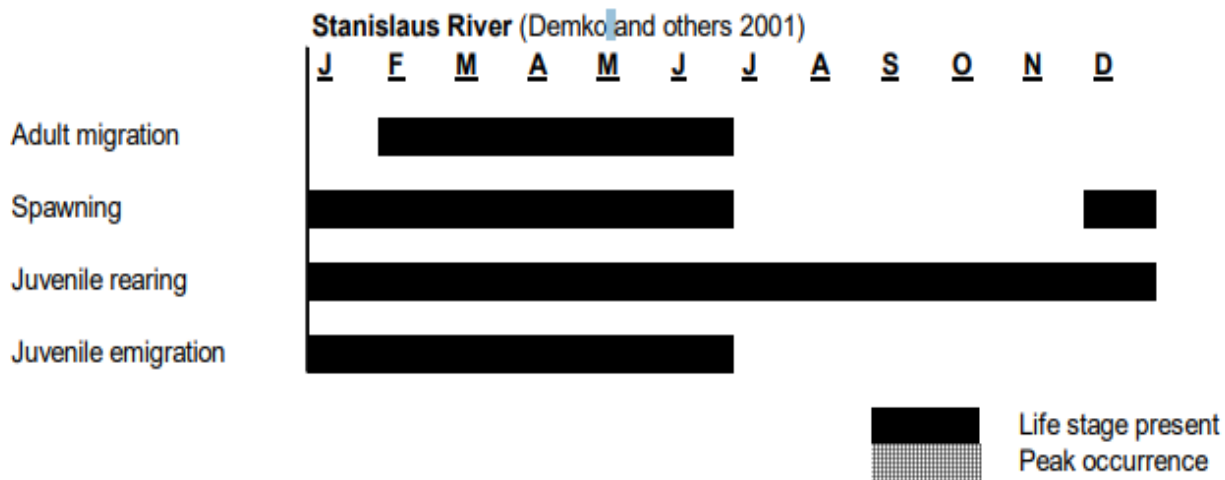


Figure 5.10-26. Stanislaus River Weir *O. mykiss* Passage (FishBio 2012)

5.10.4.9.2 Rearing to Outmigrating Juveniles

The creation of side channel and rearing habitat under the proposed action would increase the quality and quantity of off channel rearing and spawning areas in the Stanislaus River. The habitat restoration activities would improve the riparian habitat available for juvenile CV Steelhead rearing. Habitat restoration activities within the Stanislaus River would yield benefits including increasing existing riparian vegetation, providing instream and overhanging object cover, new shaded riverine habitat, and additional area for food production.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. The creation of side channel and floodplain habitat would increase the quality and quantity of rearing habitat available to CV Steelhead. Reclamation expects that the creation of 50 acres of side channel and floodplain habitat, would support the progeny of 2,800 adult salmon. The habitat restoration would result in an overall benefit to the CV Steelhead.

Construction activities associated with spawning and rearing habitat construction are not expected to result in impacts to CV Steelhead juveniles, based on timing of in-water construction (July 15 through October 15), typical seasonal occurrence of this life stage in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures.

5.10.4.9.3 Adult Migration from Ocean to Rivers

The creation of side channel and floodplain habitat under the proposed action would increase the quality and quantity of spawning available. Additionally the placement of additional spawning gravel would create an additional 34 acres of spawning habitat available to immigrating CV Steelhead. The habitat restoration would result in an overall benefit to CV Steelhead.

Construction activities associated with habitat restoration under the proposed action will not affect immigrating CV Steelhead. Construction activities would occur during an in-water work window of July 15 through October 15, when the species is not present in the Stanislaus River. No effects would occur on CV Steelhead individuals and/or populations during this life stage.

5.10.4.9.4 Adult Holding

The construction activities under the proposed action associated with spawning habitat restoration are not expected to affect adults holding in the Stanislaus River due to the implementation of general avoidance and minimization measures. The habitat restoration activities would increase the quality and quantity of off channel habitat areas available for CV Steelhead.

5.10.4.10 *Stanislaus River Temperature Management Study*

As part of the proposed action, Reclamation 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. This study will help inform operational abilities to control temperature in the Stanislaus River, which could benefit fish in the future.

5.10.4.11 *Lower SJR Habitat*

Lower San Joaquin Rearing Habitat restoration is expected to result in similar effects as those described above for Stanislaus River Spawning and Rearing Habitat.

5.10.4.12 Suisun Marsh Salinity Control Gates Operation

CV Steelhead juveniles are in the Delta in the spring. Reclamation proposes to operate the Suisun Marsh Salinity Control Gate between June to September. The last few CV Steelhead juveniles could possibly benefit from increased food production due to this action in the Delta.

5.10.4.13 Fall Delta Smelt Habitat

CV Steelhead juveniles are in the Delta in the spring. Reclamation proposes to conduct actions for Fall Delta Smelt Habitat in the fall, as adult CV Steelhead are migrating upstream. Fall Delta Smelt Habitat actions are unlikely to affect adult CV Steelhead.

5.10.4.14 Clifton Court Predator Management

Clifton Court predator management under the proposed action could reduce pre-screen loss of juvenile CV Steelhead entrained into CCF; therefore, providing a benefit for all life stages of CV Steelhead.

5.10.4.15 San Joaquin Steelhead Telemetry Study

The San Joaquin Steelhead telemetry study under the proposed action would include inserting acoustic tags into San Joaquin origin juvenile CV 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 CV Steelhead survival on the San Joaquin River. Only the juvenile lifestage of CV Steelhead would be affected by the study, as they are the only lifestage of fish that would be tagged. Tagged fish could have mortality associated with surgery to insert the tag, shock, and reduced swimming leading to increased predation as a result of the acoustic tag in their stomach cavity.

5.10.4.16 Sacramento Deepwater Ship Channel Food Study

Moderate to high proportions of CV Steelhead are expected to be exposed to the Sacramento Deepwater Ship Channel (SDWSC) conservation measure under the proposed action. This conservation measure would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018), allowing food to enter the Delta and an alternate migration pathway. Juvenile CV Steelhead abundance in the Delta peaks in February through May (Table 5.10-1). Juvenile CV Steelhead passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar.

No CV Steelhead are expected to be exposed to the Sacramento Deepwater Ship Channel construction, as the in-water work window does not overlap with their occurrence in the Delta.

5.10.4.17 North Delta Food Subsidies / Colusa Basin Drain Study

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall, and does not overlap in time or space with juvenile CV Steelhead occurrence in the Delta. There would not be any effect to CV Steelhead adults.

5.10.4.18 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on CV Steelhead juveniles, who are in the Delta between December and July. The action is not expected to have any effect on CV Steelhead adults.

5.10.4.19 Tidal Habitat Restoration

A large proportion of juvenile CV Steelhead are expected to benefit from 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Tidal habitat restoration is expected to benefit juvenile CV Steelhead in several aspects represented by the Winter-run Chinook salmon conceptual model (Figure 5.6-4) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta; however, the Delta only represents a small fraction of the total migration route.

Few if any juvenile CV Steelhead would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Table 5.10-1). There may be exposure of a few late migrants, as illustrated by timing of occurrence in Chipps mid-water trawls (Table 5.10-1).

Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes 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 (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), 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 AMMs.

5.10.4.20 Predator Hot Spot Removal

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids, including CV Steelhead. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of CV Steelhead. All 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. 2017, Sabal et al. 2017). However, implementation of this action would likely improve conditions for all life stages of CV Steelhead.

5.10.4.21 Delta Cross Channel Gate Improvements

Completion of DCC gate improvements would benefit CV Steelhead of all life stages within the CVP watershed systems. The peak migration of juvenile CV Steelhead in the Sacramento River past Hood, which is near the DCC, occurs from February through mid-June (Table 5.10-1). No San Joaquin River-

origin CV Steelhead are expected to be exposed to the DCC. As previously described, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) and, therefore, few late migrants or early migrants have the potential to be exposed to potential construction from improvements to the DCC under the proposed action.

5.10.4.22 Tracy Fish Facility Improvements

Small proportions of Sacramento River-origin CV Steelhead and moderate proportions of Mokelumne River and San Joaquin River-origin CV Steelhead are expected to be exposed to the Tracy Fish Facility. However, for fish that arrive at the facility, the proposed improvements resulting in greater salvage efficiency under the proposed action are likely to increase survival of juvenile CV Steelhead.

As previously described, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) and, therefore, none to a few late migrants or early migrants have the potential to be exposed to the effects of construction of the carbon dioxide injection device proposed for the Tracy Fish Facility Improvements. Risks of decrease CV Steelhead juvenile salvage during construction would be minimized through appropriate AMMs.

5.10.4.23 Skinner Fish Facility Improvements

Skinner fish facility improvements under the proposed action to reduce predation on listed fishes following entrainment into CCF could reduce pre-screen loss of juvenile CV Steelhead entrained into CCF; therefore, providing a benefit for all life stages of CV Steelhead.

5.10.4.24 Delta Fishes Conservation Hatchery

Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. 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 CV Steelhead would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities in the Delta under the proposed action, juvenile CV Steelhead are largely absent from the Delta between August and November (Table 5.10-1) which means that none to a few late or early migrants of this life stage could be exposed to Delta Fishes Conservation Hatchery construction. The in-water work constructing the hatchery intake and outfall could result in a small number of individuals experiencing effects such as temporary loss of habitat leading to predation, degraded water quality, 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 AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.10.4.25 Effects of Monitoring

Population estimates for wild steelhead remain outstanding in the Central Valley, therefore it is difficult to quantify the effects of the monitoring on steelhead populations. However, most existing monitoring programs in the Central Valley and Delta/SF Estuary are not designed to capture steelhead, which are much larger than Chinook Salmon upon river and Delta entry. Existing programs likely have poor capture efficiency for collecting and retaining steelhead. Therefore, it is unlikely the monitoring programs have any effects to the population.

Table 5.10-3. Monitoring Programs – Steelhead

| Species | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|--------------------------------------------------------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|------|------|------|
| Chippis Island Trawl | | | | | | | | | | | | | | | | | | |
| Steelhead | 178 | 133 | 128 | 233 | 132 | 141 | 35 | 82 | 118 | 100 | 37 | 57 | 79 | 81 | 106 | 96 | 143 | |
| Sacramento Trawl | | | | | | | | | | | | | | | | | | |
| Steelhead | 37 | 36 | 20 | 9 | 54 | 42 | 56 | 62 | 40 | 40 | 134 | 12 | 287 | 16 | 35 | 44 | 129 | |
| DJFMP Beach Seine Survey | | | | | | | | | | | | | | | | | | |
| Steelhead | 36 | 27 | 28 | 30 | 42 | 31 | 25 | 17 | 26 | 13 | 13 | 17 | 45 | 7 | 6 | 1 | 20 | 0 |
| CDFW Mossdale Trawl | | | | | | | | | | | | | | | | | | |
| Steelhead | 8 | 17 | 12 | 7 | 11 | 41 | 5 | 1 | 4 | 5 | 11 | 26 | 12 | 28 | 3 | 0 | 8 | |
| EDSM KDTR Trawls | | | | | | | | | | | | | | | | | | |
| Steelhead | na | na | na | na | na | na | na | na | na na | na | na | na | na | na | 0 | 44 | na | |
| CDFW Bay Study Trawls | | | | | | | | | | | | | | | | | | |
| Steelhead | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | na | |
| CDFW SKT Study | | | | | | | | | | | | | | | | | | |
| Steelhead | 23 | 38 | 37 | 58 | 54 | 62 | 19 | 13 | 46 | 25 | 36 | 12 | 86 | 49 | 52 | 19 | 40 | |
| Totals | | | | | | | | | | | | | | | | | | |
| Steelhead | 282 | 251 | 225 | 425 | 293 | 317 | 140 | 175 | 234 | 183 | 237 | 124 | 509 | 181 | 202 | 160 | 340 | |
| RBDD Rotary Trap or Juvenile Production Estimate (JPE) | | | | | | | | | | | | | | | | | | |
| Steelhead | | | | | | | | | | | | | | | | | | |

5.11 Steelhead, Central Valley DPS Critical Habitat

Critical habitat for the California CV steelhead DPS was designated in 2005 and includes all river reaches accessible to steelhead in the Sacramento and San Joaquin rivers and their tributaries, the Delta, and Yolo Bypass (70 FR 52488). The geographical extent of CCV steelhead critical habitat includes the Sacramento, Feather, and Yuba rivers and Deer, Mill, Battle, and Antelope creeks in the Sacramento River; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River above the Merced River confluence; and the waterways of the Delta. Critical habitat includes stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line or bankfull elevation (defined as the level at which water begins to leave the channel and move onto the floodplain, and generally corresponds with a discharge that occurs every 1 to 2 years on an annual flood series) (70 FR 52488).

The designated critical habitat includes PBFs that are essential for the conservation of CCV steelhead:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large woody material, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- 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 woody material, aquatic vegetation, large rocks and boulders, side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

5.11.1 Effects of Operation

5.11.1.1 Spawning Habitat

Proposed operations under the proposed action would have largely beneficial effects on the PBFs of spawning habitat for CV steelhead. Based on relationships between flow and spawning WUA for steelhead in the upper Sacramento River (USFWS 2003), lower flows under the proposed action would substantially increase the number of years in which velocities would be within the optimum range during the primary spawning period (January through March). Furthermore, Keswick releases during the spring would be substantially cooler under the proposed action, resulting in suitable water temperatures for eggs and alevins through May.

5.11.1.2 Freshwater Rearing Habitat

Higher flows and lower temperatures under the proposed action would have beneficial effects on the PBFs of freshwater rearing habitat for CV steelhead. Although higher summer flows under the proposed

action are associated with reductions in WUA, these flows would have positive effects on overall habitat quantity and quality. Potential benefits include increased downstream extent of suitable rearing temperatures, improved access to riparian and off-channel habitat, reduced crowding and competition, and increased prey availability. The flow-related benefits of the proposed action on critical habitat would be further enhanced by Shasta cold water management actions and cooler release temperatures at Keswick Dam to protect winter-run Chinook salmon during the summer spawning and incubation period.

5.11.1.3 Freshwater Migration Corridors

The proposed action would have both positive and negative effects on the PBFs of freshwater migration habitat for adult and juvenile CV steelhead. Lower flows during the winter and early spring (January through April) under the proposed action would have negative effects on migratory habitat for juvenile steelhead. However, higher flows and lower temperatures under the proposed action during the late spring and summer (May through September) would have beneficial effects on migratory habitat of juveniles and adults, especially in dry and critically dry years.

5.11.1.4 Estuarine Areas

The proposed action would have both positive and negative effects on the PBFs of estuarine habitat for CV steelhead. The potential for operation-related impacts on estuarine habitat would be similar to those described for freshwater rearing habitat and migration corridors above.

5.11.1.5 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix E – ROC Real-Time Water Operations Charter in section Routine Operations and Maintenance on CVP Activities would be anticipated to minimize potential negative effects to CV Steelhead critical habitats from maintenance activities.

5.11.2 Effects of Conservation Measures

5.11.2.1 Spawning Habitat

Several programmatic actions that are proposed as part of the proposed action include construction components that could affect the critical habitat PBFs of steelhead spawning habitat. These actions include proposed spawning habitat enhancement projects (e.g., gravel augmentation), rearing habitat enhancement projects (e.g., side channel creation), and installation of screens on small unscreened diversions (small screen program). Based on the proposed in-water work windows (see AMM2 *Construction Best Management Practices and Monitoring*), spawning adults, eggs, and alevins could be exposed to construction activities during November through February or mid-May, depending on the river reach. The potential effects of construction activities on steelhead spawning habitat and the proposed AMMs would be similar to those described for spring-run Chinook salmon.

5.11.2.2 Freshwater Rearing Habitat

Construction components of the programmatic actions could also affect the critical habitat PBFs of freshwater rearing habitat for steelhead. Because juvenile steelhead are present year-round in the proposed action area, juveniles would be subject to potential construction activities whenever they occur. Based on the proposed in-water work windows (see AMM2 *Construction Best Management Practices and Monitoring*), rearing juveniles could be exposed to construction activities during October through February or mid-May, depending on the river reach. The potential effects of construction activities on

steelhead rearing habitat and proposed AMMs would be similar to those described for spring-run Chinook salmon.

5.11.2.3 Freshwater Migration Corridors

Several programmatic actions that are proposed as part of the proposed action could affect the critical habitat PBFs of freshwater migration corridors for steelhead. These actions include proposed tidal and channel margin restoration, spawning and rearing habitat enhancement projects, and installation of new diversions and screens. Potential exposure of migrating juveniles to construction activities would be avoided or minimized by restricting all instream activities to the proposed in-water construction window (August 31 to October 31 in the legal Delta, and June 1 to October 1 in the Sacramento River between Red Bluff Diversion Dam and the boundary of the legal Delta). However, the potential for exposure of migrating adults to these construction activities is high, especially during the peak migration period (September through October). In addition, although the proposed in-water construction windows would avoid the primary migration periods of juvenile steelhead, timing information for brood years 2004 through 2017 (Appendix F: SacPAS Summary) indicates that juveniles may sometimes occur in the middle Sacramento River and Delta during summer and early fall. However, none of the proposed construction activities would create a migration barrier or cause significant delays in migration of steelhead adults or juveniles. Based on the proposed AMMs, potential effects would be limited to temporary delays in passage resulting from behavioral effects that could occur in response to noise, turbidity, and other physical disturbances at construction sites. Other potential effects of construction activities on steelhead migration habitat would be similar to those described for spring-run Chinook salmon rearing and migration habitat. However, because most steelhead juveniles would be large, actively migrating smolts, their sensitivity to potential construction effects (e.g., injury or mortality from in-water work activities) would be lower than that of juvenile Chinook salmon.

5.11.2.4 Estuarine Areas

The proposed action includes a number of programmatic actions that could affect the PBFs of estuarine habitat for CV steelhead, including tidal and channel margin restoration, facility improvements (Delta Cross Channel Gate improvements), Delta Fish Species Conservation Hatchery, and Small Screen Program). The potential for construction-related impacts of these projects on estuarine habitat would be similar to those described for freshwater rearing habitat and migration corridors above.

5.11.2.5 Effects of Monitoring

Monitoring would have no effect on critical habitat.

5.12 North American Green Sturgeon, Southern DPS

The proposed action has lower flows than the WOA during the spring, in particular March, April, and May, in all the watersheds when adults are migrating upstream to spawn. Releases for water supply in the summer and early fall associated with the proposed action result in higher flows relative to WOA during the period of broadcast spawning. These higher flows increase: (1) spawning habitat; (2) water velocities that flush sediment from green sturgeon redds; (3) the ability to maintain adequate levels of DO in contact with green sturgeon eggs; and (4) water depth suitable for Green Sturgeon

Reclamation has included a variety of conservation measures to increase alevin and juvenile productivity of Green Sturgeon. These include spawning and rearing habitat, cold water pool management, predator




hot spot removal, and a small screen program. Volitional passage past the Red Bluff Diversion Dam was achieved in 2013 and allows free movement for adult Green sturgeon throughout their spawning habitat.

5.12.1 Lifestage Timing

General life stage timing and location information for Green Sturgeon is provided in Table 5.12-1.

Table 5.12-1. Temporal Occurrence of (a) Spawning Adult, (b) Larval, (c) Young Juvenile, (d) Juvenile, and (e) Sub-adult/Non-spawning Green Sturgeon (NMFS 2017, Appendix B, p.68)

| (a) Adult-sexually mature (≥ 145 cm TL females, ≥ 120 cm TL males), including pre- and post-spawning individuals. | | | | | | | | | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sac River (rkm 332.5-451) | | | | | | | | | | | | |
| Sac River (< rkm 332.5) | | | | | | | | | | | | |
| Sac-SJ-SF Estuary | | | | | | | | | | | | |
| (b) Larval | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sac River (> rkm 332.5) | | | | | | | | | | | | |
| (c) Juvenile (≤ 5 months old) | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sac River (> rkm 332.5) | | | | | | | | | | | | |
| (d) Juvenile (≥ 5 months) | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Sac River (< rkm 391) | | | | | | | | | | | | |
| Sac-SJ Delta, Suisun Bay | | | | | | | | | | | | |
| (e) Sub-Adults and Non-spawning adults | | | | | | | | | | | | |
| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| SAC-SJ-SF Estuary | | | | | | | | | | | | |
| Pacific Coast | | | | | | | | | | | | |
| Coastal Bays & Estuaries ¹ | | | | | | | | | | | | |

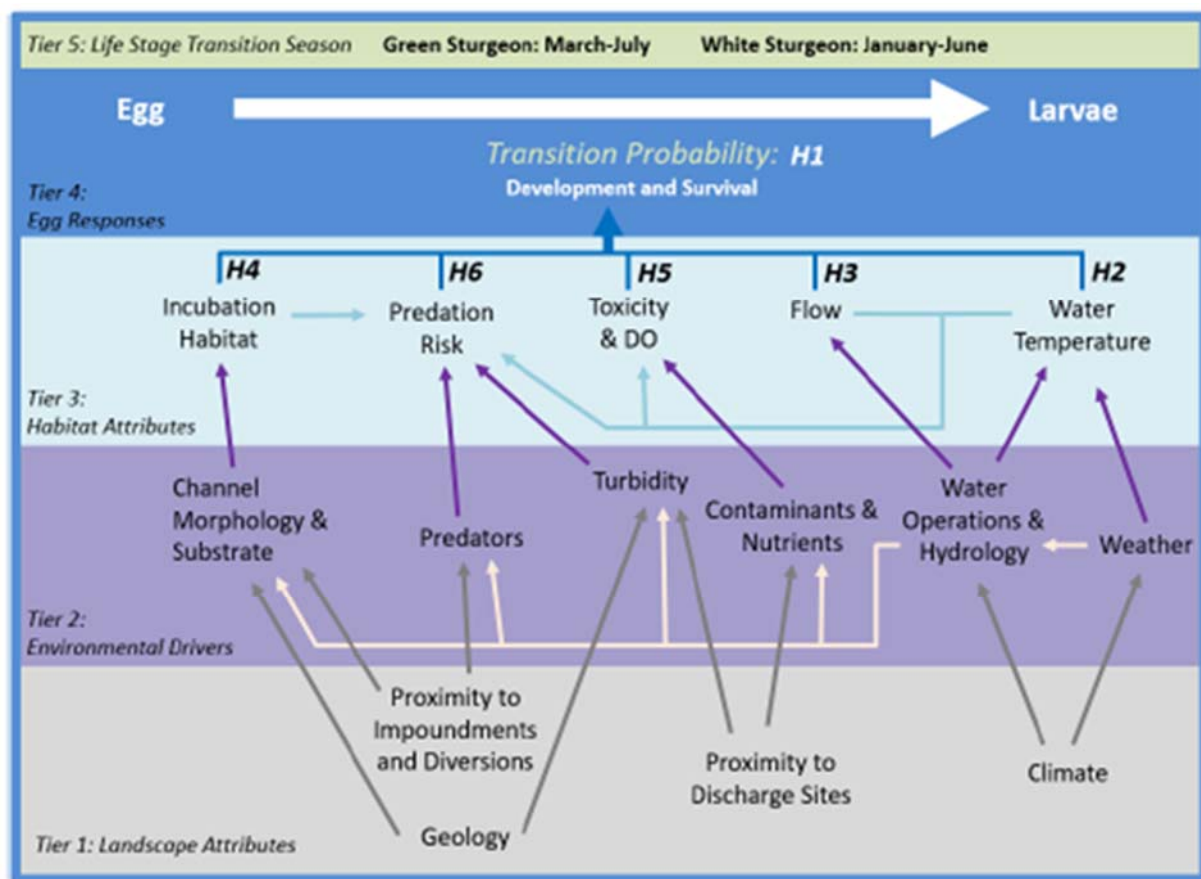
Relative Abundance:  = High  = Medium  = Low

Sources: (a) Heublein et al. 2008; Klimley et al. 2015; Poytress et al. 2015; Mora et al. 2015; (b) Poytress et al. 2015; Heublein et al. in review; (c) Heublein et al. in review, B. Poytress, unpublished; (d) Radtke 1966; CDFG 2002, Heublein et al. in review, B. Poytress, unpublished; (e) Erickson and Hightower 2007; Moser and Lindley 2006; Lindley et al. 2008, Lindley et al. 2011; Huff et al. 2011. Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bay).

5.12.2 Conceptual Model Linkages

The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Green Sturgeon. Life stage transitions are the series of changes in form that an organism undergoes throughout its life cycle. SAIL life stage transitions include egg to larval, larvae to juvenile, juvenile to subadult/adult, adult to spawning, and spawning adult to egg and post-spawn adult period.

The egg to larval period for Green Sturgeon, as described by the SAIL Conceptual model (Heublein et al. 2017), is during March to July for the geographic area from Cow Creek to the Glenn Colusa Irrigation District diversion dam (Sacramento River) and from the Fish Barrier Dam to Shanghai Bend (Feather River). The hypothesized landscape attributes (geographically and temporal characteristics of the Central Valley and Bay-Delta that do not change over the analysis timescale), environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-1.



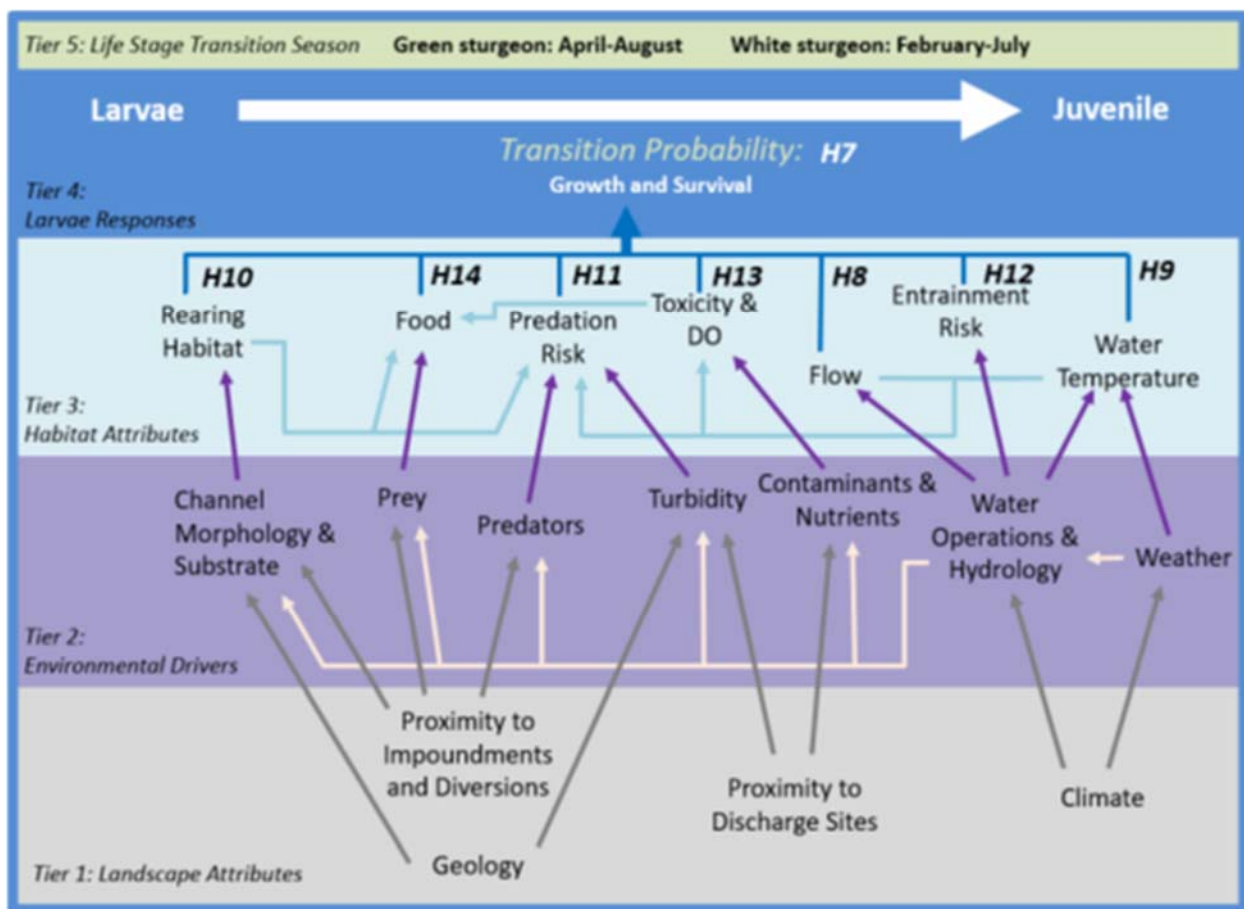
Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-1. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Egg to Larva

Eggs from spawning Green Sturgeon have been found in the middle and upper Sacramento River from the Glen Colusa Irrigation District oxbow (GCID) (River Mile [RM] 207) to Inks Creek (RM 265) and based on adult sightings and presence of suitable habitat, spawning is believed to extend upstream to the confluence with Cow Creek (RM 277) (Heublein et al. 2017b). Green sturgeon spawn in deep pools (averaging about 28 feet deep) (NMFS 2018).

Green Sturgeon spawn primarily from April through July, although they periodically spawn in late summer and fall (as late as October) (Heublein et al. 2009, 2017b, NMFS 2018) (Table 5.12-1). Northern DPS Green Sturgeon eggs incubate at about 60 degrees Fahrenheit from hatch to about a week after fertilization, and incubation time of southern DPS Green Sturgeon eggs is assumed to be similar (Heublein et al. 2017b). Because the incubation time for Green Sturgeon is so short, the effects analysis period for egg to larvae transition is considered to be the same as the spawning period, April through July, occasionally extending to October.

The larvae complete metamorphosis and become juveniles during April through August, as described by the SAIL Conceptual model (Heublein et al. 2017), for the geographic area from Bend Bridge (Sacramento River) and Thermalito Outlet (Feather River) to the Golden Gate Bridge. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-2.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-2. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Larva to Juvenile

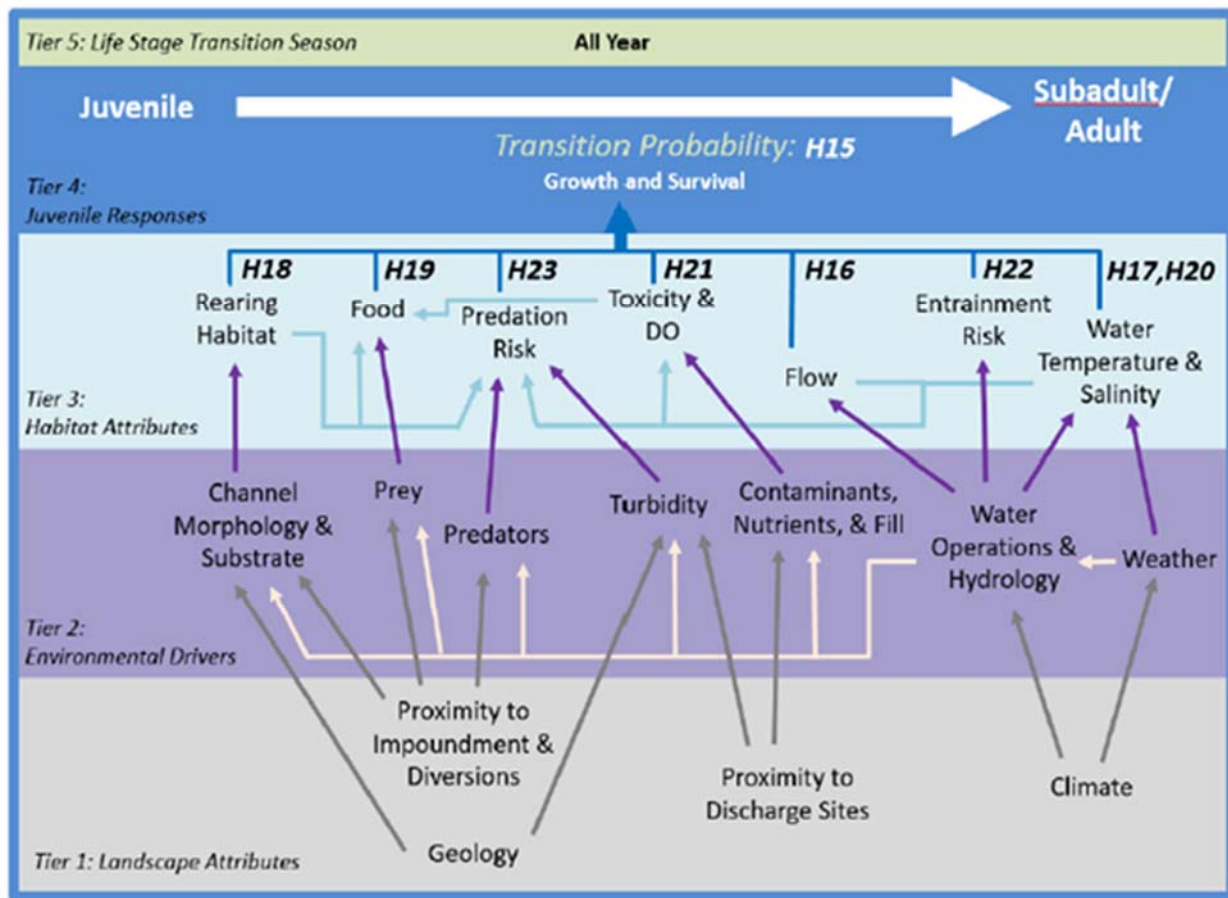
According to field observations, Green Sturgeon larvae begin to disperse from hatching areas at 18 days post hatch (dph), and dispersion is complete at about 35 dph (Poytress et al. 2011, cited in Heublein et al. 2017b). They begin exogenous feeding at about 15 dph. The larvae use benthic structure and seek refuge within crevices, but also forage over hard surfaces (Nguyen and Crocker 2007 cited in Heublein et al.

2017b). The juvenile stage begins when metamorphosis of the larvae is complete, typically at about 45 dph (Heublein et al. 2017b).

July is the end of the peak spawning period, so the end of the larva to juvenile period is considered to be September.

The downstream distribution of Green Sturgeon larvae in the Sacramento River is uncertain, but is estimated to extend to the Colusa area, at River Mile 157 (Heublein et al. 2017b). The larvae occur upstream to the Cow Creek confluence, which is the upstream limit of their spawning distribution (Heublein et al. 2017b).

The juvenile life stage transition, as described by the SAIL Conceptual model (Heublein et al. 2017), from complete metamorphosis to ocean migration or 75 cm fork length occurs in the geographic area from Bend Bridge (Sacramento River) and Thermalito Outlet (Feather River) to the Golden Gate Bridge. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-3.

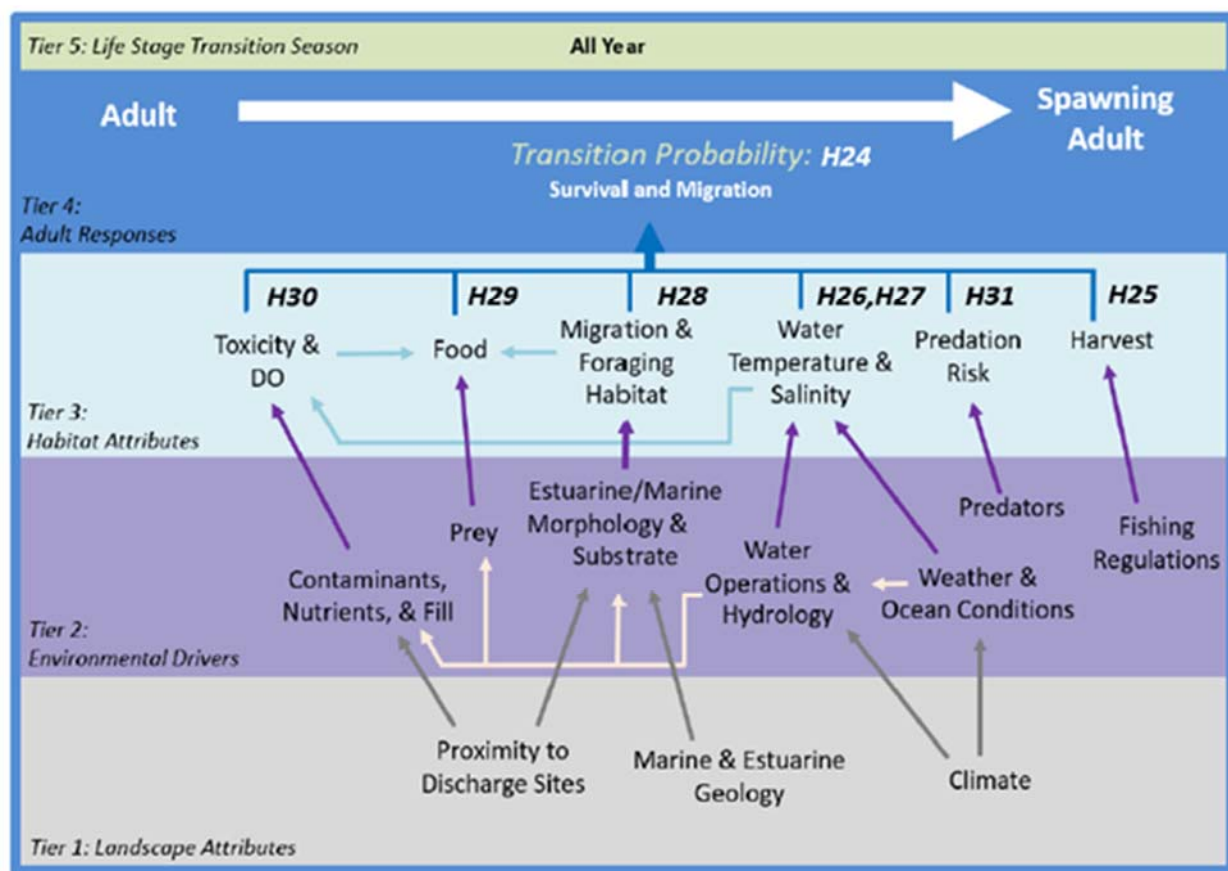


Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-3. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Juvenile to Subadult/Adult

The Green Sturgeon juvenile stage begins when metamorphosis of the larvae is complete, typically at about 45 dph and about 75 mm in length (Heublein et al 2017b). It is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017b). The period for juveniles less than or equal to 5 months old, considered to be the ages of most juveniles rearing in or migrating through the Sacramento River upstream of the Delta, is given in Table 5.12-1 as May through December. During most of the juvenile Green Sturgeon rearing period, the juveniles are likely to be found anywhere from the upstream spawning habitat near the Cow Creek confluence to the Delta.

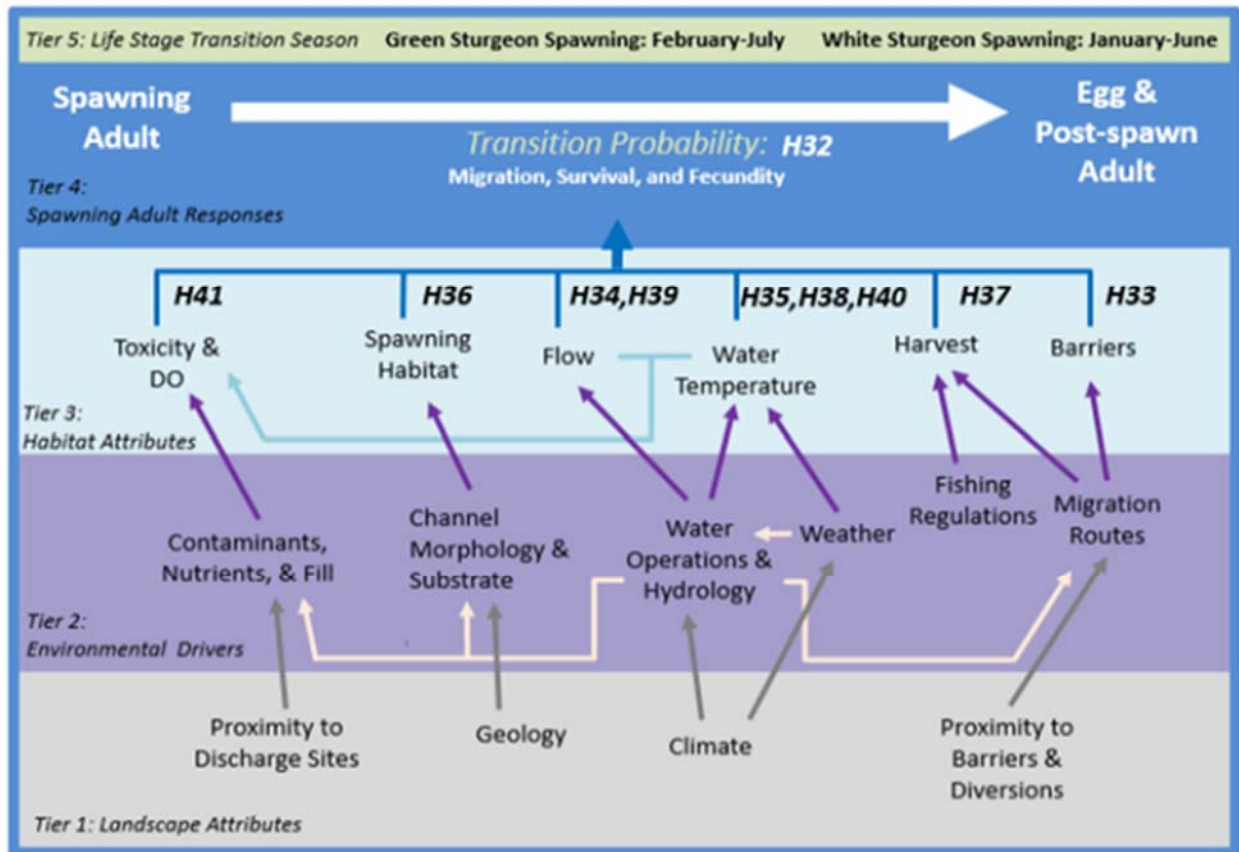
The adult to spawning adult life stage transition, as described by the SAIL Conceptual model (Heublein et al. 2017), is geographically located in California, Oregon, and Washington estuaries during May-October, as well as the nearshore marine environment all year. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-4.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-4. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Adult to Spawning Adult

The spawning adult life stage transition from spawning adult to egg and post-spawn adult, as described by the SAIL Conceptual model (Heublein et al. 2017), occurs in the geographic area for migration and spawning from the Golden Gate Bridge to Cow Creek (Sacramento River), Fish Barrier Dam (Feather River), and Daguerre Point Dam (Yuba River). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.12-5.



Source: Heublein et al. (2017). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.12-5. Conceptual Model of Drivers Affecting the Transition of Green Sturgeon from Spawning Adult to Egg and Post-Spawn Adult.

Continuing their upstream migration from the Delta, Green Sturgeon adults enter the Sacramento River as early as February and ultimately make their way upstream to spawn in deep pools from the Glenn Colusa Irrigation District oxbow (GCID) to the Cow Creek confluence (Heublein et al. 2017b). Elevated flows during the late winter and early spring months may provide an important cue for spawning Green Sturgeon adults to initiate their upstream migrations (Heublein et al. 2009; NMFS 2017b). Green Sturgeon spawn in most years from April through July, but spawn in occasional years as late as October. After spawning, the adults hold in the river for varying amounts of time, but typically emigrate back to the San Francisco Estuary and the ocean from about October through December (Heublein et al. 2017b). Emigration may occur as early as late spring or summer and may be related to elevated flows (Heublein et al. 2009).

As indicated by the SAIL conceptual model (Figures 5.12-1 to 5.12-5), hydrologic conditions and operations of Shasta and Keswick reservoirs affect flows and water temperatures in the upper Sacramento River, which combined with other environmental drivers, affect DO, water quality, predation, and other habitat attributes that influence the timing, condition, growth, and survival of Green Sturgeon in all life stages in the Sacramento River.

Hydrologic conditions and operations of water diversions also affect entrainment risk (Verhille et al. 2014; Heublein et al. 2017a [SAIL model]; Mussen et al. 2014). The proportion of larvae surviving to the juvenile stage, as well as juveniles surviving to emigrate from the Sacramento River depends largely on

habitat conditions, including instream flow (Heublein et al. 2017b). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect bioenergetics, food availability, and predation), entrainment, and potentially affects cues that stimulate outmigration (Heublein et al. 2017b, NMFS 2017b). The proportion of eggs to hatch, during the egg to larvae lifestage, is affected by substrate composition, depth, contaminants, sedimentation, predators of the spawning habitat, as well as the other aforementioned factors (Heublein et al. 2017a [SAIL model], 2017b). In addition, instream flow from Keswick Dam releases, relative to flow from the lower Yolo and Sutter bypasses and agricultural drains, may affect navigation cues and increase straying risk of Green Sturgeon adults into these canals and behind these bypass weirs (Figure 5.12-5). Instream flows may affect sedimentation and substrate composition of the spawning habitat and may affect channel morphology (Heublein et al. 2017a [SAIL model] and 2017b). Flow and water temperature also affect the area of river bed suitable for spawning and may influence the timing of spawning (Heublein 2017a [SAIL model] and 2017b). Flows may also disperse larvae to more favorable downstream habitats (NMFS 2018). Larval abundance and distribution may be influenced by spring and summer outflow (Heublein et al. 2017b). Flows may also transport juveniles to more favorable habitats (NMFS 2018). Juvenile abundance and distribution may be influenced by winter outflow (Heublein et al. 2017b).

In addition, water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of Green Sturgeon for all life stages. The egg and larval life stages are the most sensitive to temperature exceedances outside of optimal ranges, and exposure to the effects of elevated water temperatures include elevated mortality and increased occurrence of morphological abnormalities in eggs that do hatch (Van Eenennaam et al. 2005). Thermal tolerance ranges for Green Sturgeon egg and larvae are considered optimal between 53 to 64 °F, and are suboptimal at 65 to 66 °F. Temperatures between 67 to 72 °F result in impaired fitness and temperatures greater than 73 °F are likely lethal (NMFS 2016).

The life stages of juvenile to subadult/adult Green are not particularly sensitive to temperatures below the lethal level of 73.5 °F (NMFS 2016). Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease and physiological stress potentially leading to mortality and altered migration timing and speed. Juvenile Green Sturgeon require temperatures of 58 to 66 °F for optimal survival and growth, 42 to 57 °F and 67 to 68 °F are suboptimal, and temperatures greater than 69 °F may lead to impaired fitness (NMFS 2016).

For the adult to spawning adult life stage, Green Sturgeon require temperatures between 53 °F and 64 °F for optimal survival, with temperatures from 67 °F to 72 °F leading to impaired fitness and temperatures over 73 °F being lethal. Migrating and holding Green Sturgeon require temperatures between 46 °F and 68 °F for optimal survival, with temperatures from 70 °F to 76 °F leading to impaired fitness and temperatures over 77 °F being lethal (NMFS 2016).

5.12.3 Effects of Operation & Maintenance

5.12.3.1 Seasonal Operations

Under the WOA condition, there would be 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 (other than upstream hydropower operations not under Reclamation control), where Green Sturgeon spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage, and assuming stratification developed, the cold water pool would be small and would not be managed. Flows under these conditions, especially in the upper Sacramento

River, would approximate uncontrolled flows. The similarity to uncontrolled flows is reflected in the seasonal flows modeled under the CalSim WOA scenario in the Sacramento River at Keswick, with low summer and fall flows and high winter and spring flows (Figure 5.12-6). Other locations in the Sacramento River would show similar seasonal flow patterns as illustrated by flows at the Hamilton City gauge in the middle the Sacramento River (see Appendix D, *Modeling*).

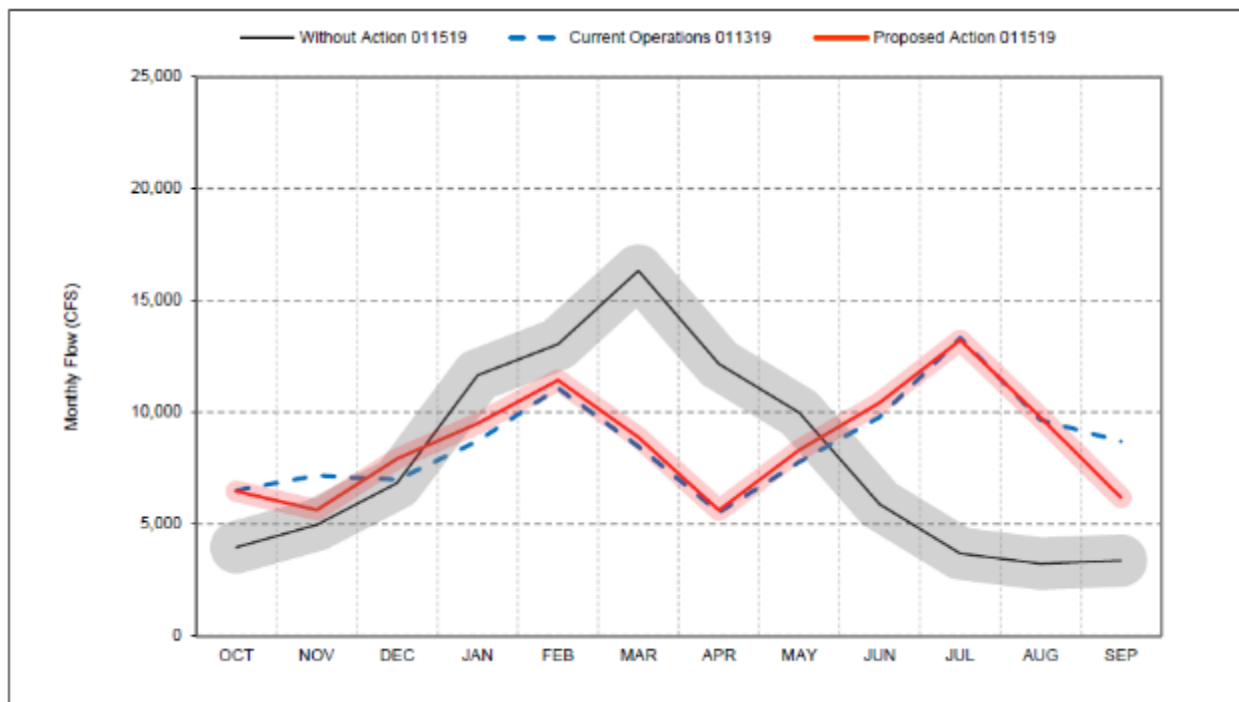


Figure 5.12-6. Flows at Keswick under the Proposed Action (PA), Current Operations (COS), and without Action (WOA)

CalSim modeling indicates that from February through April, when Green Sturgeon adults migrate upstream through the middle Sacramento River to their spawning habitats, the WOA modeling scenario mean monthly flows at Wilkins Slough would range from about 2,500 cfs in April to 24,000 cfs in March (Figures 19-11 and 19-12 in the CalSim flow section of Appendix D), and the flows at Red Bluff Diversion Dam would range from about 3,500 cfs in April to 77,000 cfs in February and March (Figures 17-11 through 17-13 in the CalSim II flow section of Appendix D). From May through July, when adults have begun spawning and some are emigrating downstream, the WOA mean monthly flows at Wilkins Slough would range from 0 cfs in May through July to about 20,000 cfs in May (Figures 19-14 through 19-16 in the CalSim II flow section of Appendix D), and flows at RBDD would range from about 2,950 cfs in June to 36,000 cfs in May (Figures 17-14 through 17-16 in the CalSim II flow section of Appendix D). Flows below about 3,250 cfs are considered to result in passage difficulties for adult Green Sturgeon in the Sacramento River (NMFS 2017b). From August through December, most of the adults remaining in the river after spawning hold for varying amounts of time and then emigrate downstream to the San Francisco Estuary. As previously noted, in occasional years Green Sturgeon may spawn until October. WOA mean monthly flows at Wilkins Slough during August through December range from a low of about 0 cfs in August to a high of 23,000 cfs in December (Figures 19-7, 19-8, 19-9, 19-17, 19-18, in the CalSim II flow section of Appendix D) and at Red Bluff from about 1,650 cfs in August to about 56,000 cfs in December (Figures 5.12-7 through 5.12-10).

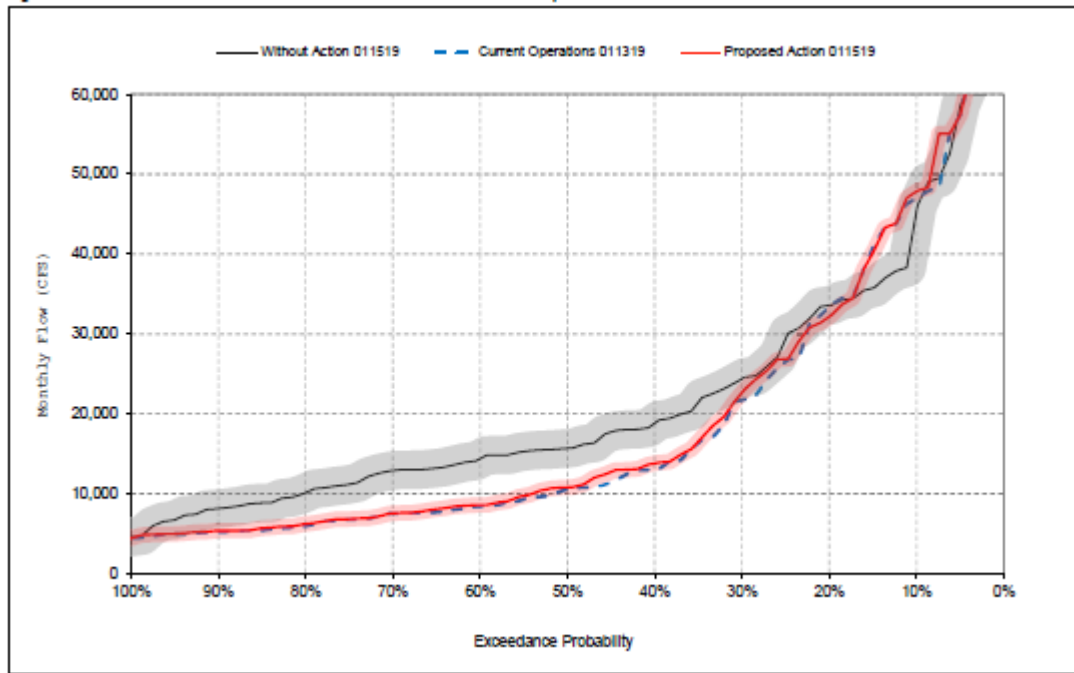


Figure 5.12-7. CalSim II Sacramento River Flows at Red Bluff, February

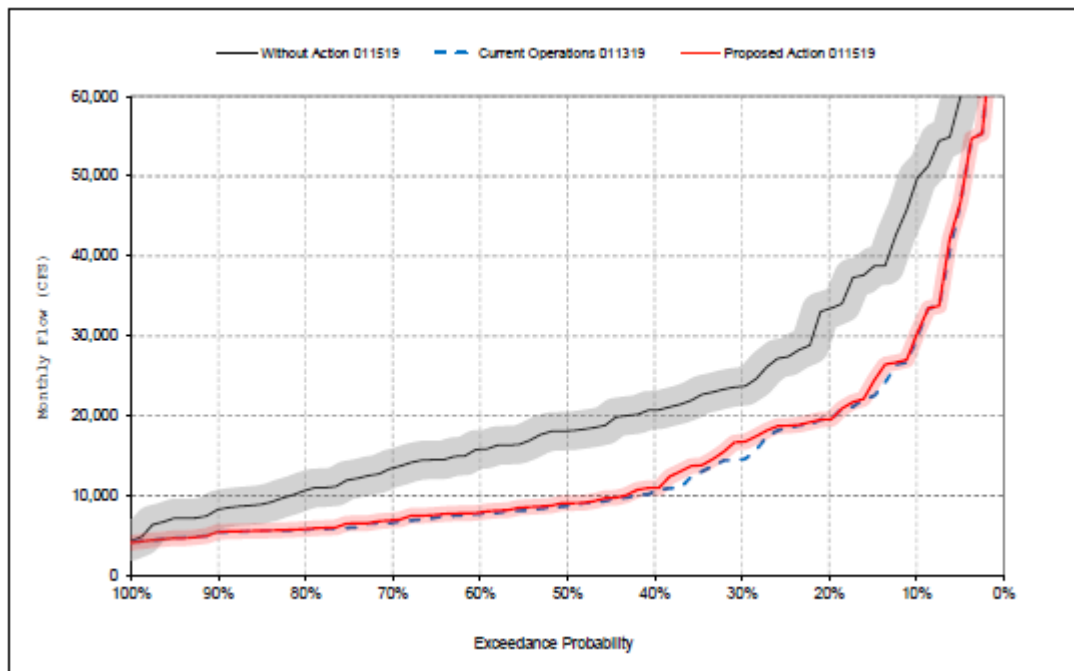


Figure 5.12-8. CalSim II Sacramento River Flows at Red Bluff, March

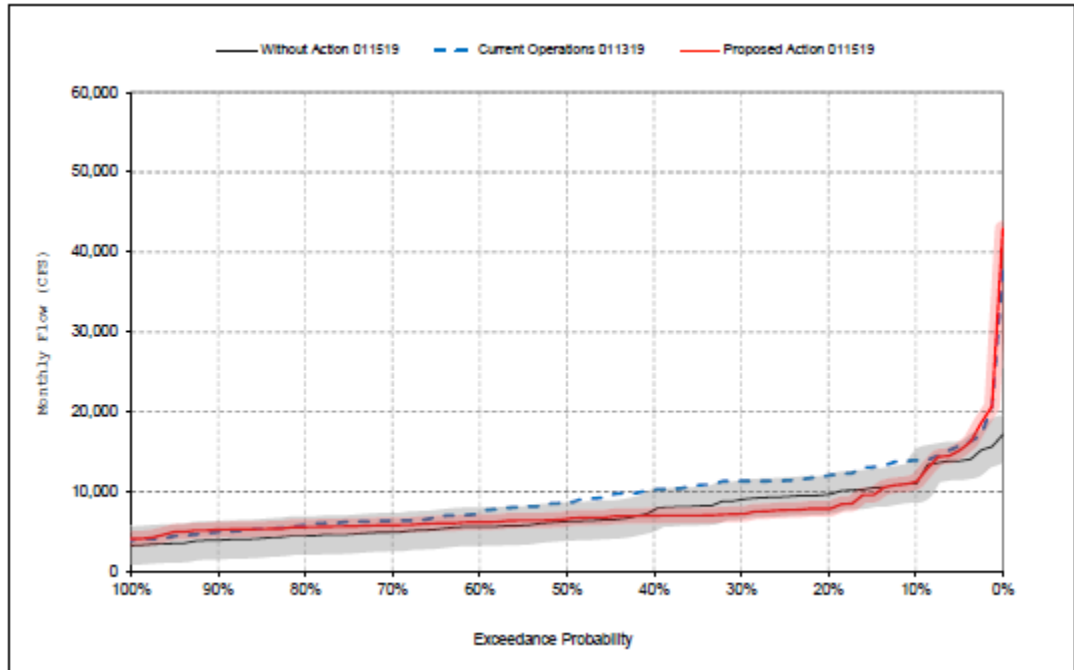


Figure 5.12-9. CalSim II Sacramento River Flows at Red Bluff, November

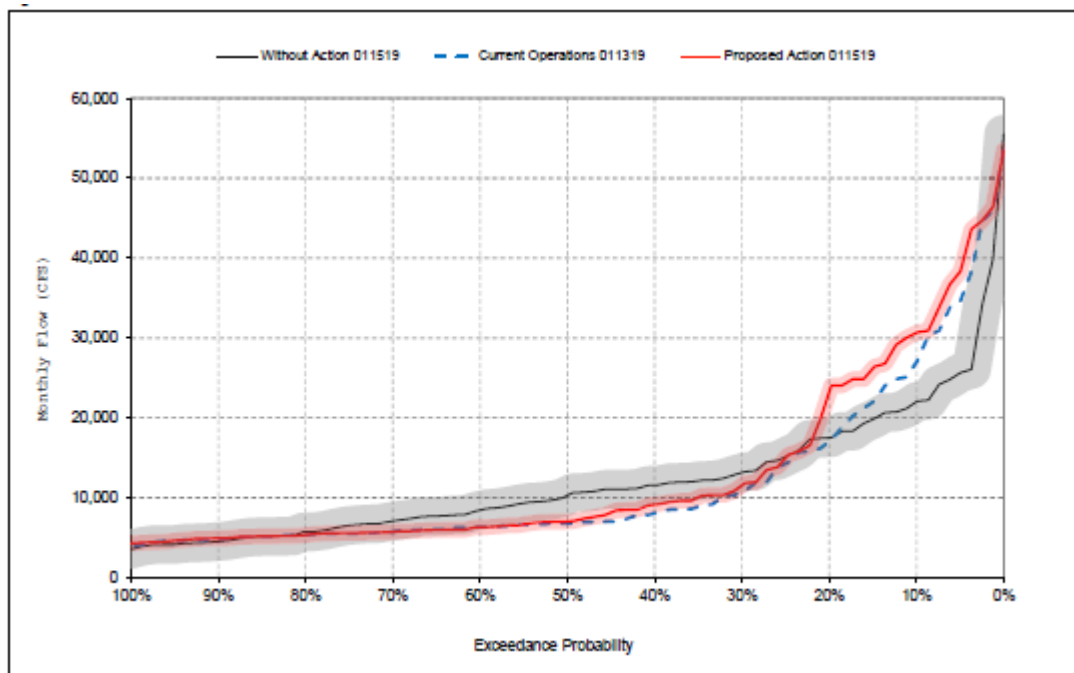


Figure 5.12-10. CalSim II Sacramento River Flows at Red Bluff, December

The very low WOA flows in some years during late spring through the fall would be likely to negatively impact migrating, spawning and holding Green Sturgeon adults. At Wilkins Slough, the mean monthly flow during June through August is less than 100 cfs in 10 to 20 percent of years, and during June through October is less than 3,250 cfs in at least 50 percent of years each month, including over 90 percent of years in July and August. These low flows would potentially cause passage problems for adults emigrating from May through November. They could also affect immigrating adults, but the peak period of immigration is generally complete by early summer. The low flows at RBDD would have potential adverse effects on spawning and holding habitats of Green Sturgeon adults, which include reduced area of river bed suitable for spawning, insufficient depths for spawning and holding habitats, reduced flushing of metabolic wastes from spawning and holding pools, and greater concentration of toxic contaminants and disease organisms.

Sacramento River water temperatures under the WOA conditions vary greatly during the May through December Green Sturgeon juvenile rearing and emigration period (see Appendix D, *Modeling*). During May and October, the mean monthly water temperatures at Woodson Bridge under the WOA modeling scenario lie within the 59 to 66 degrees Fahrenheit optimal temperature range in about 85 percent of years, with a total range of 59 to 70 degrees Fahrenheit for May and 57 and 65 degrees Fahrenheit for October. However, during June through September, the WOA mean monthly water temperatures exceed the 66 degrees Fahrenheit upper limit in every year, and during November and December, they lie below the 59 degrees Fahrenheit threshold in every year. The WOA mean monthly water temperatures would be greater than 78 degrees Fahrenheit during July and August in 25 and 10 percent of years, respectively. Temperatures exceeding 78 degrees Fahrenheit are identified as “likely lethal” (Heublein 2017b et al.). The WOA water temperatures in the upper Sacramento River (upstream of Red Bluff) would be cooler than those at Woodson Bridge, but July and August temperatures at Keswick would exceed the 66 degrees Fahrenheit threshold in every year. The November and December water temperatures at Keswick are consistently below the lower limit of the optimal temperature range for Green Sturgeon larvae (66 degrees Fahrenheit). Under the WOA conditions, Green Sturgeon juveniles are not likely to survive July and August water temperatures at Woodson Bridge and downstream. While they might be able to survive upstream of Red Bluff, they would not be able to migrate downstream until the river had cooled off later in the season.

Sacramento River water temperatures under the WOA conditions vary greatly during the April through September Green Sturgeon larval rearing and emigration period. During April, the WOA mean monthly water temperatures at Woodson Bridge are consistently below the optimal range for Green Sturgeon larvae (63 to 68 degrees Fahrenheit), ranging from 52 to 62 degrees Fahrenheit (Figure 5.12-11). During May, the WOA mean monthly water temperatures are within the optimal range in about 52 percent of years, with a total range of 59 to 70 degrees Fahrenheit (Figure 5.12-12). However, during June, the WOA mean monthly water temperatures exceed the 68 degrees Fahrenheit threshold in 90 percent of years (Figure 5.12-13) and during July through September, they exceed the threshold in every year (Figure 5.12-14 through 5.12-16). The July and August water temperatures under the WOA modeling scenario would be greater than 74 degrees Fahrenheit in all years, which is within a range of temperatures identified as “increasing chance of lethal effects”, and the highest water temperatures in these months (79 to 81 degrees Fahrenheit) are identified as “lethal” (Heublein 2017b et al.). The WOA water temperatures in the upper Sacramento River (upstream of Red Bluff) would be cooler than those at Woodson Bridge, but July and August water temperatures at Keswick would exceed the 68 degrees Fahrenheit threshold in almost every year (Figures 15-16 and 15-17 in the CalSim II flow section of Appendix D). Both April and May water temperatures at Keswick are consistently below the lower limit of the optimal temperature range for Green Sturgeon larvae (63 degrees Fahrenheit). Under the WOA conditions, Green Sturgeon larvae would likely not be able to survive July and August water temperatures at Woodson

Bridge and downstream. While they might be able to survive upstream of Red Bluff, they would not be able to survive dispersion downstream.

Sacramento River water temperatures under the WOA conditions vary greatly during the April through July Green Sturgeon spawning and egg incubation period. During April, at Hamilton City, which is at the lower end of the Green Sturgeon spawning reach in the Sacramento River, the WOA mean monthly water temperatures (HEC-5Q WOA modeling scenario) are consistently low, ranging from 52 to 62 degrees Fahrenheit (Figure 5.12-11). During May, the mean monthly water temperatures range from 59 to 70 degrees Fahrenheit, exceeding the 63 degrees Fahrenheit threshold in 56 percent of years (Figure 5.12-12), and in June and July, the water temperatures exceed the 63 degrees Fahrenheit threshold in all years, and range up to 81 degrees Fahrenheit in July (Figures 5.12-13 and 5.12-14). About 40 percent of years in June and all years in July have mean monthly water temperatures greater than 72 degrees Fahrenheit, which is identified as a likely lethal temperature for Green Sturgeon eggs by Heublein et al. (2017b). During the August through October period, the water temperatures at Woodson Bridge exceed the 63 degrees Fahrenheit threshold in all years in August, about 30 percent of years in September, and about 4 percent of years in October (Figures 5.12-15 through 5.12-17). The WOA water temperatures would be more favorable for Green Sturgeon spawning and egg incubation at more upstream locations, but even at Keswick, water temperatures in July and August would exceed the 63 degrees Fahrenheit threshold in every year and would exceed 68 degrees Fahrenheit, which is identified as “increasing chance of lethal effects” for Green Sturgeon eggs by Heublein et al. (2017b), in July of 90 percent of years (Figures 5.12-13 and 5.12-14). The water temperatures in the Sacramento River under the WOA conditions, especially during July and August, would make survival of incubating eggs unlikely.

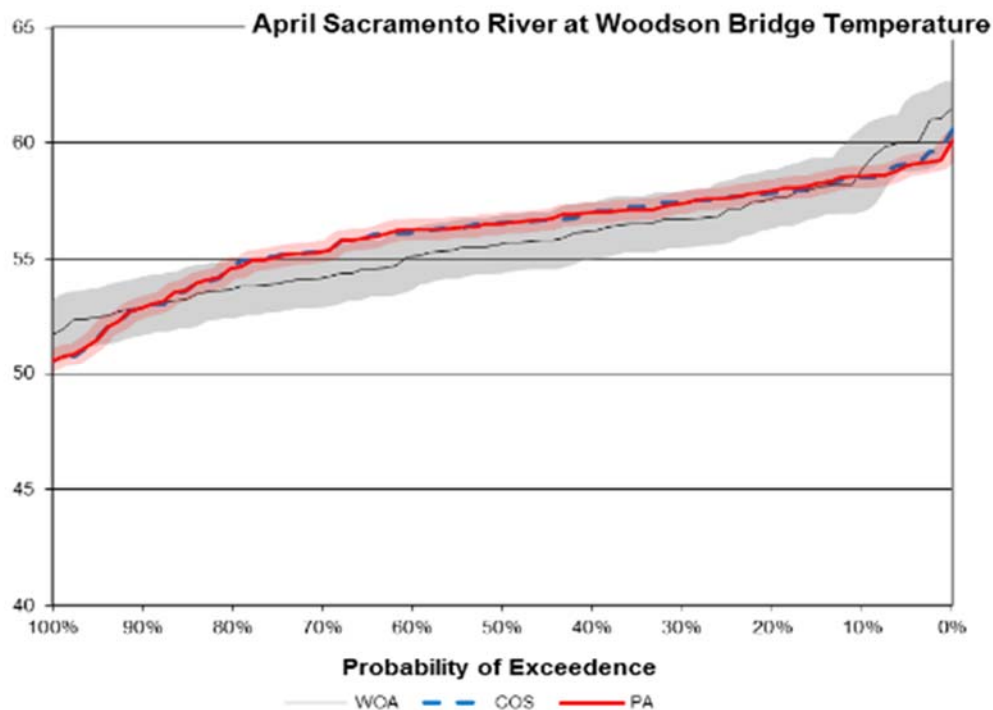


Figure 5.12-11. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed action and COS scenarios, April.

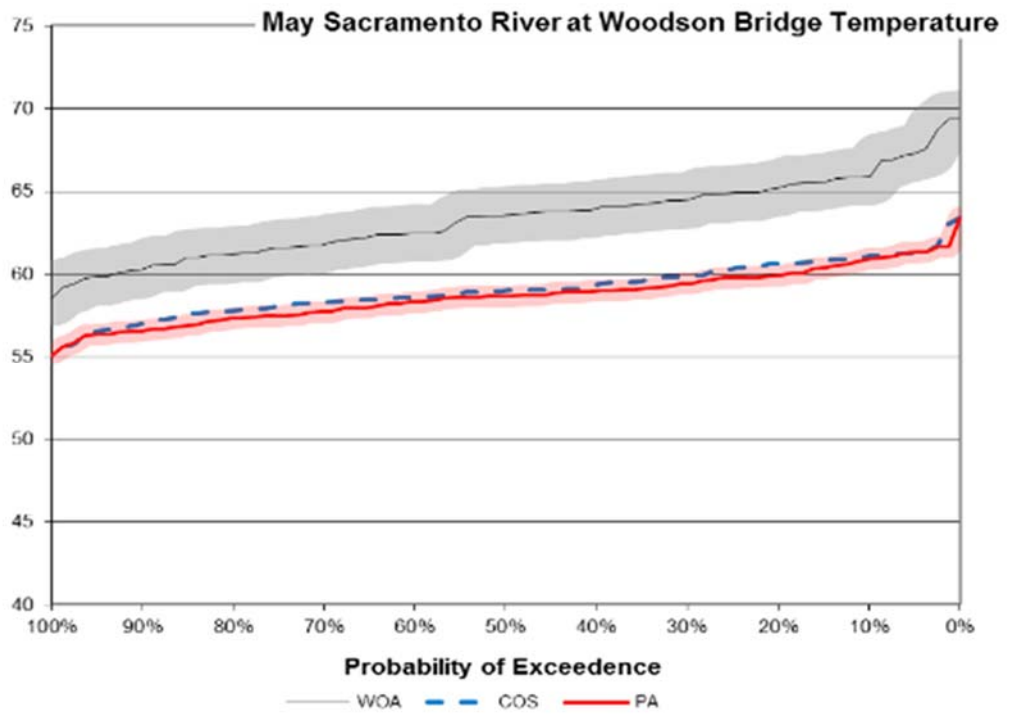


Figure 5.12-12. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed action and COS scenarios, May.

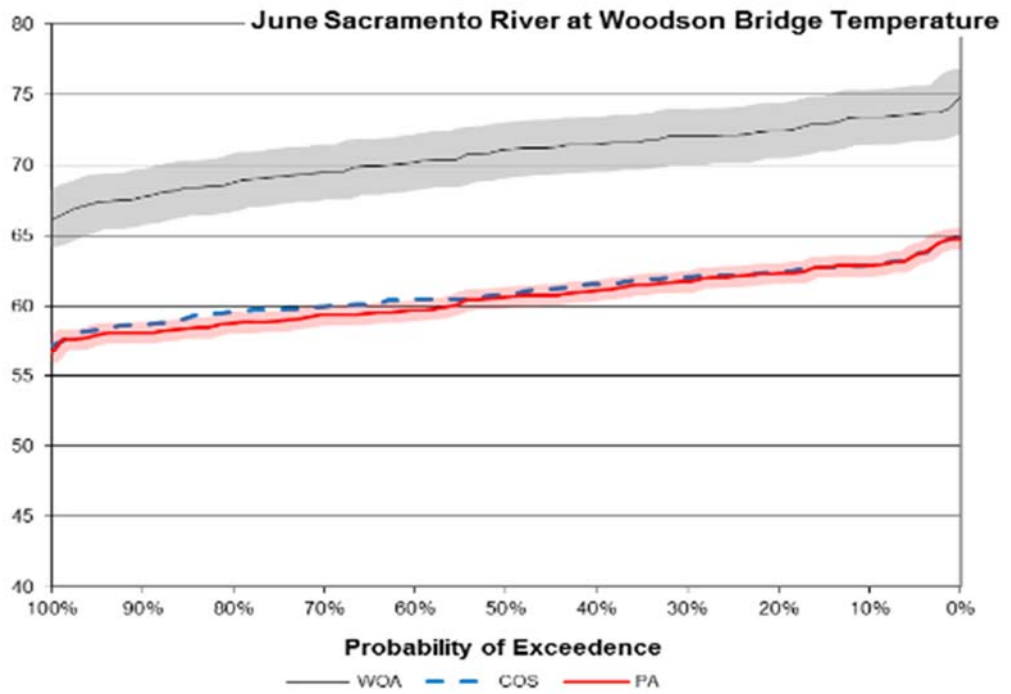


Figure 5.12-13. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, June.

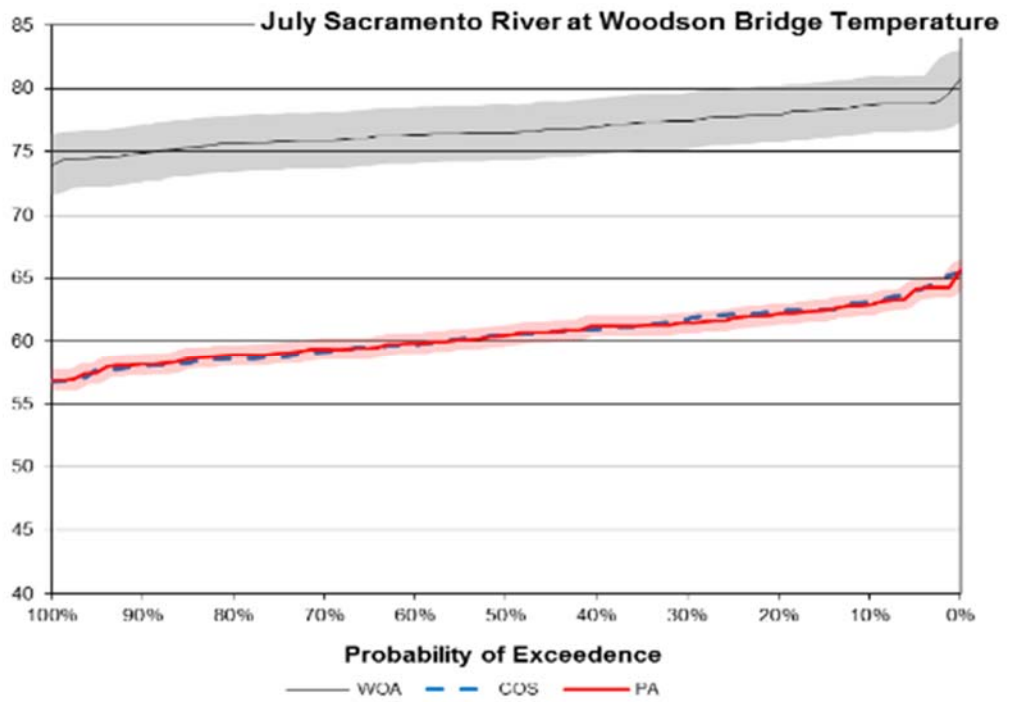


Figure 5.12-14. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, July.

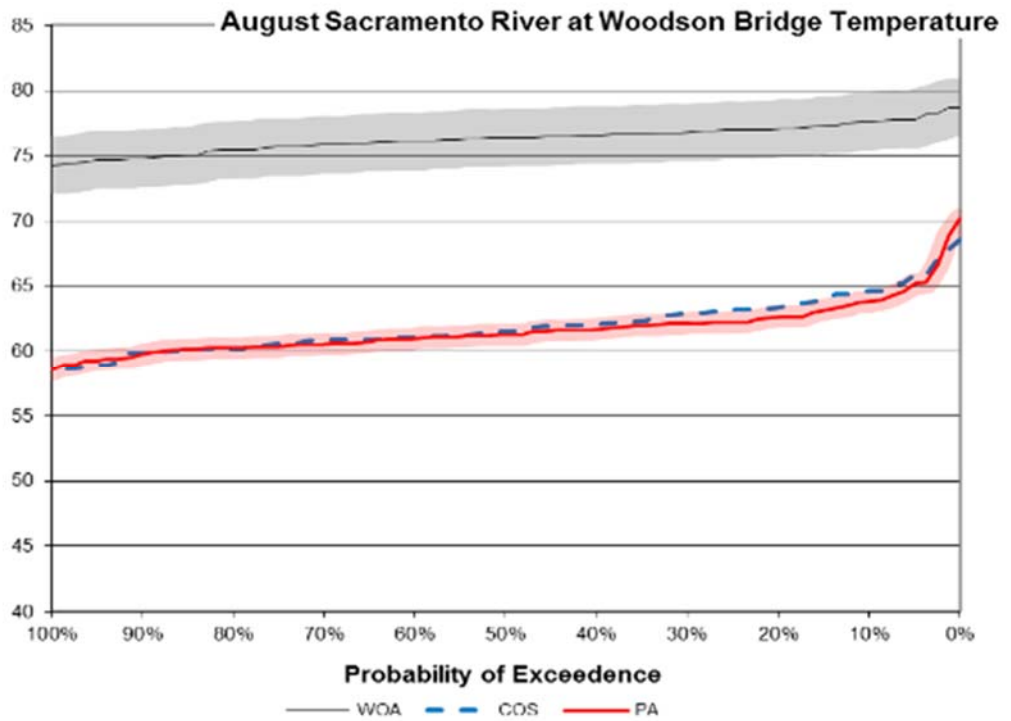


Figure 5.12-15. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, August.

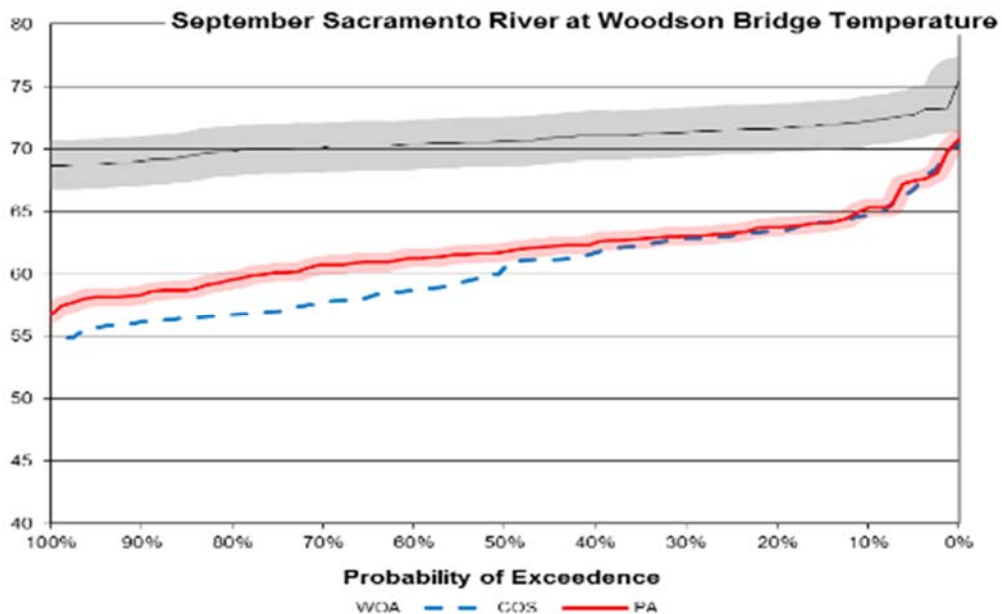


Figure 5.12-16. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, September.

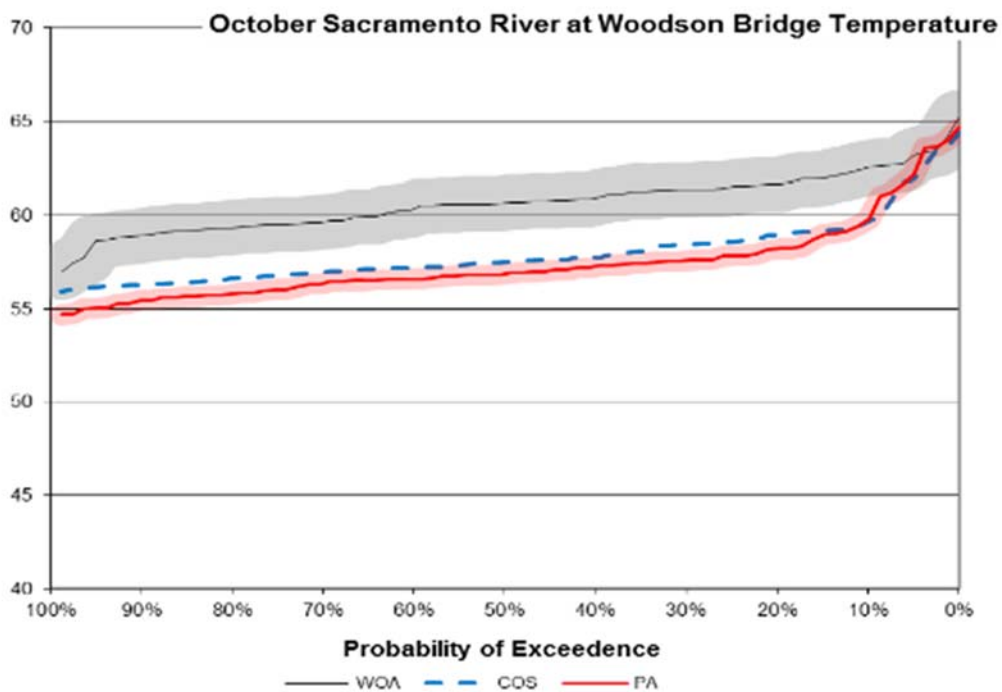


Figure 5.12-17. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Scenarios, October.

The COS is described herein to provide context for the potential positive and negative effects of the proposed action. Under COS, Shasta and Keswick reservoir operations, during most of the juvenile rearing, emigration, and larval period, primarily target flow and water temperature requirements for Winter-run Chinook Salmon and other anadromous fishes, including spring-run and fall/late fall-run Chinook Salmon, steelhead, and Green Sturgeon (NMFS 2011). Fall X2 conditions for Delta smelt are also considered (USFWS 2008). In addition, reservoir operations must balance the current needs of the fish populations with cold water storage needed to satisfy requirements in the following year, while also providing sufficient space for flood control in the winter and spring. During spring, primary operational considerations for the reservoirs in most years are to maximize storage in preparation for summer and fall releases, while during June through September, operations are largely dictated by needs of incubating Winter-run eggs and larvae. Under the proposed action, flow and water temperature management in the upper Sacramento River would be similar to the COS.

5.12.3.2 Sacramento Seasonal Operations including Shasta Cold Water Pool Management

5.12.3.2.1 Spawning Adult to Egg and Post-Spawn Adult

5.12.3.2.1.1 Flows

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the proposed action and the WOA scenario. In February, the proposed action flows are generally similar to or lower than the WOA flows for most years at both Wilkins Slough and RBDD (see Appendix D, *Modeling*). In March and April, the proposed action flows are lower than WOA flows at both locations in almost every year (see Appendix D, *Modeling*). In May, the proposed action flows at Wilkins Slough are substantially lower than WOA flows for the 60 percent of highest flow years and are substantially higher for the 25 percent of lowest flow years, while at RBDD, the proposed action flows are higher than the WOA and COS flows for the highest two thirds of flow years and are slightly higher in the other years. For most of the remainder of the Green Sturgeon adult immigration, spawning and holding period (June through November), the proposed action and COS flows are generally higher or much higher than the WOA flows at both locations, but flows of all three modeling scenarios were roughly similar during November and December. The higher flows during May through October in years with dry hydrology at Wilkins Slough and Red Bluff under proposed action relative to the WOA conditions would likely benefit adult Green Sturgeon migrating, spawning and holding in the middle and upper Sacramento River by enhancing water quality and passage, and reducing disease risks (Heublein et al. 2017a[SAIL model]).

Flows during the February through December period of Green Sturgeon immigration, spawning and holding would generally be similar between the proposed action and COS at both Wilkins Slough and Red Bluff (see Appendix D, *Modeling*). Exceptions include higher flows (up to ~2,500 cfs higher) at Wilkins Slough during May and June for the proposed action scenario. The differences in flow occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults. There are also substantial flow differences between the proposed action and COS scenarios at Red Bluff during June, September and November, with higher proposed action flows in June and higher COS flows in September and November (see Appendix D, *Modeling*). These flow differences occur within a range of river flows (6,000 cfs to 17,000 cfs) not expected to substantially affect migrating Green sturgeon, but the flow reductions under the proposed action in September and November could result in reduced habitat quality in holding pool habitats. See Figures 5.12-18 through 5.12-24.

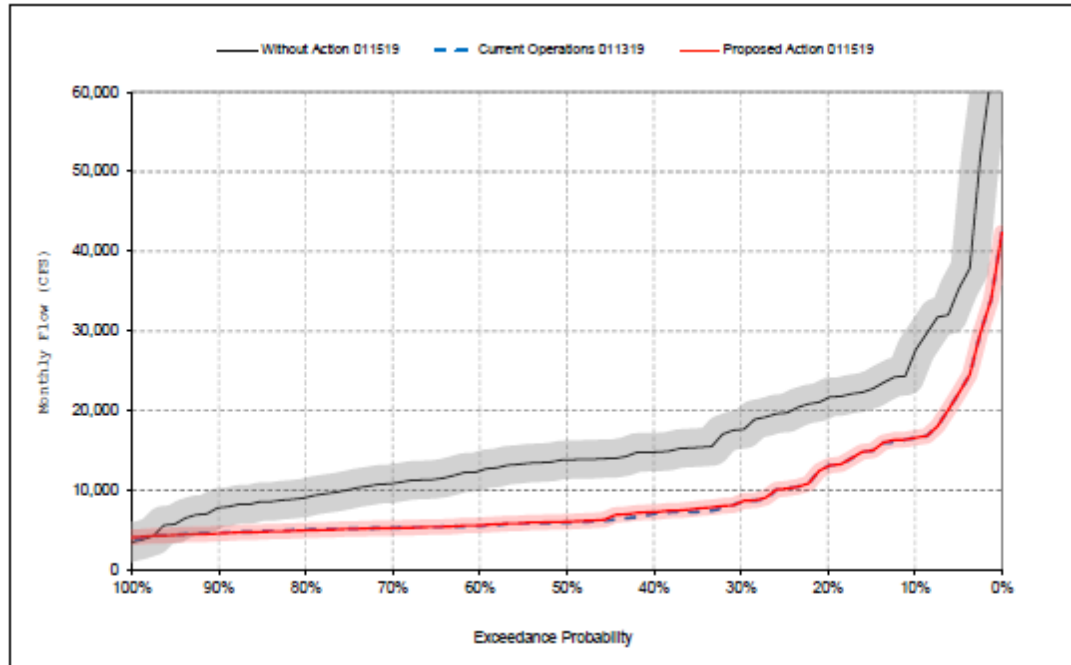


Figure 5.12-18. CalSim II Sacramento River Flows at Red Bluff, April

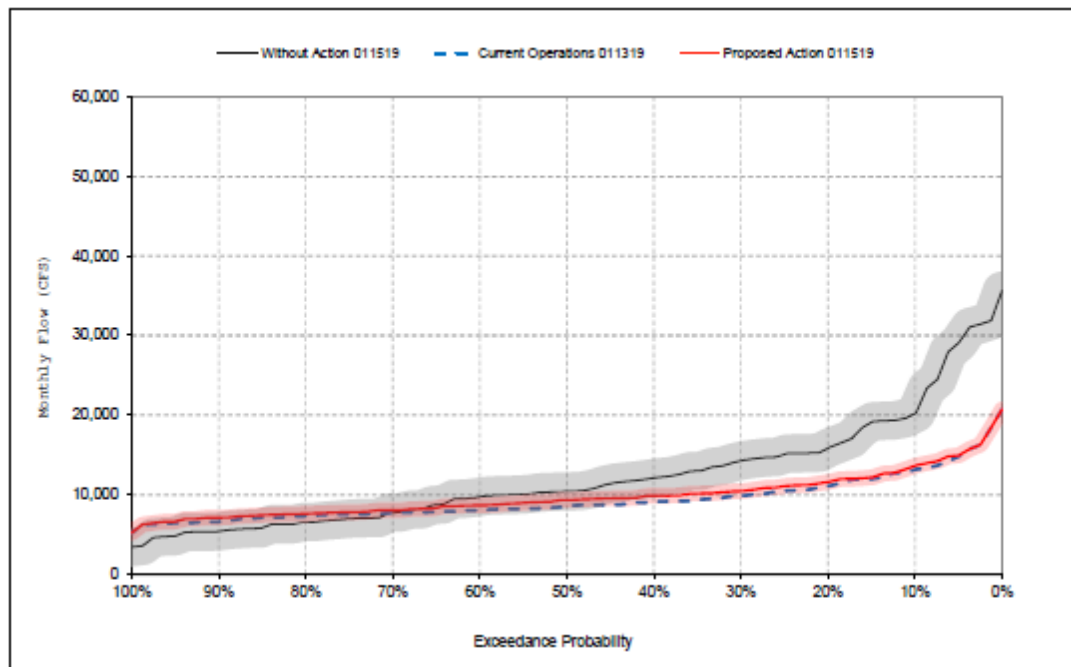


Figure 5.12-19. CalSim II Sacramento River Flows at Red Bluff, May

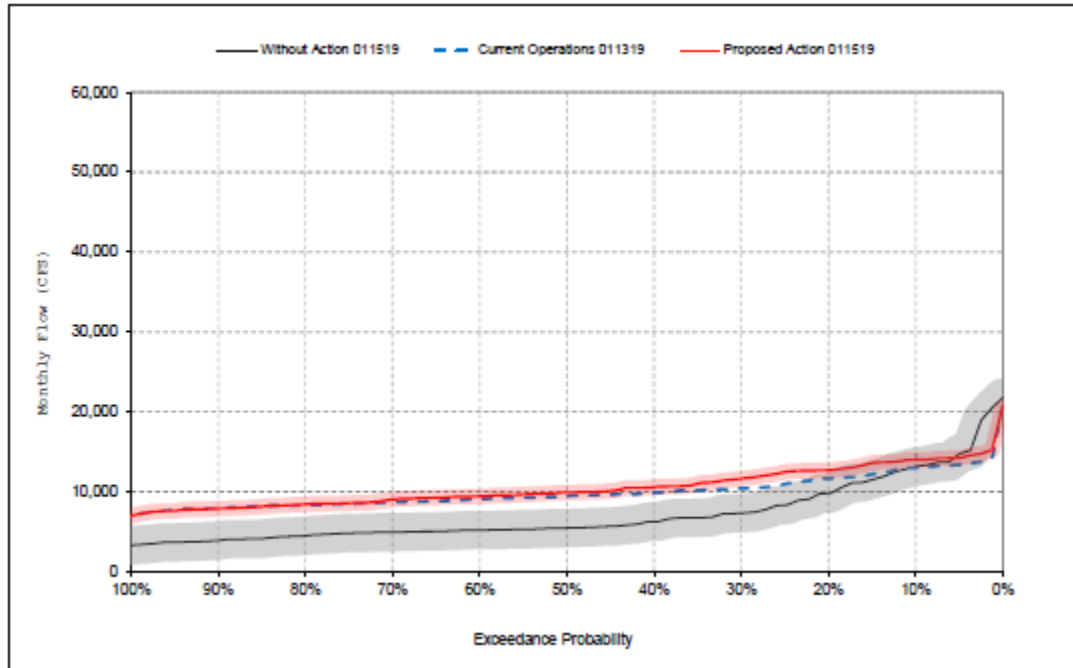


Figure 5.12-20. CalSim II Sacramento River Flows at Red Bluff, June

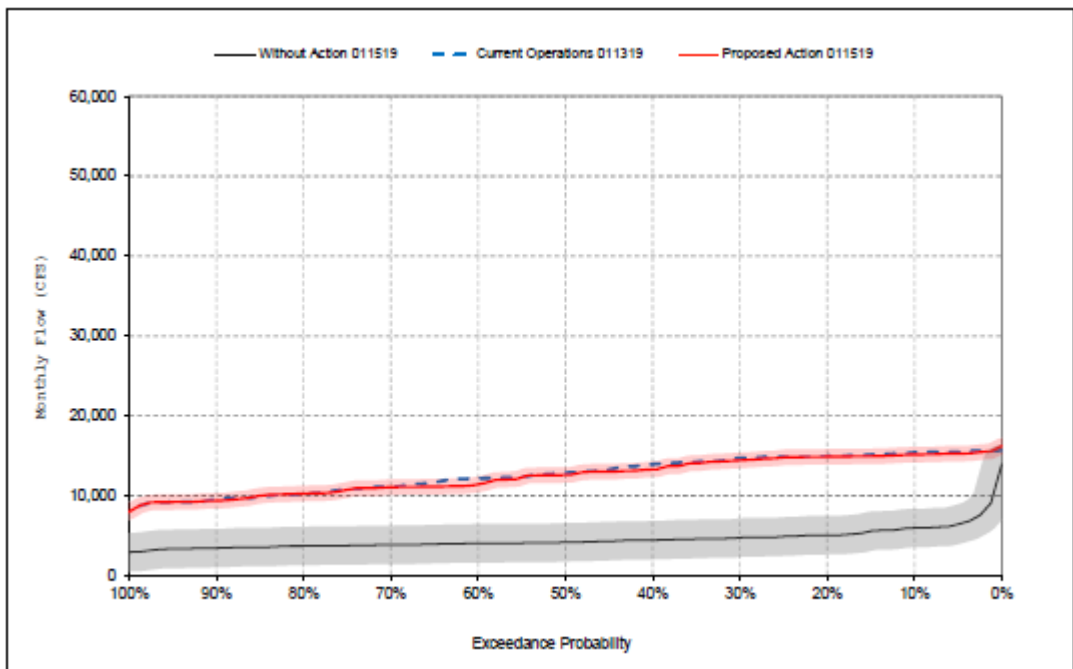


Figure 5.12-21. CalSim II Sacramento River Flows at Red Bluff, July

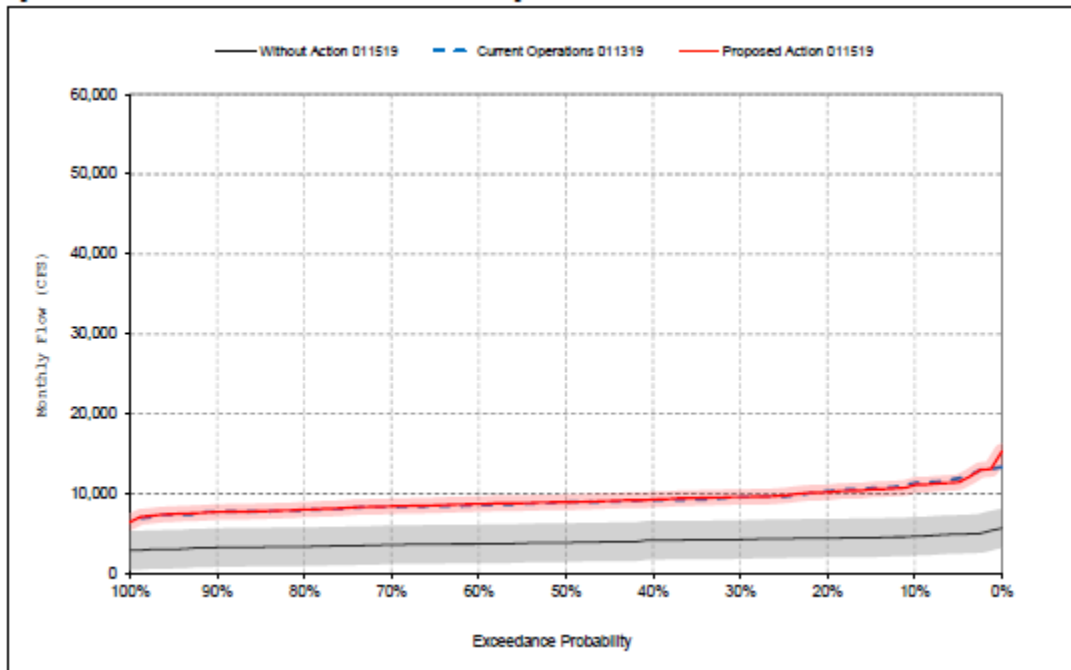


Figure 5.12-22. CalSim II Sacramento River Flows at Red Bluff, August

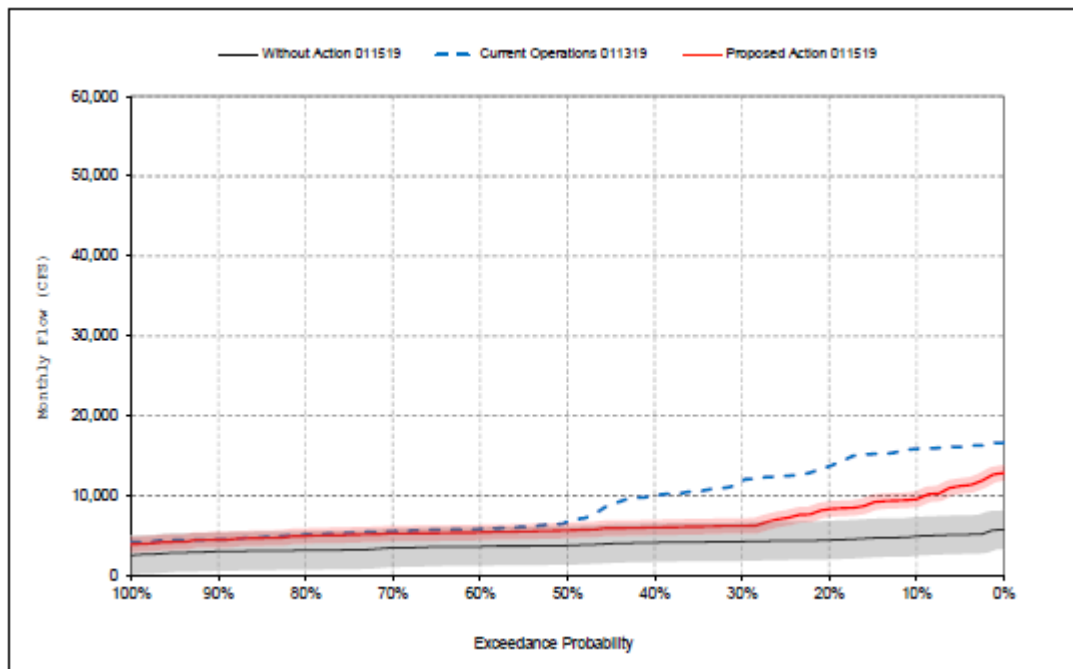


Figure 5.12-23. CalSim II Sacramento River Flows at Red Bluff, September

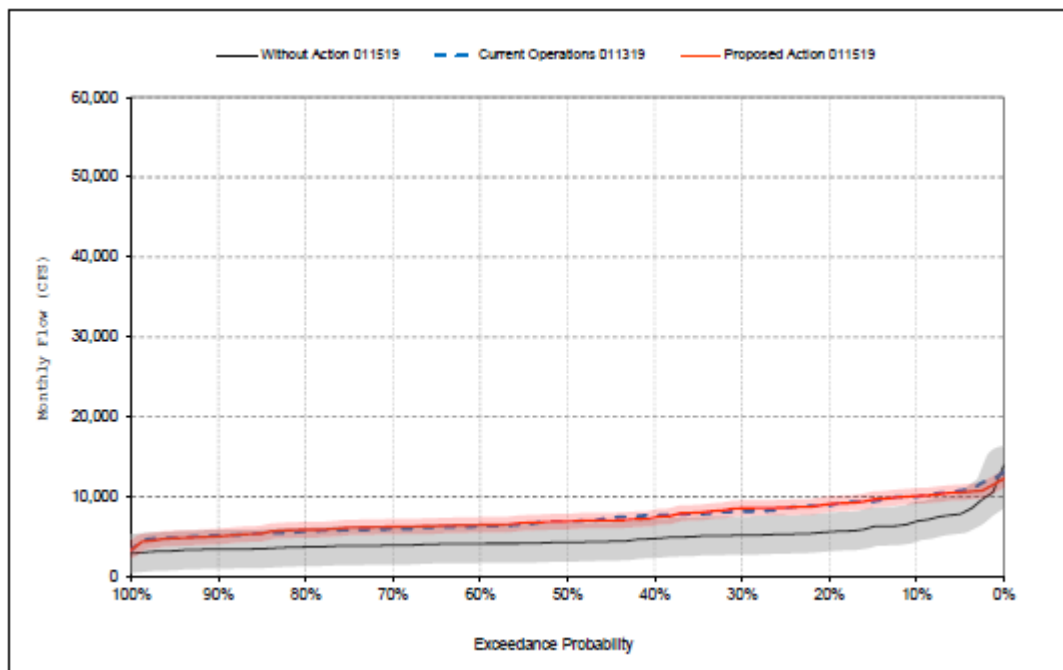


Figure 5.12-24. CalSim II Sacramento River Flows at Red Bluff, October

5.12.3.2.1.2 Water Temperature

The USEPA (2003) gives 61 degrees Fahrenheit as the critical 7DADM water temperature for Green Sturgeon adults holding, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of operating to 7DADM. The upper limit for mean monthly water temperature of spawning adults is assumed to be similar to that given for incubating eggs, 63 degrees Fahrenheit. In addition, assuming that adults are at least as tolerant to warm temperatures as juveniles, the upper limit for mean monthly water temperatures of migrating adults, whether immigrating or emigrating, is treated as 66 degrees Fahrenheit.

In the middle Sacramento River below the Colusa Basin Drain, which is downstream of any Green Sturgeon spawning areas, the WOA modeling scenario mean monthly water temperatures during February through April and November and December would consistently fall below the 66 degrees Fahrenheit threshold for migrating adults (see Appendix D, *Modeling*). However, the water temperatures would exceed the threshold during May of about 65 percent of years, during June through September in every year, and during October of about 50 percent of the years (see Appendix D, *Modeling* and Figure 5.12-25, for example). Adults migrating downstream from May through October would potentially be negatively impacted by the high water temperatures, but most upstream immigration occurs before late spring (Heublein et al. 2009) when water temperatures are below the 66 degrees Fahrenheit threshold.

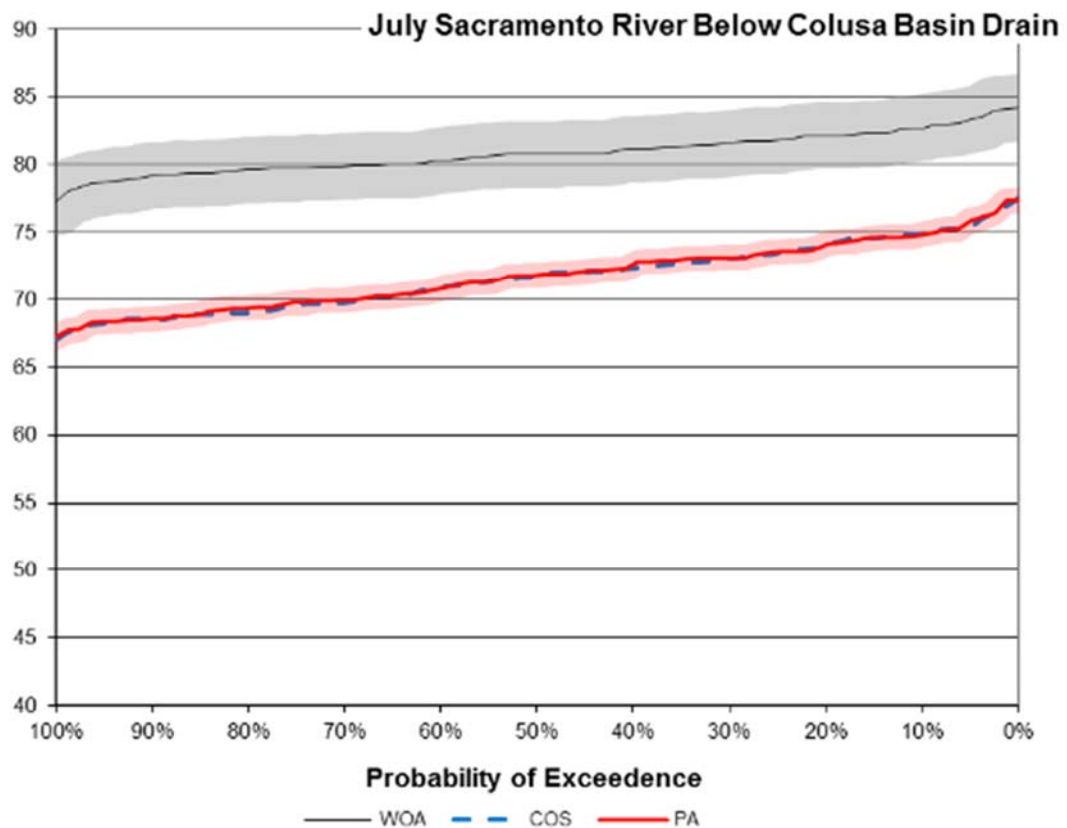


Figure 5.12-25. HEC-5Q Sacramento River Water Temperatures below Colusa Basin Drain under the WOA, Proposed Action and COS Scenarios, July

In the Sacramento River at Woodson Bridge, the WOA mean monthly water temperatures during February through April are below 68 degrees Fahrenheit threshold for migrating adults in every year. This area is located near the GCID oxbow at the most downstream, warmest section of the Green Sturgeon spawning reach. During May through July, which are the peak spawning months, mean monthly water temperatures exceed the 63 degrees Fahrenheit threshold for spawning adults during about 65 percent of the years in May and during every year in June and July (Figures 18-14 through 18-16 in the CalSim II flow section of Appendix D). During August and September, when most Green Sturgeon are holding after spawning or are emigrating downstream, the mean monthly water temperatures at Woodson Bridge under the WOA modeling scenario range from a low of 70 degrees Fahrenheit in September to a high of 81 degrees Fahrenheit in August, thus greatly exceeding the 61 degrees Fahrenheit threshold for holding adults in every year (Figures 18-17 and 18-18 in the CalSim II flow section of Appendix D). During October, the water temperatures exceed the 61 degrees Fahrenheit threshold in about 40 percent of years and during November and December, the water temperatures are well below the threshold in every year (Figures 18-7 through 18-9 in the CalSim II flow section of Appendix D.).

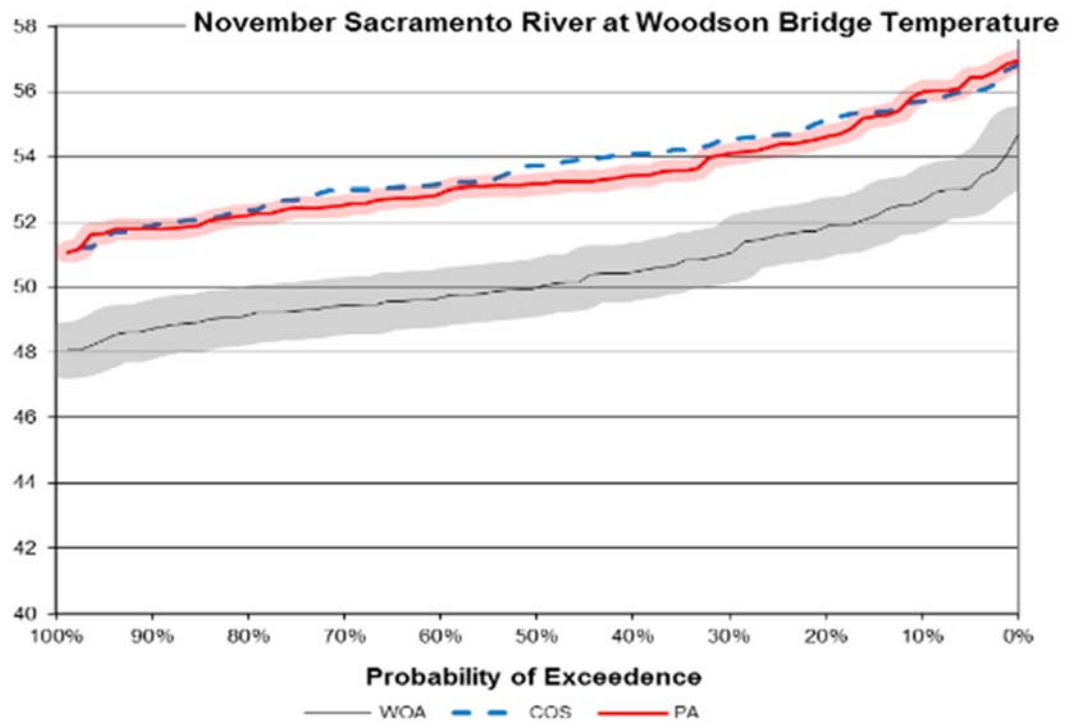


Figure 5.12-26. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, proposed Action and COS Modeling Scenarios, November

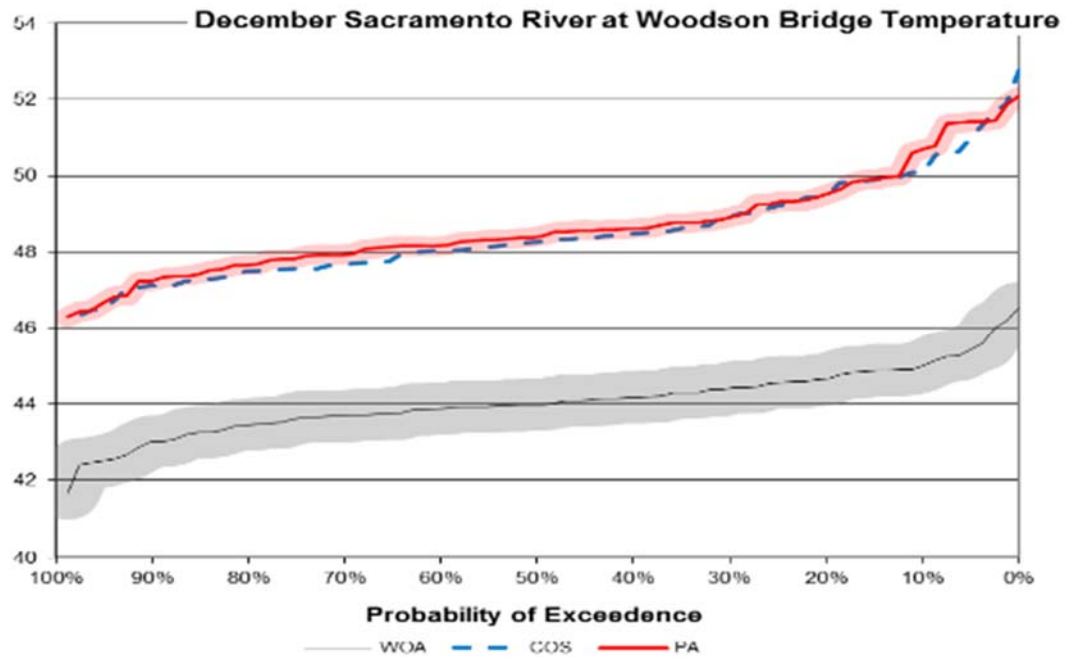


Figure 5.12-27. HEC-5Q Sacramento River Water Temperatures at Woodson Bridge under the WOA, Proposed Action and COS Modeling Scenarios, December

Water temperatures conditions under the WOA modeling scenario in the summer months, June through September, would be highly stressful to adult Green Sturgeon spawning and holding in the Sacramento River. Spawning sturgeon are particularly vulnerable to the effects of elevated water temperature, which may result in egg resorption and reduced fecundity (Heublein et al. 2017a [SAIL model]). Water temperatures in the lower reaches of spawning habitat on the Sacramento River may reach levels that cause egg resorption, affecting fertilization of eggs and survival of embryos (Heublein et al. 2017a [SAIL model]).

There are few major differences in mean monthly water temperatures between the proposed action and COS scenarios in the Sacramento River below the Colusa Basin Drain during the February through April period that most adult Green Sturgeon migrate upstream or during the later months when the sturgeon migrate downstream after spawning (see Appendix D, *Modeling*). The biggest difference occurs in September of cooler years, when water temperatures under the proposed action scenario are higher than those of the COS modeling scenarios, by up to 5 degrees Fahrenheit. The temperatures in September exceed the 66 degrees Fahrenheit threshold for migrating Green Sturgeon adults in 95 percent of years under the proposed action scenario, whereas they exceed the threshold in 65 percent of years under the COS modeling scenario. The temperature difference between the scenarios results from higher flows in wetter years under the COS modeling scenario, which, as previously noted, results from Fall X2 releases.

During the May through December spawning and post-spawn holding period for Green Sturgeon, water temperatures at Woodson Bridge, which is located in the most downstream, warmest section of the Green Sturgeon spawning reach, are generally similar between the proposed action and COS scenario, except for higher temperatures under the proposed action scenario in September, as discussed above for the Colusa Basin Drain location. Adults migrating downstream from May through September would potentially be adversely affected by the high water temperatures. Most upstream immigration occurs before late spring (Heublein et al. 2009), when water temperatures are below the 66 degrees Fahrenheit threshold. Water temperatures during warm years, especially in August and September, would likely be stressful to spawning and holding adult Green Sturgeon.

In the Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action are similar to WOA water temperatures during May, generally higher than the WOA modeling scenario water temperatures from December through April, and below the WOA modeling scenario water temperatures during June through October. In the Sacramento River at Woodson Bridge, water temperatures under the proposed action and COS scenarios are similar to WOA water temperatures during April (Figure 5.12-2), above the WOA modeling scenario water temperatures during February, March, November and December, and below the WOA modeling scenario water temperatures in all years during May through October (see Appendix D, *Modeling*).

Water temperatures in the Sacramento River below the Colusa Basin Drain and at the Woodson Bridge are suitable for adult Green Sturgeon immigrating in the Sacramento River during February through April under all three scenarios, so no negative effects are expected. However, under the WOA modeling scenario during the peak spawning season, May through July, water temperatures at the Woodson Bridge location, near the downstream limit of the Green Sturgeon spawning reach, exceed the 63 degrees Fahrenheit threshold for spawning adults in the majority of years during May and in all years during June and July. Under the proposed action, water temperatures during this period exceed the threshold in at most 50 percent of years (in June and July). During May through December, when most post-spawning Green Sturgeon adults are holding near spawning areas or emigrating back to the estuary, water temperatures under the WOA modeling scenario at Woodson Bridge exceed the 61 degrees Fahrenheit threshold for holding adults during about 85 percent of years in May, in every years during June through September, and in about 40 percent of years in October. The water temperatures at this location under the

proposed action exceed the 61 degrees Fahrenheit threshold for holding adults in about 50 percent of years in May, about 95 to 70 percent of years in June through September, and about 10 percent of years in October. Water temperatures below the Colusa Basin Drain during this period, which would affect Green Sturgeon adults emigrating from the Sacramento River, would exceed the 66 degrees Fahrenheit threshold from migrating adults under the WOA modeling scenario in all years during June through September and well over half of years in October. Although the water temperatures below the Colusa Basin Drain exceed the threshold for emigrating adults in all or almost all years during June through September under all three scenarios, the amount by which the threshold is exceeded is consistently much greater under the WOA modeling scenario than under the proposed action.

Summer water temperatures under proposed action are consistently lower than those under the WOA, with far fewer years exceeding the 63 degrees Fahrenheit threshold for spawning adults or the 61 degrees Fahrenheit threshold for holding adults. Summer water temperatures for emigrating adults would also be lower under proposed action for emigrating adults. These results indicate that the proposed action, relative to the WOA, provide a clear benefit to adult Green Sturgeon spawning and holding in the Sacramento River, as well as those emigrating from the river.

5.12.3.2.2 Juvenile to Subadult/Adult

5.12.3.2.2.1 Flows

As noted in the Larvae to Juveniles section, there appears to be a positive relationship between annual outflow and abundance of Green Sturgeon larvae in rotary screw traps at RBDD (Heublein et al. 2017a[SAIL model], 2017b). At federal and state Delta pumping facilities, the highest juvenile Green Sturgeon collection on record occurred in a wet year (2006; Gartz 2007 cited in Heublein et al. 2017b). These findings are consistent with white sturgeon and the relationship between recruitment to age-0 and wet years (Heublein et al. 2017b). These relationships may result from flows transporting larvae and juveniles to areas with greater prey availability and/or enhancing nutrient availability to the Sacramento River and Delta/Estuary.

Green Sturgeon juveniles are believed to be highly susceptible to entrainment in unscreened diversions and impingement on screened diversions (Mussen et al. 2014, NMFS 2018). Risks of entrainment and impingement in the Sacramento River are increased because the period of juvenile presence in the river (May through December), coincides with peak period of irrigation diversions (April to September).

High WOA flows occur frequently during May and December, and these could have both positive and negative effects on rearing and emigrating Green Sturgeon juveniles (Figures 5.12-28 to 5.12-35). The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse impacts, including higher contaminant concentrations from stormwater runoff.

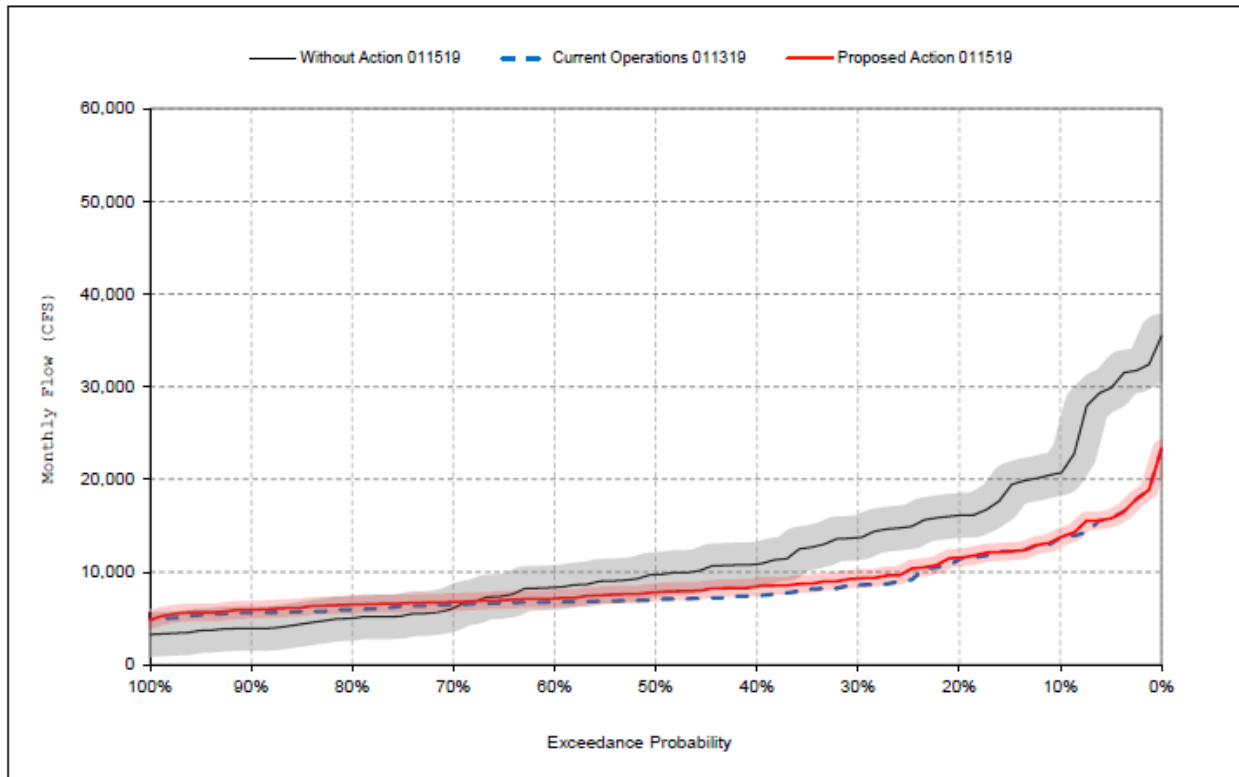


Figure 5.12-28. CalSim II Sacramento River Flows at Hamilton City, May

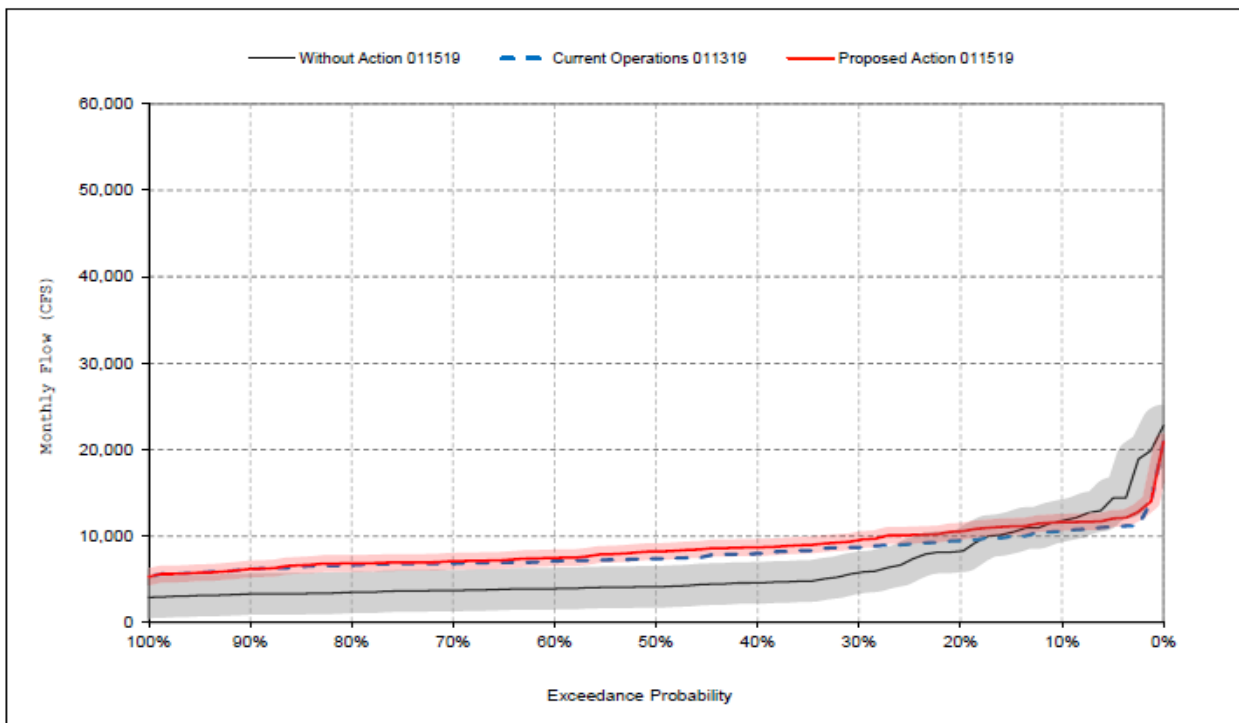


Figure 5.12-29. CalSim II Sacramento River Flows at Hamilton City, June

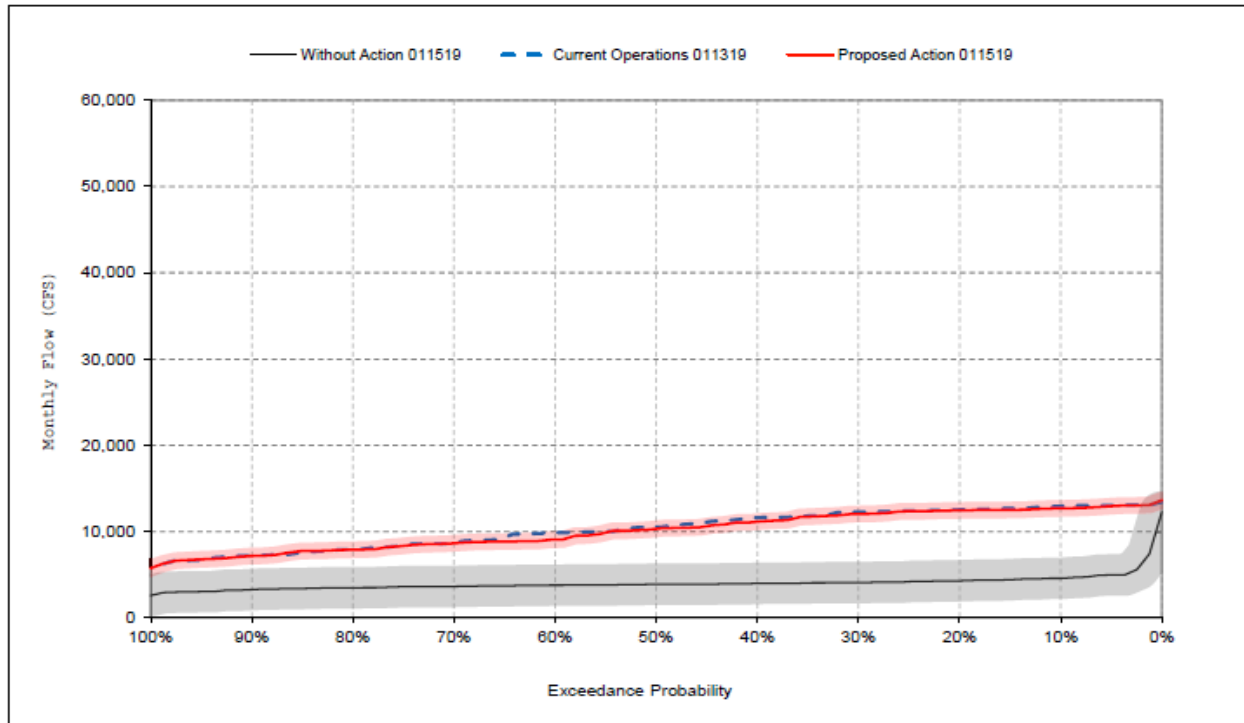


Figure 5.12-30. CalSim II Sacramento River Flows at Hamilton City, July

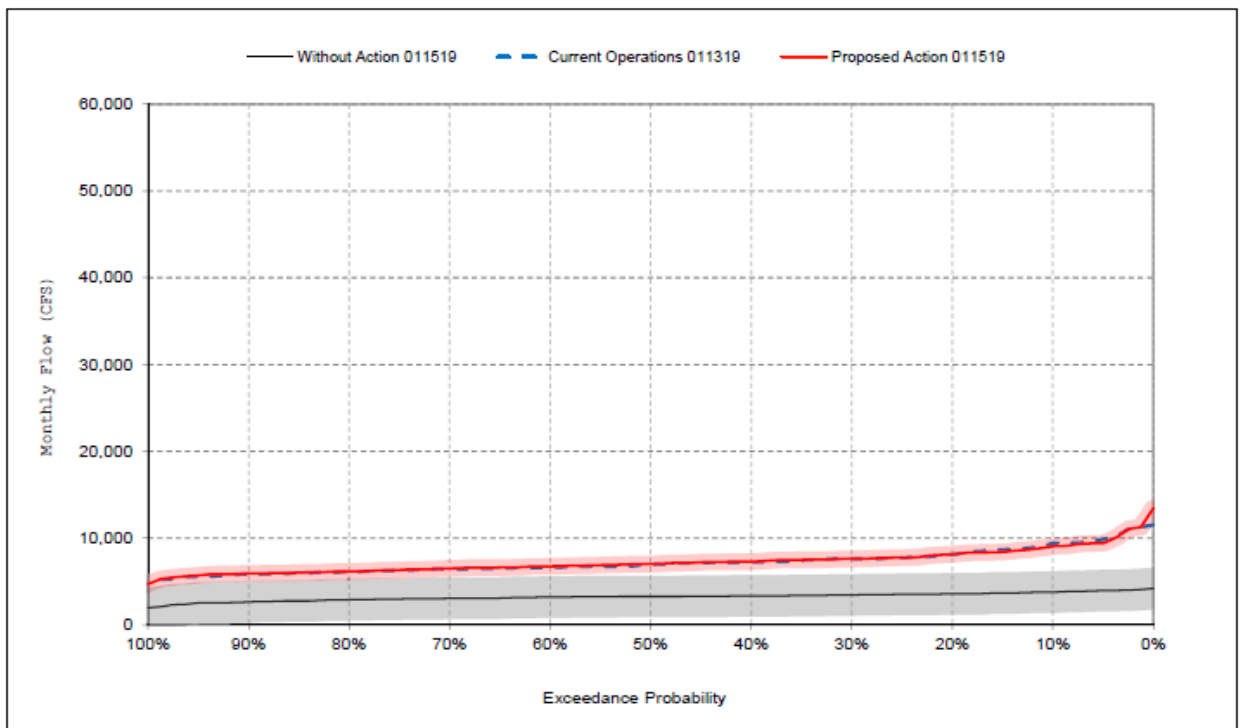


Figure 5.12-31. CalSim II Sacramento River Flows at Hamilton City, August

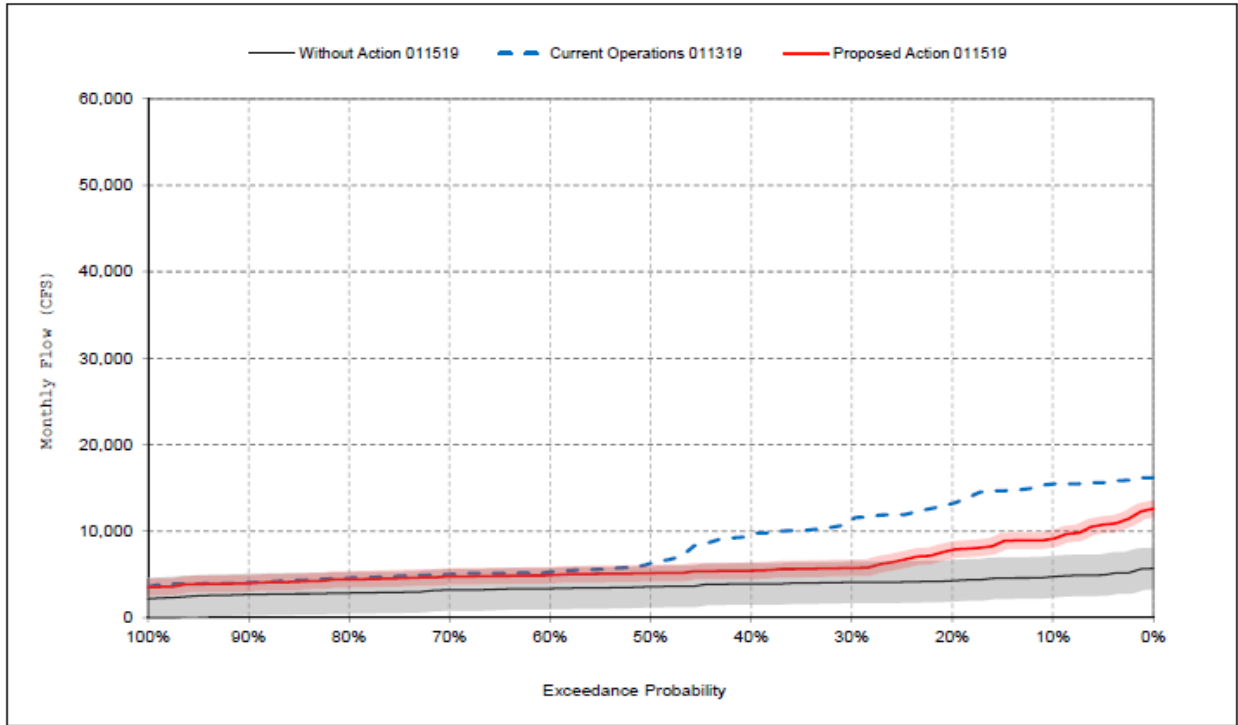


Figure 5.12-32. CalSim II Sacramento River Flows at Hamilton City, September

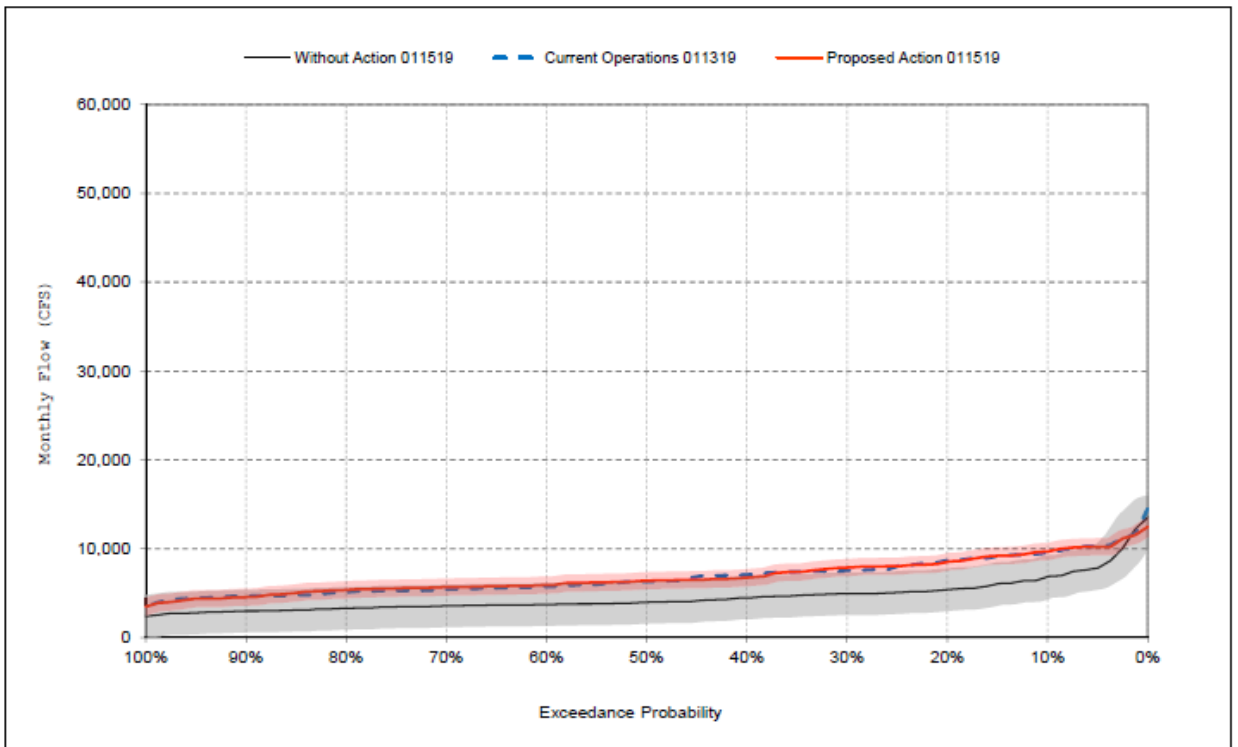


Figure 5.12-33. CalSim II Sacramento River Flows at Hamilton City, October

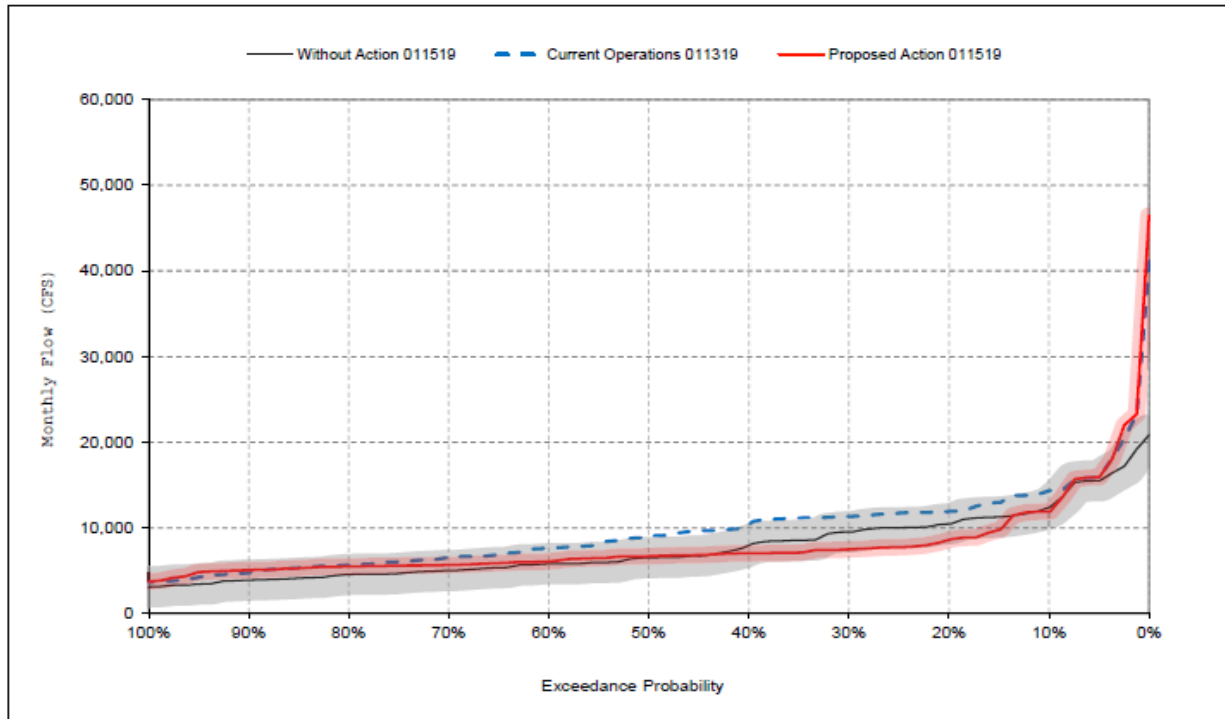


Figure 5.12-34. CalSim II Sacramento River Flows at Hamilton City, November

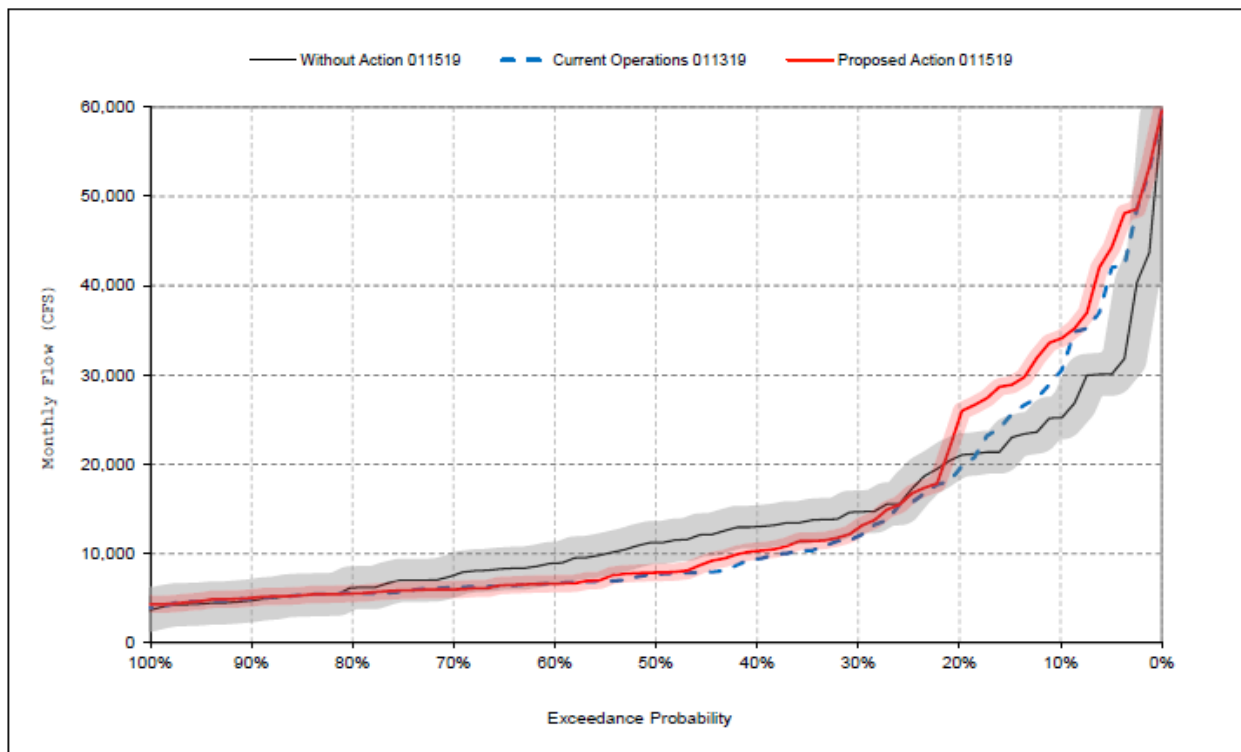


Figure 5.12-35. CalSim II Sacramento River Flows at Hamilton City, December

CalSim modeling for the Sacramento River at Hamilton City indicates that flows during the period of juvenile rearing and emigration are generally similar between proposed action and COS except, as described previously, for much higher flows during September under the COS modeling scenario in the upper range of flows (Figure 5.12-32), which result from Fall X2 releases under COS that are not included in the proposed action. Differences between proposed action and COS flows are also large in June and November (Figures 5.12-29 and 5.12-34), with higher flows for the proposed action in June and for the COS in November, but the differences are much less high than those in September.

The CalSim modeling shows large seasonal changes during the larval period between the WOA modeling scenario and the proposed action. For most years in May, the WOA flows are greater than the proposed action flows (Figure 5.12-28), but for almost all years in June through October, the proposed action flows are higher than the WOA flows (Figures 5.12-29 through 5.12-33). The WOA flows are similar to the proposed action flows in November and December (Figures 5.12-34 and 5.12-35). These seasonal changes result primarily from diversions to Shasta Reservoir storage under the proposed action scenarios during spring, when uncontrolled flows are high, and Shasta Reservoir storage releases under the proposed action scenarios during June through October, when uncontrolled flows are low.

The higher summer and fall flows under the proposed action would potentially result in improved conditions in juvenile rearing habitats, as previously described, and increase transport of the juveniles to favorable rearing habitats.

5.12.3.2.2.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon, but it is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein et al. 2017b). Based on laboratory studies, Mayfield and Cech (2004) concluded that 59 to 66 degrees Fahrenheit is the optimal range of water temperatures for growth of juvenile sturgeon. This temperature range overlaps the optimal range temperatures range for Green Sturgeon eggs (below 63 degrees Fahrenheit) and larvae (63 to 68 degrees Fahrenheit)

There is little difference in water temperatures at Woodson Bridge between the proposed action and COS scenarios during the Green Sturgeon juvenile rearing and emigration period in any month except for September. During well over half of the years in September, the proposed action water temperature is greater than the COS water temperature, with a maximum difference of about 4 degrees Fahrenheit (see Figure 12-18 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures under the proposed action at Hamilton City fall within the 59 to 66 degrees Fahrenheit optimal range for Green Sturgeon juveniles during most years in June through September. Temperatures exceed 66 degrees Fahrenheit under the proposed action in 5% of Junes, 8% of Julys, 15% of Augusts, and 20% of Septembers (see Appendix D, *Modeling*). Water temperatures for about 80% of the years in May, most years in June to October, and all years during November and December fall below the 59 degrees Fahrenheit threshold for juvenile Green Sturgeon optimal growth. Water temperatures under the proposed action would be suitable for survival of Green Sturgeon juveniles throughout the rearing and emigration period, although temperature in the colder months would be below the range for optimal growth.

May through October water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario (See Figures 12-7, 12-14, 12-15, 12-16, 12-17 and 12-18 in the HEC5Q temperature section of Appendix D), while November and December temperatures are consistently higher than WOA temperatures (See Figures 12-8 and 12-9 in the HEC5Q temperature section of Appendix D). During June through September, the WOA water temperatures always exceed the

optimal range, and during the same months, the proposed action water temperatures lie within the optimal range in most years and exceed the upper threshold (66 degrees Fahrenheit) in only a few percent of years in August and September. Only in May under the WOA modeling scenario, do the majority of years lie within the optimal temperature range. These results indicate that the proposed action provides more favorable water temperature conditions for Green Sturgeon juveniles than the WOA modeling scenario, although it also provides temperatures too cold of optimal growth in some months. As previously noted, the juveniles would be unlikely to survive water temperature conditions in the middle Sacramento River expected under the WOA scenario in July and August.

5.12.3.2.3 Larvae to Juvenile (April – August)

5.12.3.2.3.1 Flow

The effects of flow on Green Sturgeon larvae are poorly understood. There appears to be a positive relationship between annual outflow and abundance of Green Sturgeon larvae and juveniles in rotary screw traps at RBDD (Heublein et al. 2017a [SAIL model], 2017a). Also, there is a positive correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength (CDFG 1992 and USFWS 1995, cited in NMFS 2018). These relationships may result from flows transporting larvae to areas with greater food availability, dispersing larvae over a wider area, and/or enhancing nutrient availability to the Sacramento River and Delta/Estuary.

Green Sturgeon larvae may be particularly susceptible to entrainment at water diversions. The larvae are present in areas where substantial water volumes are diverted, such as the Red Bluff Diversion Dam and Glen-Colusa Irrigation District (GCID) facilities and, due to their small size and relatively poor swimming performance, it is highly likely that entrainment effects larval survival (Heublein et al. 2017a[SAIL model]; Verhille et al. 2014). Modern fish screens are designed to reduce entrainment of juvenile salmonids, but the effectiveness of screens and facility operations in reducing larval Green Sturgeon entrainment is poorly understood. Furthermore, many small-scale unscreened diversions are present near larval habitat throughout the mainstem Sacramento River. Periods of extended low flow may reduce the effectiveness of fish protection devices and operational measures intended to reduce entrainment (Heublein et al. 2017a[SAIL model]).

Flows under the WOA modeling scenario would generally be low in summer and fall, potentially affecting the Green Sturgeon larvae. High WOA flows occur during April and May in many years, and these could have both positive and negative effects on rearing Green Sturgeon larvae. The impacts of low flows listed above are generally ameliorated by higher flows, but there can be adverse effects including higher stranding risk because of greater flow fluctuations and higher contaminants concentrations from stormwater runoff.

The CalSim modeling shows large seasonal changes during the larval period between the WOA modeling scenario and the proposed action. For all years in April and most years in May, the WOA flows are greater than the proposed action flows, but in June through September, the proposed action flows are almost always higher than the WOA flows. These seasonal changes result primarily from diversions to Shasta Reservoir storage under the proposed action during spring, when uncontrolled flows are high, and Shasta Reservoir storage releases under the proposed action during June through September, when uncontrolled flows are low.

The lower summer and fall flows under the WOA modeling scenario would potentially result in reduced conditions in larval rearing habitats, as previously described, and reduce dispersion of the larvae to favorable rearing habitats.

5.12.3.2.3.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon, but it is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein 2017b). Based on laboratory studies, Van Eenennaam et al. (2005) concluded that 63 degrees Fahrenheit is the minimum water temperature for optimal growth and survival of larvae and 68 degrees Fahrenheit is the maximum. This water temperature range exceeds the upper limit of optimal temperatures for Green Sturgeon eggs (63 degrees Fahrenheit)

Water temperatures under the proposed action fall below the 63 to 68 degrees Fahrenheit optimal range for Green Sturgeon larvae in most years throughout the entire April to October period of potential larval presence in the Sacramento River. During April, May and October, the mean monthly water temperatures at Hamilton City are above 63 degrees Fahrenheit in no more than about 10 percent of years, while during June through September, the water temperatures fall within the optimal range for a minimum of 50 percent of years to a maximum of 70 percent of years. The water temperatures exceed the 68 degrees Fahrenheit upper temperature threshold in at most 8 percent of years in any month.

Late spring, summer, and early fall water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario, except during April, when water temperatures for all three scenarios are similar. During July through September, the WOA water temperatures always exceed the optimal range, and under the proposed action water temperatures are within the optimal range approximately half of the time at Hamilton City. Only in May under the WOA modeling scenario do the majority of years lie within the optimal temperature range. These results indicate that neither the WOA, proposed action, nor COS provide optimal water temperature conditions for Green Sturgeon larvae. However, cooler water temperatures under the proposed action would have beneficial impacts on Green Sturgeon larvae (especially July and August) because WOA temperatures frequently approach lethal levels.

5.12.3.2.4 Egg to Larvae (March – July)

5.12.3.2.4.1 Flows

In the section of the Sacramento River where Green Sturgeon spawn, the WOA flows during the April through July period, when most Green Sturgeon spawning and egg incubation occurs, vary greatly, ranging from about 3,000 cfs for about two percent of years during July to well over 50,000 cfs for three percent of years in April. During years with dry hydrology (left-hand portion of the flow probability of exceedance plots), the July flows in about five percent of years would drop below the proposed action minimum flow of 3,250 cfs. During June in about 40 percent of years and July in about 80 percent of years, flows would be below 5,000 cfs, which is the proposed action minimum flow for the Sacramento River at Wilkins Slough.

Higher flows may also adversely impact spawning and egg incubation. If flows are sufficiently high, incubating eggs are at risk of being scoured from the river bed. Dewatering of Green Sturgeon eggs is less of a risk than it is for most fish species because eggs are generally spawned in deep water.

During the April through July Green Sturgeon spawning period, mean monthly flows at Red Bluff under the proposed action range from about 3,000 cfs for a few years in July to about 40,000 cfs in April. Flows in the majority of years during this period are moderate (~10,000 cfs to 15,000 cfs), with the percentage of years with flows under 10,000 cfs decreasing progressively from 75 percent in April to only 15 percent in July. The reductions in low flows over the course of this period reflects the increased flow releases

needed for water temperature management in the river and instream demands and Delta requirements. The proposed action flow levels in most years throughout the April through July period are suitable for Green Sturgeon spawning and egg incubation, and no impacts are expected to result. During the August through October period, when Green Sturgeon spawning occurs in occasional years, the proposed action flows tend to be lower than those in April through July, but flows would drop below 5,000 cfs for only about 15 percent of years in September and no years and 5 percent of years in August and October, respectively. The late summer and fall spawning by Green Sturgeon has occurred sporadically and primarily in wetter years (NMFS 2018), so the occasional moderately low September flows (less than 5,000 cfs) under the proposed action scenarios are not expected to have any meaningful biological effect on spawning and egg incubation of the Sacramento River Green Sturgeon population.

Differences in flows between the proposed action are small in most months, but flows are moderately higher for the proposed action in June (Figures 5.12-20). The flow differences are expected for years with relatively wet hydrology (~10,000 cfs to 15,000 cfs) and, therefore, are not expected to have a meaningful effect on development or survival of incubating Green Sturgeon eggs.

During April, WOA flows are consistently well above proposed action flows (Figure 5.12-18) and likely provide more favorable conditions for Green Sturgeon spawning and egg incubation, except in the wettest years, when the WOA flows may be high enough to scour the incubating eggs. During June and July, the proposed action flows are almost always higher than the WOA flows (Figures 5.12-20 and 5.12-21) and during May, flows under the proposed action are lower than flows under the WOA modeling scenario in wetter years, but are higher than WOA flows in drier years (Figures 5.12-19). During May through July, therefore, the potential adverse impacts of low flows on Green Sturgeon spawning and egg incubation listed above are expected to occur less frequently and with less severity under the proposed action than under the WOA conditions.

5.12.3.2.4.2 Water Temperature

Critical water temperatures thresholds have been determined for Northern DPS Green Sturgeon but not for Southern DPS Green Sturgeon. It is assumed that the temperature tolerances of the two distinct population segments are similar (Heublein et al. 2017b). Based on laboratory studies, Van Eenennaam et al. (2005) concluded that 63 degrees Fahrenheit is the maximum water temperature for normal embryo development.

The presence of a large cold water pool and the flexibility afforded by the TCD under the proposed action make possible the provision of cold water in the upper Sacramento River during the summer and fall, which would benefit Green Sturgeon spawning and egg incubation. Under the proposed action, monthly mean water temperatures at Hamilton City range from about 51 to 69 degrees Fahrenheit during April through July (Figures 5.12-36 through 5.12-42). About 50 percent of years in June and July have mean monthly water temperatures exceeding the 63 degrees Fahrenheit threshold. During August and September, about 70 percent of years have mean monthly water temperatures that exceed 63 degrees Fahrenheit, but during October the frequency of exceedance is less than 5 percent (Figures 5.12-36 through 5.12-42).

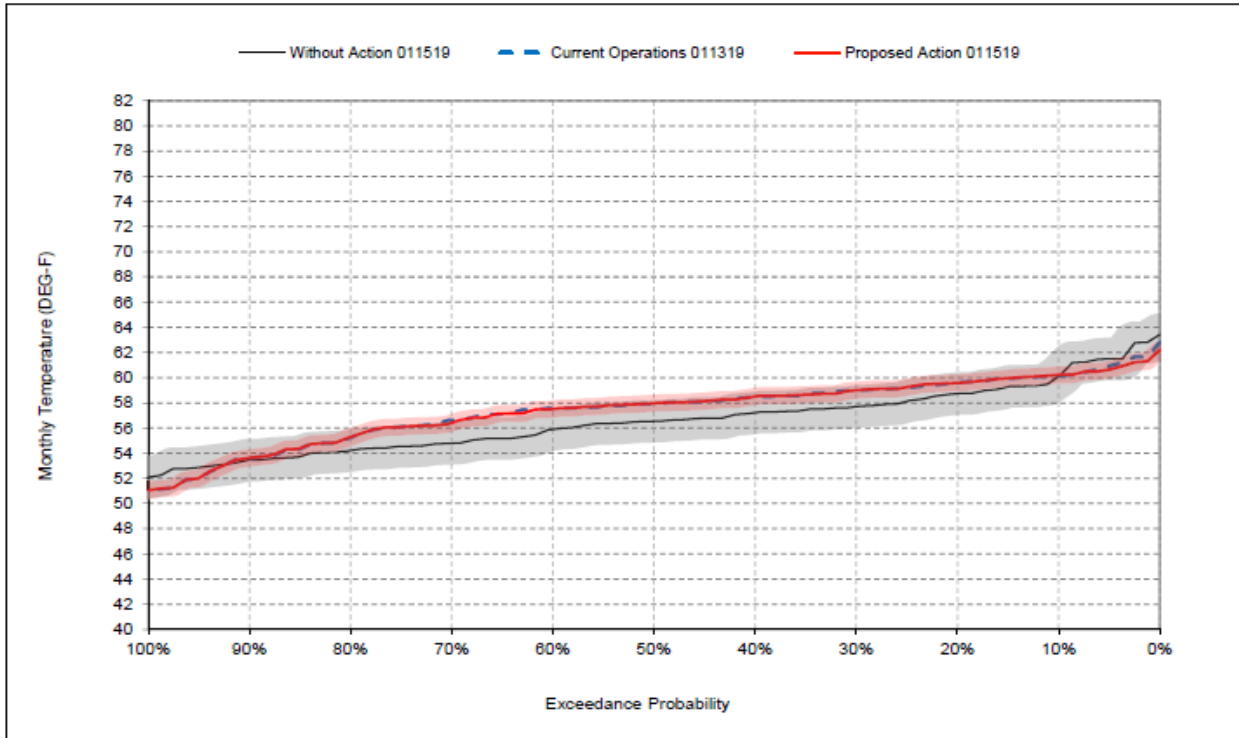


Figure 5.12-36. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, April

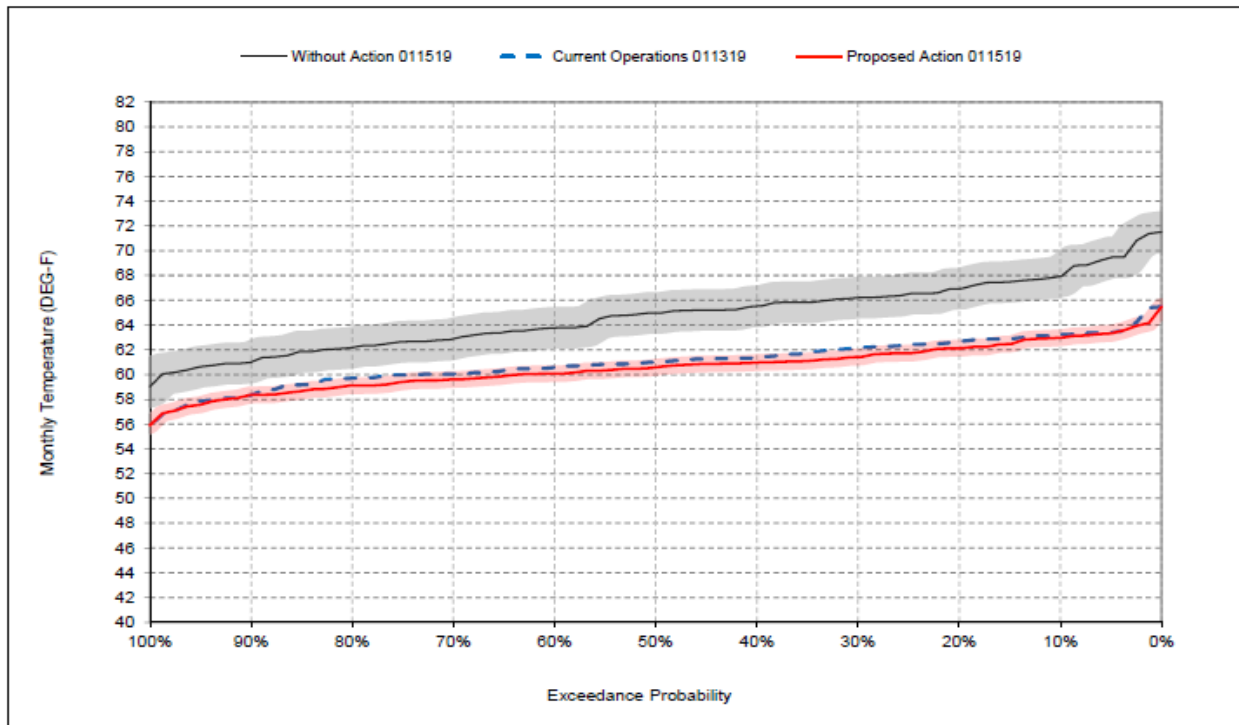


Figure 5.12-37. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, May

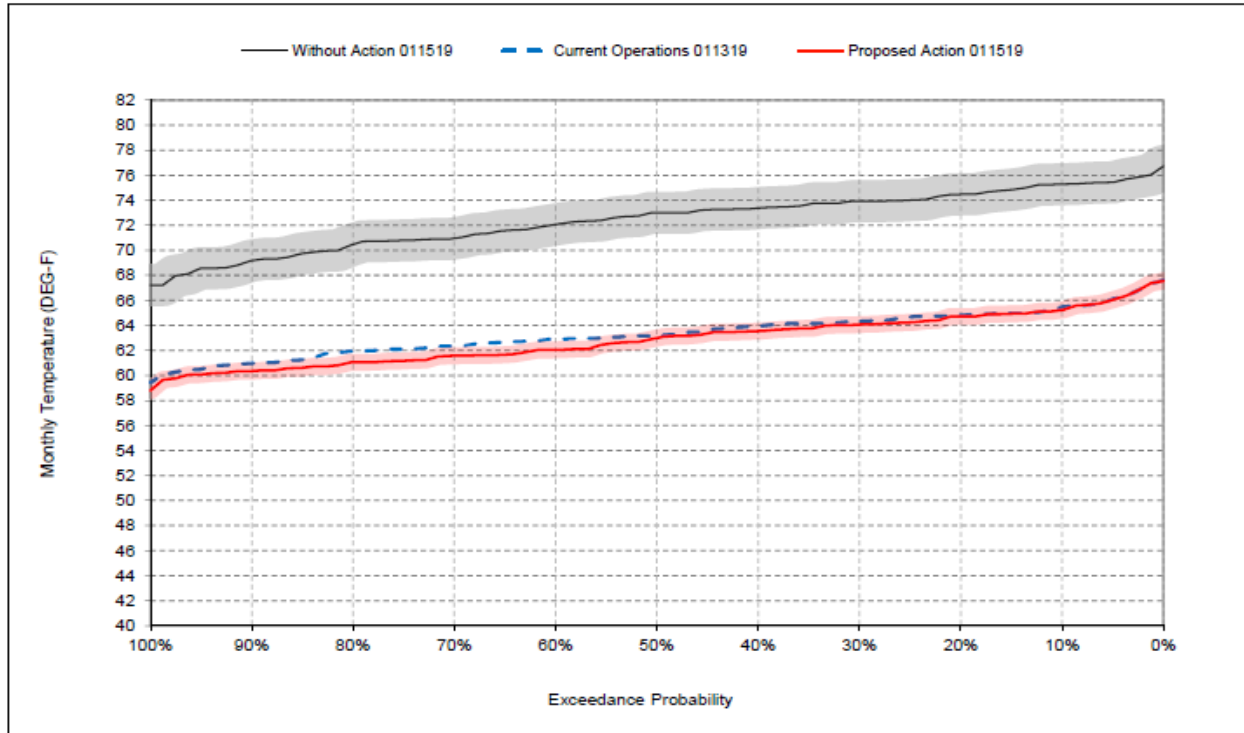


Figure 5.12-38. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, June

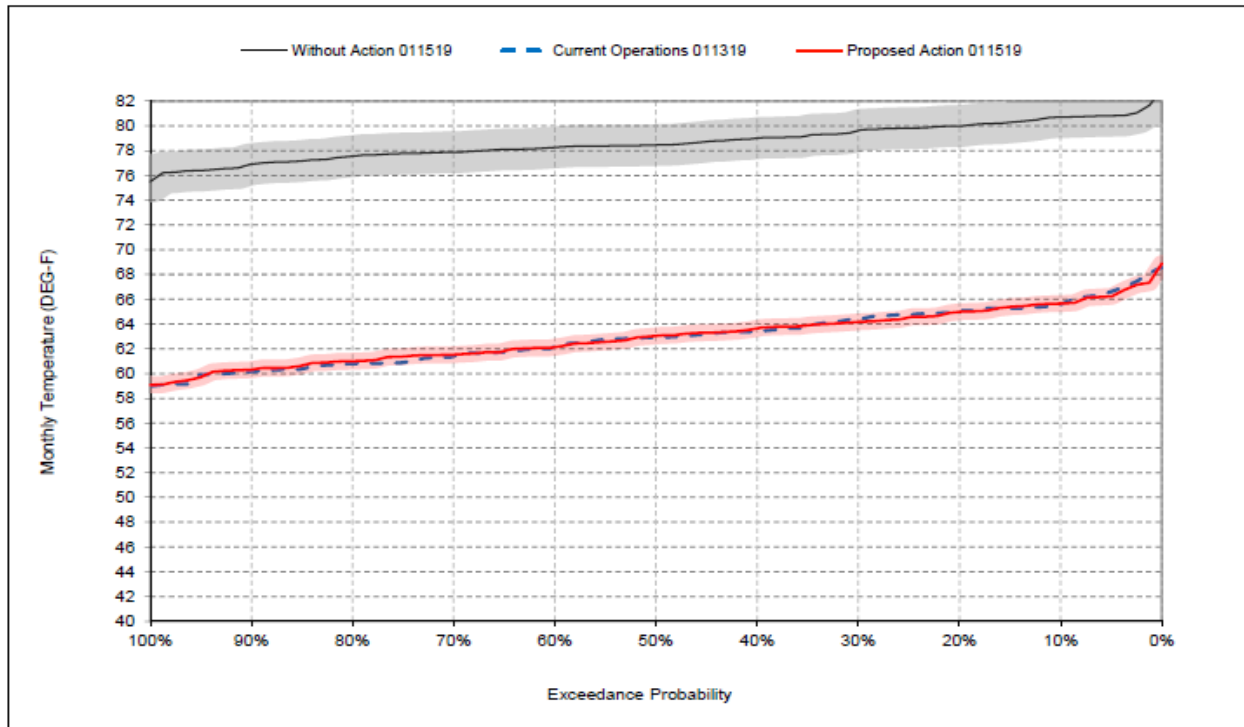


Figure 5.12-39. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, proposed Action and COS Scenarios, July

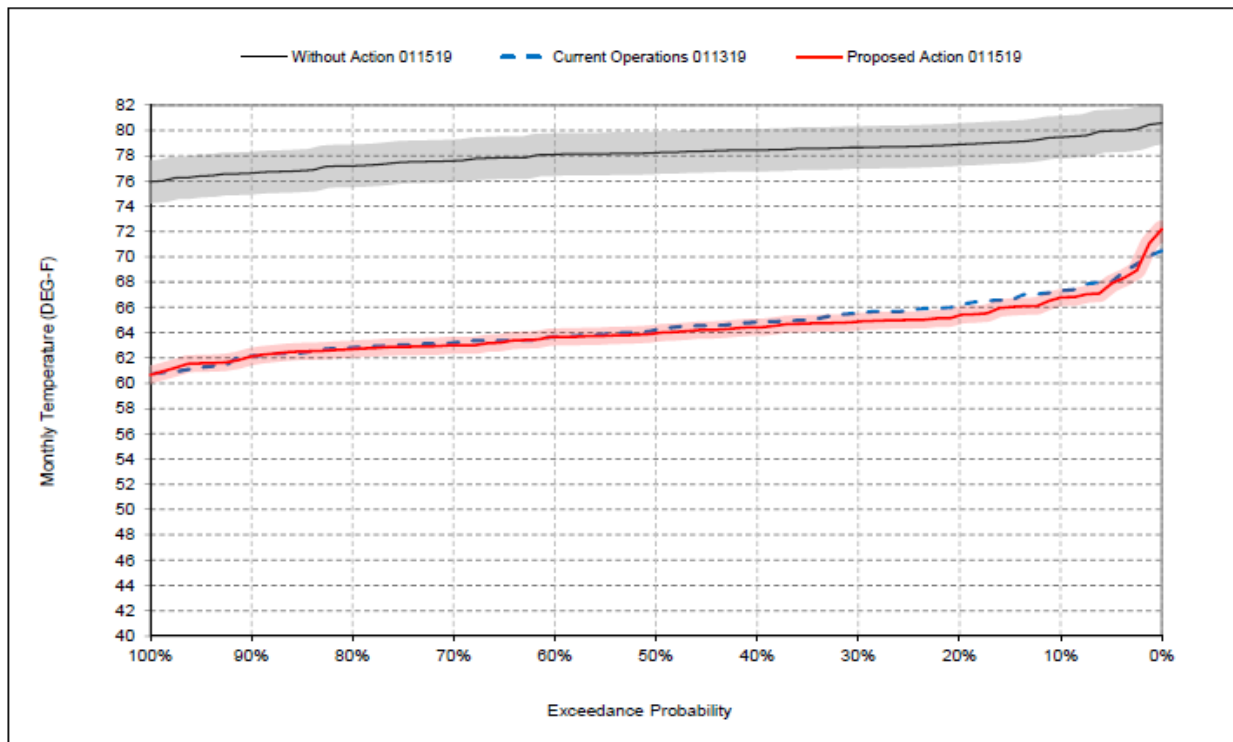


Figure 5.12-40. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, August

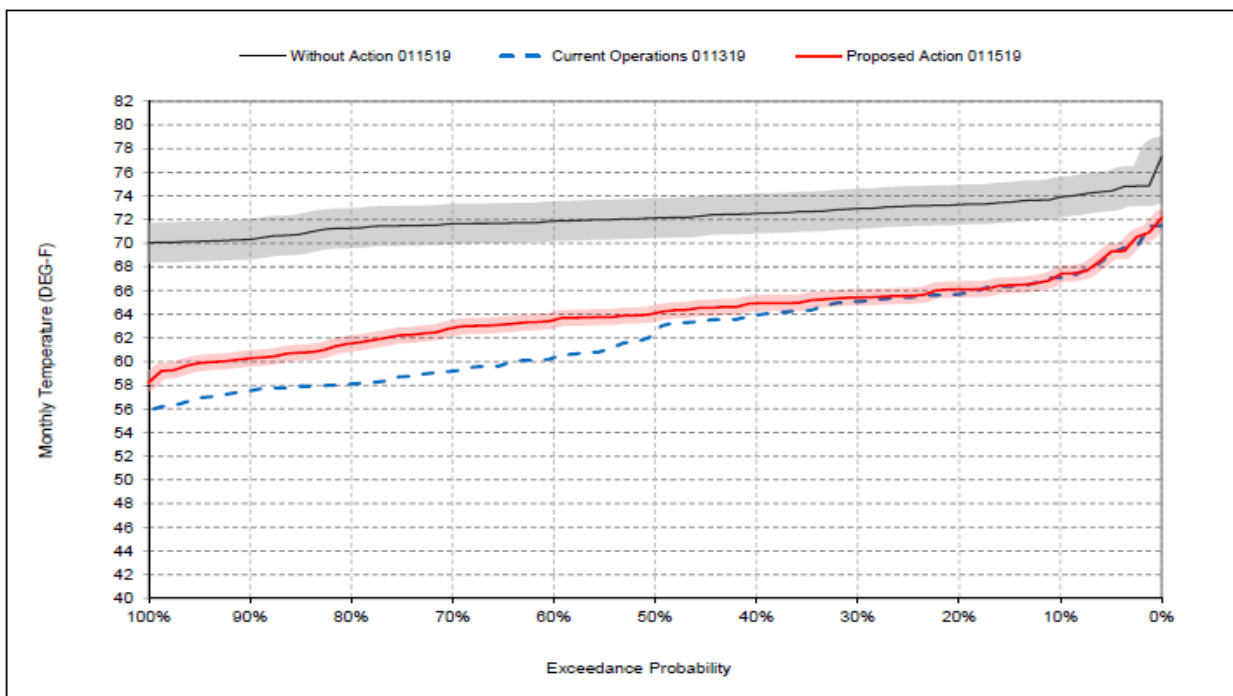


Figure 5.12-41. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, September

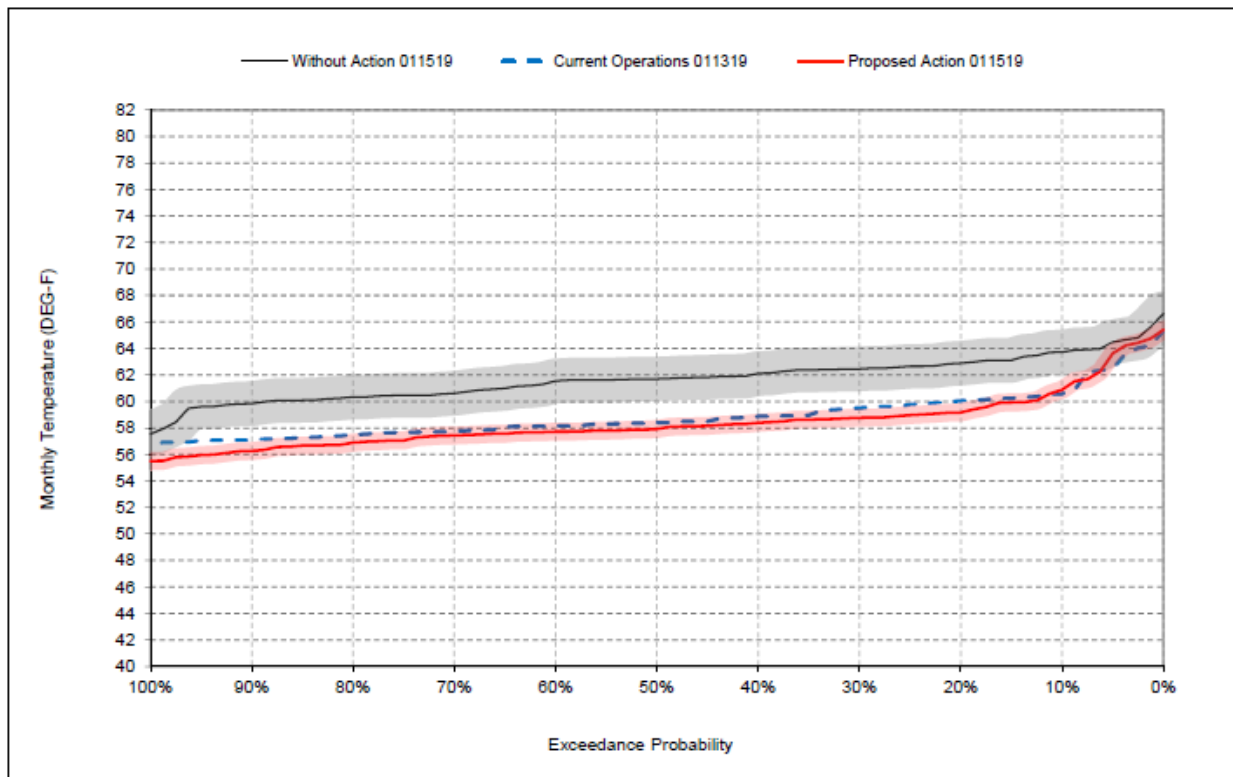


Figure 5.12-42. HEC-5Q Sacramento River Water Temperatures at Hamilton City under the WOA, Proposed Action and COS Scenarios, October

Summer water temperatures under the proposed action are consistently lower than those under the WOA modeling scenario (Figures 5.12-38 to 5.12-41), with far fewer years exceeding the 63 degrees Fahrenheit threshold. These results indicate that the proposed action, relative to the WOA modeling scenario, provide a clear benefit to Green Sturgeon spawning and egg incubation in the Sacramento River. The temperature management operations under the proposed action are likely to benefit Green Sturgeon egg survival relative to the WOA modeling scenario.

5.12.3.3 Spring Pulse Flows

Under WOA, spring pulse flows would occur naturally and more often. Under the Proposed Action, Reclamation would release spring pulse flows for juvenile salmonid outmigration when storage levels allow. These flow increases could reduce temperatures during the early portion of larval stage of Green Sturgeon, which could help keep temperatures below the 63 degree Fahrenheit threshold for Green Sturgeon egg development.

5.12.3.4 Fall and Winter Refill and Redd Maintenance

Under WOA, fall flows would be low. Under the Proposed Action, Reclamation would increase fall flows based on Shasta storage levels to avoid redd dewatering of fall-run and winter-run Chinook salmon redds. Higher flows in the fall could negatively affect the juvenile lifestage of Green Sturgeon, but reducing temperatures further below the 63 to 68 degree optimal range for Green Sturgeon juvenile development.

5.12.3.5 Feather River

5.12.3.5.1 Egg to Larvae (March – July)

Eggs and larvae of southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the high flow channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the seasonal occurrence of this life stage in the Feather River (May to July; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Table 5.12-2. Feather River High Flow Channel minimum instream flow requirements

| High Flow Channel Minimum Instream Flow | | | |
|--------------------------------------------------------------|---------------|-------------|------------------|
| Preceding April – July Unimpaired runoff (Percent of Normal) | Oct-Feb (cfs) | March (cfs) | April-Sept (cfs) |
| 55% or greater | 1,700 | 1,700 | 1,000 |
| Less than 55% | 1,200 | 1,000 | 1,000 |

Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (see figure from Spring-run section). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Feather River flows under the proposed action would be generally higher in the summer and fall and lower in the winter and spring compared to the WOA (see figures in Spring-run section).

Flows in the Feather River HFC under the proposed action during the May to July egg incubation, larval development, and early larval rearing period are lower in May during all water year types, and similar or higher in June and July in below normal, dry, and critically dry water years; flows in July are higher under the proposed action during all water year types (Figure 5.12-43). Importantly, CalSimII model output indicates June and July flows projected under the proposed action will increase the likelihood of minimum instream flow compliance in June and July of many drier water year types, minimizing potential exposure to low flows (Figure 5.12-43). As a result, potential adverse impacts of low flows on this life stage are anticipated to be less severe under the proposed action. Therefore, flow-related actions in the proposed action are anticipated to produce benefits for this life stage.

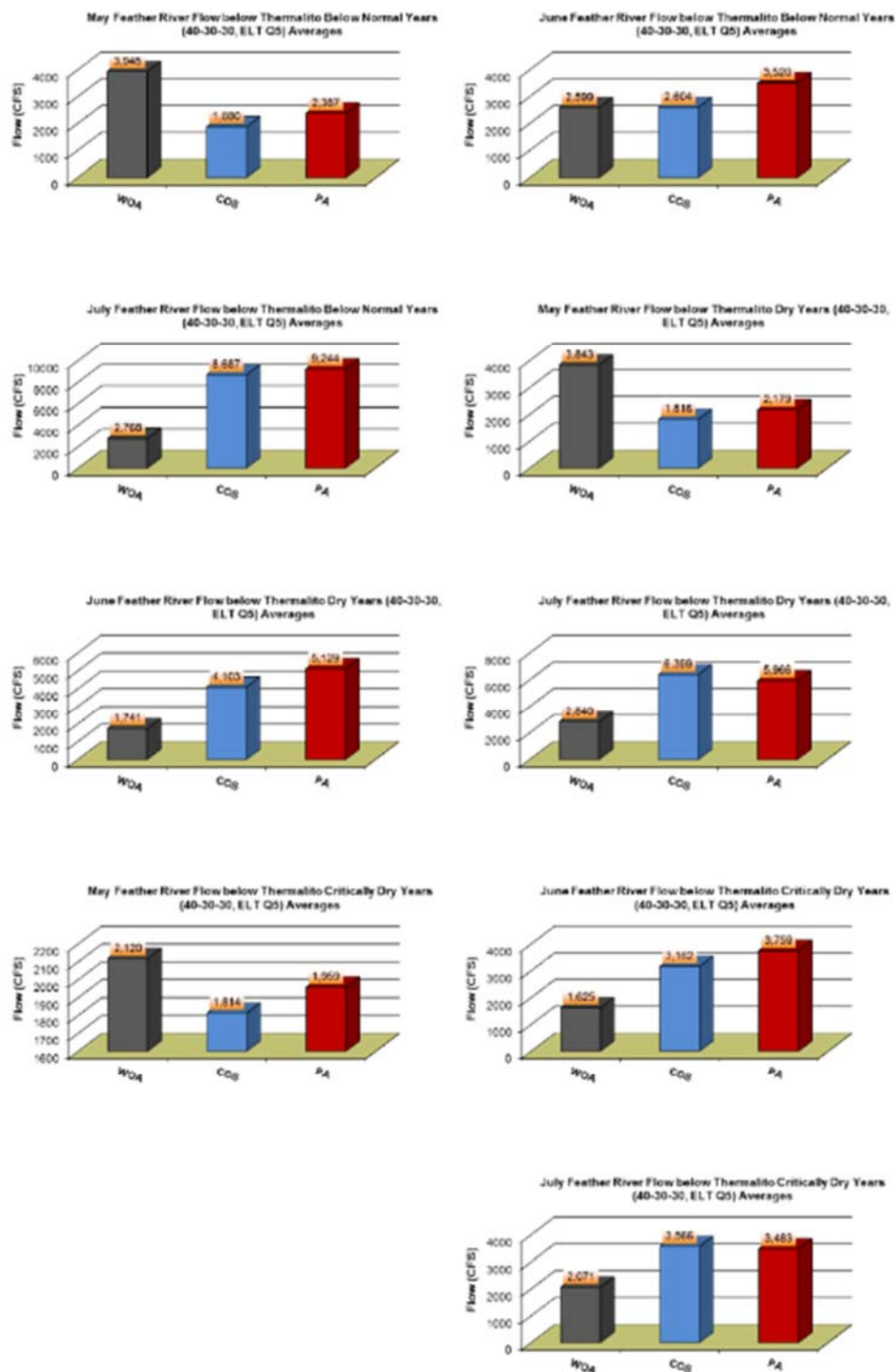


Figure 5.12-43. CalSim II estimates of Feather River Flow below the Thermalito Afterbay in May–July under the WOA, Proposed Action, and COS Scenarios.

5.12.3.5.1.1.1 Temperature Effects

Eggs and emerging fry of southern DPS Green Sturgeon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (May-July; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-3). Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in Article A108.1(b) [(i) curtailment of pump-back operation, (ii) shutter removal on Hyatt Intake, (iii) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Table 5.12-3. Maximum Daily Mean Water Temperature for the HFC.

| Maximum Daily Mean Water Temperature Objectives for the HFC (measured at the downstream FERC project boundary) | |
|---------------------------------------------------------------------------------------------------------------------------|-------------|
| Period | Temperature |
| January 1 – March 31 | 56 |
| April 1 – 30 | 61 |
| May 1 – 15 | 64 |
| May 16 – 31 | 64 |
| June 1 – August 31 | 64 |
| September 1 – 8 | 61 |
| September 9 – 30 | 61 |
| October 1 – 31 | 60 |
| November 1 – December 31 | 56 |

Water temperatures in the Feather River during summer and fall are heavily influenced by flow releases from Lake Oroville which are determined by operations and storage releases. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC from the Thermalito After Bay Outlet Pool downstream to the vicinity of the Gridley Bridge, where spawning occurs (NMFS 2016). Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp

temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78 °F occurring in July and August (see figures in Spring-run section).

Under almost all conditions, the WOA scenario would increase the likelihood of temperature related stress and mortality during the months of June and July. In addition, modeled water temperatures at Gridley Bridge under the proposed action indicate the proposed action would increase the likelihood of temperature compliance at the compliance point (lower FERC project boundary). Temperature objectives at the compliance point in April to July (maximum daily mean water temperatures of 61 °F in April, 64 °F May to July) fall within the optimal range of Green Sturgeon egg and larval temperature tolerances (NMFS 2016).

Water temperatures exceeding the objectives would have a number of adverse impacts on this life stage, including acute to chronic physiological stress, eventually leading to egg and larval mortality. Water temperatures in the Feather River HFC under the proposed action during the egg and larval development period are similar to or lower than WOA water temperatures. Importantly, RecTemp model output indicates water temperatures projected under the proposed action will increase the likelihood that May to July water temperatures will be less likely to reach lethal levels (> 73 °F) (see figures in spring-run section). As a result, potential adverse impacts of water temperature objectives on this life stage are anticipated to be less severe under the proposed action. Therefore, water temperature-related actions in these scenarios are anticipated to produce benefits for this life stage.

5.12.3.5.2 Larvae to Juvenile (April – August)

Larval rearing to juvenile southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the seasonal occurrence of this life stage in the Feather River (May–October; Table 5.12-1), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Feather River flows below Thermalito Afterbay under the WOA are generally greater than the proposed action during the months of May and June and are less than the proposed action during the months of July through October during the larval to juvenile period of southern DPS Green Sturgeon (see figures in Spring-run section). Proposed action flows exceed WOA flows during the months of June through September, a period of peak abundance for this life stage. In addition, the likelihood of projected flows under all scenarios declining below the required minimum flow for April–September (1,000 cfs depending on preceding April–July) is very low (Figure 5.12-44).

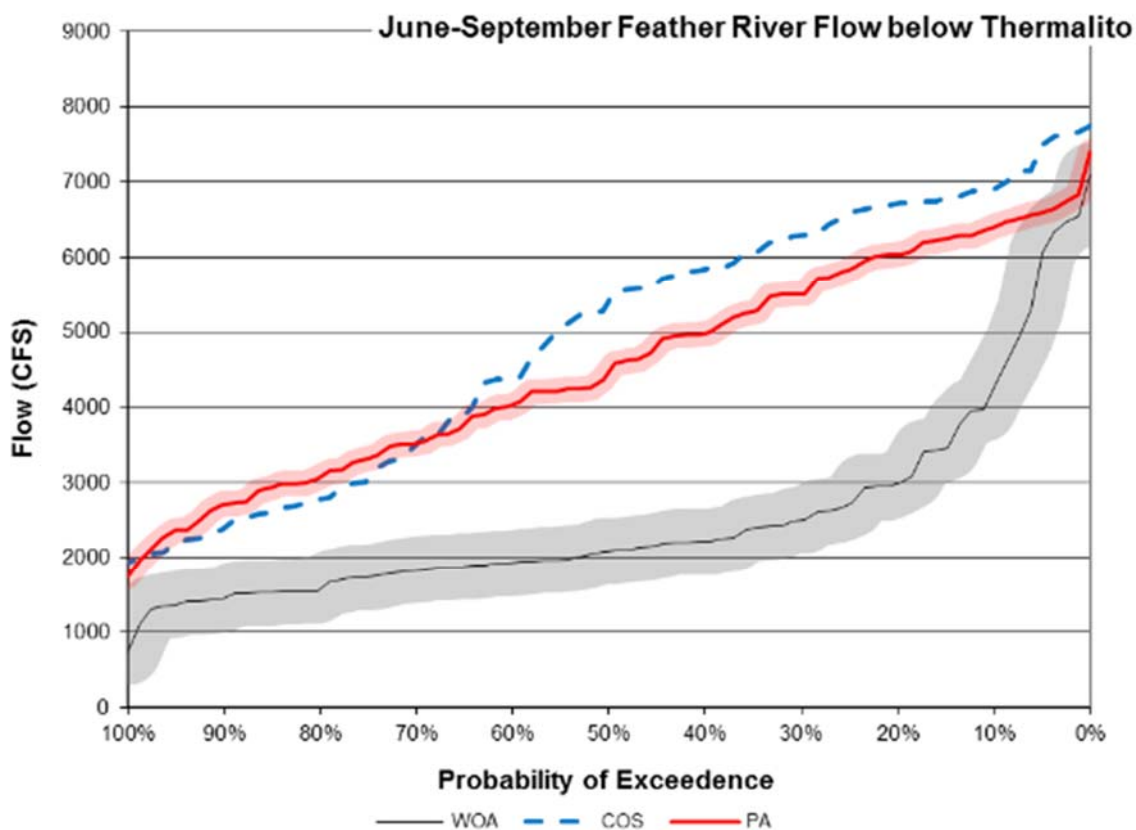


Figure 5.12-44. CalSim II Estimates of Feather River Flow below the Thermalito Afterbay in June–September under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) Scenarios.

5.12.3.5.2.1.1 Temperature Effects

Larval and juvenile life stages of Green Sturgeon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (May to October; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-2).

Water temperatures on the Feather River at Gridley Bridge under the proposed action during the months of May to October are lower than the impaired fitness temperature tolerance limit (72 °F) for larvae in all water year types but dry and critically dry years when July and August temperatures exceed this threshold. However, the proposed action provide substantial temperature reductions compared to the WOA under these conditions (see Figures 3-1 through 3-6 in the RecTemp Temperature Results section of Appendix D, *Modeling*).

In addition, modeled water temperatures at Gridley Bridge indicate the proposed action would increase the likelihood of temperature compliance at the compliance point (lower FERC project boundary). As a result, potential adverse impacts of water temperature objectives on this life stage are anticipated to be less severe under the proposed action. Therefore, water temperature related actions in these scenarios are anticipated to produce benefits for this life stage compared to the COS.

5.12.3.5.3 Juvenile to Subadult/adult in Bay-Delta

Juvenile to subadult/adult southern DPS Green Sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary proposed in the proposed action, based on the occurrence of this life stage in the Feather River (year round; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

The differences in flows between the WOA scenario and the proposed action scenarios may affect the development, survival and downstream migration of juvenile Green Sturgeon to the subadult/adult phase. Lower proposed action flows compared to WOA flows from January to June could reduce migration cues and conditions resulting in harmful impacts on juvenile Green Sturgeon foraging conditions, water temperatures and DO, toxicity, and habitat area. Higher flows under the proposed action from July to September could similarly benefit juvenile to subadult Green Sturgeon during these months. The comparative magnitude of positive and negative impacts under the proposed action are difficult to quantify, however impacts of lower flows under the proposed action from January to June are anticipated to be minimal since projected proposed action flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

Therefore, the proposed action will have no negative impacts on juvenile to subadult Green Sturgeon.

5.12.3.5.3.1 Temperature Effects

Juvenile and subadult/adult southern DPS green sturgeon would be exposed to the impacts of water temperature objectives for the Feather River HFC, based on the year-round occurrence of this life stage in the Feather River (NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-3). Water temperature objectives would be expected to be met in years when the Oroville Temperature Management Index (OTMI) is greater than 1.35 MAF and would be achieved through a combination of flow releases from Lake Oroville, and operations modifications stipulated in Article A108.1(b) [(i) curtailment of pump-back operation, (ii) shutter removal on Hyatt Intake, (iii) increase flow releases in the Low Flow Channel up to a maximum of 1,500 cfs]. If OTMI is equal to or less than 1.35 MAF a Conference Year is designated, triggering consultation between DWR and NMFS, USFWS, CDFW, and the SWRCB to prepare a strategic plan to manage the coldwater pool to minimize temperature exceedances at the lower FERC project boundary, while maintaining water supply and other legal obligations.

Water temperatures in the Feather River from March to June are relatively less influenced by flow releases from Lake Oroville than in late summer and fall, given the larger flow volumes, and cooler air temperatures during these months. Under the WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be limited control of flow or water temperature in the Feather River HFC where this life stage occurs. However, resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are similar to proposed action water temperatures from March to May, with small differences projected in June. Water temperatures under the WOA in the Feather River HFC at Gridley bridge as modeled by the RecTemp temperature model are significantly higher in July to September and are above the lethal limits of temperature tolerance of this life stage (Figure 5.12-44). There are no temperature-related stress and mortality impacts under the proposed action. These impacts produce a substantial reduction in projected water temperatures compared to the WOA

5.12.3.5.4 Adult to Egg and Post-Spawn Adult

5.12.3.5.4.1 Flow Effects

Spawning adult to egg and post-spawn adult Green sturgeon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrences of these life stages in the Feather River (March-August with peak seasonal occurrence March-May; NMFS 2016), minimum instream flow requirements in the high flow channel of the Feather River (year-round requirements; Table 5.12-2), and compliance with Water Rights Decision 1641 (D-1641).

Instream flow from Lake Oroville releases may influence upstream and downstream passage of physical barriers on the Feather River.

Proposed action flows during this period are lower than WOA flows, however flows are not anticipated to decline below minimum instream flow standards or to a level that results in any increased passage or barrier issues in the Feather River HFC. A potential passage barrier exists at the Sunset Pumps Rock Weir (RM 28.5), which require flows of 2,500–3,000 cfs for passage. Flows below the Thermalito Afterbay and at the Feather River mouth are well above this threshold during the peak seasonal timing of this life stage (Figures 21-1 and 22-1 in the CalSim II Flows section of Appendix D, *Modeling*). Post-spawning downstream migration is triggered by increased flows (6,150–14,725 cfs) in the late summer (NMFS 2016) and long-term average flows below Thermalito Afterbay and at the Feather River mouth are slightly below this during the months of July and August. However, flows are significantly higher under the proposed action than under the WOA (Figures 21-1 and 22-1 in the CalSim II Flows section of Appendix D, *Modeling*).

Differences in flow between the WOA, proposed action, and COS are likely to impact migrating adults and their habitat. Higher WOA flows from March to May could result in positive impacts on migrating, spawning, and post-spawning adults in the Feather River, including increased migration success and an increase in spawning habitat. However, flows at the Thermalito Afterbay and at the Feather River mouth during this period are not expected to be sufficiently low to create substantial negative impacts. Increased flows under the proposed action during July to August are expected to have beneficial impacts on post-spawn adults. As a result of these offsetting impacts, there are not expected to be any negative impacts on spawning adult to egg and post-spawn adult Green Sturgeon.

5.12.3.5.4.2 Temperature Effects

Spawning adult to egg and post-spawn adult Green sturgeon would be exposed to the impacts of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (March to August with peak seasonal occurrence March to May; NMFS 2016), and the timing of the temperature objectives (year-round objectives; Table 5.12-3).

Temperatures at Gridley Bridge under the proposed action are similar to temperatures under the WOA from March to May, which coincides with the peak seasonal timing of Green Sturgeon upstream migration and spawning. The risk of temperature-related stress and mortality during this period is low as temperatures are projected to be equal to or lower than the optimal ranges for migrating, spawning, and holding Green Sturgeon (Figure 3-1 in the RecTemp Temperature Results section of Appendix D). Reduced water temperatures under the proposed action from July to August are expected to produce temperature benefits for post-spawn adults. Therefore, water temperature-related actions in the proposed action are anticipated to produce benefits for this life stage.

5.12.3.6 American River Seasonal Operations, 2017 FMS and “Planning Minimum”

North American Green Sturgeon are not known to occur in the American River and their historical distribution in the American River is not known (Beamesderfer et al. 2004). However, there is the potential for juvenile rearing in the lower reaches of the American River near the confluence with the Sacramento River (NMFS 2009). If the North American Green Sturgeon do occur in the American River, the proposed action would likely provide beneficial effects to North American Green Sturgeon relative to WOA through increased fall flows increasing inundated habitat.

5.12.3.7 Delta Seasonal Operations and OMR Management

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to negatively impact southern DPS Green Sturgeon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, 2) “far-field” mortality resulting from altered hydrodynamics. The SST completed a thorough review of this subject and defined a driver- linkage-outcome (DLO) framework for specifying how water project operations (the “driver”) can influence juvenile salmonid behavior (the “linkage”) and potentially cause changes in survival or routing (the “outcome”). A similar analysis is not available for southern DPS Green Sturgeon.

5.12.3.7.1 Entrainment

As described by NMFS (2009: 386), impacts to the migratory corridor function of juvenile and sub-adult Green Sturgeon critical habitat from south Delta exports are less clear than for juvenile salmonids because Green Sturgeon spend one to three years rearing in the Delta environment before transitioning to their marine life history stage. During this Delta rearing phase, Green Sturgeon are free to migrate throughout the Delta. In the conceptual model, it is hypothesized that higher rates of exports may result in higher rates of entrainment. However, estimating entrainment risk from raw salvage data is not possible due to a lack of information on the number of juvenile Green Sturgeon potentially exposed to salvage.

Juvenile southern DPS Green Sturgeon (> 5 mo) are present in the Delta all year and sub-adults are most abundant from June through November. As there are no exports under WOA, there is no Green Sturgeon entrainment risk under WOA. In the June through September period under the proposed action Reclamation proposes an average total export rate slightly higher than COS (41 cfs; Figure H-27 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will, therefore, have a similar entrainment risk. Total exports proposed for proposed action in September-November (121 cfs higher than COS; Figure H-28 – Appendix H, *Bay-Delta Aquatics Effects Figures*) are unlikely to measurably increase entrainment risk relative to COS. Relative to WOA, the proposed action significantly increases entrainment risk.

Juvenile white and green sturgeon are infrequent at the TFCF, but may occur in the facility salvage year-round. Salvage is expected to be similar and slightly higher than COS under the proposed action.

5.12.3.7.2 Routing

Juvenile Green Sturgeon (>5 mo) are present in the Delta all year and sub-adults are most abundant from June to November (Table 5.12-1). Juvenile Green Sturgeon swim and behave quite differently and have distinct body morphologies and habitat associations in the Delta compared to outmigrating salmonids, so it is hypothesized that juvenile Green Sturgeon have different routing-hydrology survival relationships. Per NMFS (2009: 338), Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. It is highly uncertain how Green Sturgeon routing would change with the proposed action.

5.12.3.7.3 Through Delta Survival

Little is known about the relationship between survival of juvenile Green Sturgeon and Delta hydrology. Green Sturgeon reside in the Delta for one to three years suggesting they encounter a variety of daily, seasonal, and annual hydrological conditions. The majority of Green Sturgeon in the Delta are likely not surviving through the Delta per se, but using these habitats for rearing and foraging. Per NMFS (2009: 338), Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. For juvenile outmigrating Green Sturgeon present in these regions, increasing negative velocities under the proposed action may result in lower survival. However, as described above, there is a lower probability of juvenile Green Sturgeon residing in this area.

5.12.3.8 *Delta Cross Channel Operations*

Delta Cross Channel operations under the proposed action are changed to allow Reclamation to predict water quality exceedances and open the DCC if D-1641 criteria are predicted to be exceeded. This results in greater opening times of the DCC.

Little is known about the migratory behavior of juvenile Green Sturgeon in the Sacramento River basin. It is likely that juvenile Green Sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. If juvenile Green Sturgeon are exposed to the open DCC gates, they could be entrained into the central / south Delta and exposed to biological and physical conditions in this area, including potentially greater predation. It is likely that these fish will enter the Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta.

5.12.3.9 *Agricultural Barriers*

Agricultural Barriers (Temporary Barrier Project, TBP) are included in the proposed action and consists of three rock barriers across south Delta channels to improve water levels for agricultural diversions. The temporary rock barriers are installed and removed at Middle River near Victoria Canal, Old River near Tracy, and Grant Line Canal near Tracy Boulevard Bridge. The TBP is operated based on San Joaquin River flow conditions. The agricultural barriers at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

Juvenile Green Sturgeon are present in the Delta in all months of the year. However, little is known about their spatial distribution. When the south Delta agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up (May 16 to May 31), outmigrating Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). It could be inferred that passage of outmigrating juvenile Green Sturgeon may also be improved when flap gates are tied up. Therefore, the potential negative effects of the agricultural barriers under the proposed action depends on when they are installed and whether the flap gates are down or tied up.

5.12.3.10 *Contra Costa Water District Operations*

As discussed in Chapter 4, CCWD's operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD's intakes

and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG 1994; CDFG 2009). The operation of the Rock Slough Intake for the Proposed Action remains unchanged.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory routes for southern DPS Green Sturgeon (NMFS 2017), approximately 18 miles from the Sacramento River and 10 miles from the San Joaquin River via the shortest routes. Water temperatures in Rock Slough range from lows of about 40 degrees F in winter (December and January) to over 70 degrees F beginning in May and continuing through October (NMFS 2017).

A review of the 24 years of fish monitoring data (1994-2018) near the Rock Slough Intake both pre- and post-construction of the Rock Slough Fish Screen (RSFS) showed that southern DPS Green Sturgeon have never been observed in Rock Slough (CDFG 2002; Reclamation 2016; NMFS 2017; Tenera 2018b, ICF 2018).

5.12.3.10.1 Juvenile to Subadult/Adult

It is unlikely that juvenile and sub-adult Green Sturgeon would be present in Rock Slough due to the shallow depth, warm water temperatures, and low DO which make the area unsuitable habitat during most of the year. Currently, there is not a reliable measure of juvenile southern DPS Green Sturgeon population abundance in the Delta, nor is there a reliable estimate of the relative fraction of the population utilizing the area near the Rock Slough Intake (NMFS 2017). The Rock Slough intake maximum capacity is 350 cfs for the maximum annual diversion of 195 TAF.

5.12.3.10.2 Adult to Spawning Adult

Adult Green Sturgeon are unlikely to be present near the Rock Slough Intake since they typically prefer to migrate upstream through the mainstem Sacramento River and adult Green Sturgeon have not been observed spawning in the San Joaquin River (Jackson and Van Eenennaam 2013). It is unlikely that Green Sturgeon will be entrained into the Rock Slough Intake, and unlikely to be impacted by operations.

5.12.3.10.3 Spawning Adult to Egg and Post-Spawn Adult

Since it is unlikely that adult Green Sturgeon will be present near the Rock Slough Intake, it is also unlikely that eggs or post-spawn adults will be present in the area.

5.12.3.11 *North Bay Aqueduct*

Overall, the modeled exports in the proposed action represent a significant increase in export levels and, thus, a greater risk to Green Sturgeon in the waters adjacent to the pumping facility compared to their historical vulnerability (NOAA 2009). However, Green Sturgeon are expected to be fully screened out of the facilities by the positive barrier fish screen in place at the pumping facility.

5.12.3.12 *Water Transfers*

As discussed under the Spring-run Chinook Salmon water transfer section, while there is no pumping from the Delta for the CVP or SWP under WOA, under the proposed action Reclamation proposes to expand the transfer window to November. This extended transfer window could result in approximately 50 TAF of additional pumping per year in most years, with associated entrainment, routing, and through-Delta survival impacts. Please see the OMR management section for a discussion of the effects of pumping.

Juveniles older than 5 months, sub-adults, and adult Green Sturgeon could be exposed to the effects of increased pumping due to water transfers. Although southern DPS Green Sturgeon are present in the Delta in all months of the year, Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways (NMFS 2009:338). Therefore, there are no negative impacts of increased pumping at Jones and Banks Pumping Plants due to water transfers under the proposed action.

Juvenile southern DPS Green Sturgeon are present in the Delta in every month of the year (Table 5.12-1). Thus, some portion of the population would be exposed to this action. Increases in Delta inflow during water transfers may have benefits for juvenile Green Sturgeon. However, there is no information on relationships between flow and juvenile Green Sturgeon ecology.

5.12.3.13 *Clifton Court Forebay Aquatic Weed Control Program*

Few southern DPS juvenile Green Sturgeon Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program as part of the proposed action. Although southern DPS juvenile Green Sturgeon are present in the Delta in all months of the year, Green Sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways (NMFS 2009:338). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the likelihood of exposing juvenile Green Sturgeon to the herbicide is very low. Mechanical harvesting would occur on an as-needed basis and, therefore, juvenile Green Sturgeon could be exposed to this action, if entrained into the Forebay.

5.12.3.14 *Suisun Marsh Facilities*

Under WOA, the Suisun Marsh facilities would be left open, resulting in a more saline and variable Suisun Marsh.

5.12.3.14.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from June through September under the proposed action coincides with a portion of the downstream migration of juvenile southern DPS Green Sturgeon, as well as adult southern DPS Green Sturgeon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. During full gate operation, the flashboards are installed and the radial gates open and close twice each tidal day. Green Sturgeon are thought to successfully pass through either the boat lock or through the gates during periods when the gates are open. NMFS (2009) determined that operation of the SWSCG is unlikely to produce conditions that support unusually high numbers of predators, change habitat suitability or availability for rearing or migration of juvenile and adult Green Sturgeon. Green Sturgeon are strong swimmers and therefore the operation of the Suisun Marsh Salinity Control Gate will have no impact on adults or juvenile Green Sturgeon.

5.12.3.14.2 Roaring River Distribution System

The low screen velocity at the intake culverts combined with a small screen mesh size are expected to successfully prevent Green Sturgeon from being entrained into the RRDS under the proposed action. (NOAA 2009).

5.12.3.14.3 Morrow Island Distribution System

The MIDS intakes under the proposed action do not currently have fish screens, and juvenile Green Sturgeon are more prone to entrainment than other species such as white sturgeon (Poletto et al. 2014). However, fisheries monitoring performed in 2004-05 and 2005-06 identified entrainment of 20 fish species, none of which were Green Sturgeon (NOAA 2009). Presence of Green Sturgeon in the area of the MIDS intake is not well studied or documented, but if Green Sturgeon are present they may potentially avoid entrainment as they do not typically swim along the surface where the diversion is located.

5.12.3.14.4 Goodyear Slough Outfall

Due to its location and design, Green Sturgeon are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall under the proposed action likely benefits juvenile Green Sturgeon in Suisun Marsh by improving water quality and increasing foraging opportunities (NOAA 2009).

5.12.3.15 *Maintenance Activities*

Under WOA, no maintenance would occur as the CVP and SWP are not operating. Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Green Sturgeon adults from maintenance activities.

5.12.3.16 *Operation of a Shasta Dam Raise*

Under the proposed action, Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report. Shasta Dam raise is anticipated to increase the cold water pool in Shasta Reservoir, to the benefit of salmonids holding or spawning downstream in the summer and fall. As shown in the Winter-run Chinook salmon section, the operation of the Shasta Dam raise would result in similar flow releases to the proposed action without the Shasta Dam raise. The effect of a raised Shasta Dam operating for CVP only on the proposed action may be uncertain, however all scenarios provide the same or greater flows compared to the WOA between June-November (Figure 5.6-40). Average monthly flows are similar between June-August under the proposed action with and without a raised Shasta Dam. The operation of a Shasta Dam raise would be anticipated to increase flows in September and November and decrease flows in December to May, as compared to the proposed action without Shasta Dam raise. Decreased temperature in the summer and fall could negatively impact juvenile Green Sturgeon, which desire temperatures between 63 and 68 degrees Fahrenheit for optimal rearing.

5.12.4 *Effects of Conservation Measures*

The following are proposed conservation measures that are intended to offset the effects of operations and maintenance. These conservation measures would only occur due to the implementation of the Proposed Action and are beneficial in nature. The following analysis examines the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under WOA.

5.12.4.1 Lowering Intakes in Wilkins Slough

5.12.4.1.1 Egg to Larvae (March – July)

The installation of fish screens near Wilkins Slough under the proposed action would be beneficial to Green sturgeon. The fish screens would prevent fish entrainment at diversions, thus, increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. Specifically, operation of diversions with fish screens near Wilkins Slough would decrease entrainment risk.

Green sturgeon egg and fry, as well as the population, would benefit from this action.

In the southern DPS, adult Green Sturgeon begin their upstream spawning migrations into the San Francisco Bay in March and reach Knights Landing on the Sacramento River during April (Heublein et al. 2006 *as cited in* OCAP BA 2008). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, DFG (2002 *as cited in* OCAP BA 2008) indicated that Green Sturgeon spawn in late spring and early summer in the upper Sacramento River. Peak spawning is believed to occur between April and June (OCAP BA 2008). Construction activities under the proposed action would occur during an in-water work window (June 1 through October 1); therefore, effects on Green Sturgeon eggs and fry are not anticipated.

Additionally, preferred spawning habitats are thought to be deep, cool pools with turbulent water and large cobble (DFG 2002; Moyle 2002; Adams et al. 2002 *as cited in* OCAP BA 2008). Wilkins Slough does not contain suitable spawning habitat; therefore, the potential for egg or fry to be present is low.

5.12.4.1.2 Larvae to Juvenile (April – August)

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Larval Green Sturgeon are present within the Sacramento River between May and August, with a peak from June through July, both at RBDD and GCID (OCAP BA 2008). Larval Green Sturgeon have the potential to be exposed to construction activities as the larvae migrate downstream from the upper Sacramento River; however, implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would minimize those effects.

Juvenile Green Sturgeon (greater than 10 months old, younger than 3 years old) are located in the Bay-Delta (OCAP BA 2008). Wilkins Slough is not located in the legal Delta. Wilkins Slough is not tidally influenced; therefore, no effects to juvenile Green Sturgeon are expected due to construction activities associated with construction of diversions and screens.

5.12.4.1.3 Juvenile to Subadult/Adult

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults.

Juvenile to subadult/adult Green Sturgeon are located in the Bay-Delta; and therefore are located outside of the action area.

5.12.4.1.4 Adult to Spawning Adult (May - October)

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

Adults migrate upstream primarily through the western edge of the Delta into the lower Sacramento River between March and June (Adams et al. 2002). Adult Green Sturgeon do not spawn every year, and are believed to spawn every three to five years. Green sturgeon spawn in late spring and early summer above Hamilton City, possibly up to Keswick Dam (Brown 2007). Peak spawning is believed to occur between April and June. Wilkins Slough is outside of known spawning habitat; therefore, construction activities would not affect spawning adults. Additionally, implemented of an in-water work window and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further reduce effects to adults and spawning adults.

5.12.4.1.5 Spawning Adult to Egg and Post-Spawn Adult

The installation of fish screens near Wilkins Slough would be beneficial to Green Sturgeon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning.

5.12.4.2 Shasta TCD Improvements

5.12.4.2.1 Egg to Larvae (March – July)

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO) in the Sacramento River that would be suitable for Green Sturgeon, improving conditions for their eggs and larvae.

5.12.4.2.2 Larvae to Juvenile (April – August)

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO). However, under the proposed action, summer flows are kept cold for Winter-run Chinook salmon, which results in temperatures that are too cold for Green sturgeon juvenile rearing.

5.12.4.2.3 Juvenile to Subadult/Adult

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO).

Juvenile to subadult/adult Green Sturgeon are located in the Bay-Delta; and therefore are located outside of the action area for the improvements.

5.12.4.2.4 Adult to Spawning Adult (May - October)

The Shasta TCD improvements under the proposed action would not be expected to have an effect on adult Green Sturgeon.

5.12.4.2.5 Spawning Adult to Egg and Post-Spawn Adult

The implementation of the proposed Shasta TCD improvements under the proposed action would improve Reclamation's ability to manage flows, and water quality (e.g., water temperatures and DO) in the Sacramento River that would be suitable for Green Sturgeon, improving conditions for spawning and post-spawning adults.

5.12.4.3 *Spawning and Rearing Habitat (Sacramento River)*

Reclamation proposes to create additional spawning habitat by injecting 40-55 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. As green sturgeon are broadcast spawners in deep pools, adding spawning gravel would not benefit Green Sturgeon. Addition of rearing habitat could provide benefits to green sturgeon juveniles.

Construction of spawning and rearing habitat could affect Green Sturgeon larvae in the river. Based on the proposed in-water work windows for the upper Sacramento River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Green Sturgeon would be subject to potential adverse effects from proposed spawning (e.g., gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of larvae or juveniles by crushing if heavy equipment enters the stream channel or otherwise disturbs larvae or juveniles during in-water activities. Larvae and juveniles could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure of the Green Sturgeon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.12.4.4 *Small Screen Program*

Under WOA, small diversions would not be screened. Under the proposed action, Reclamation would work with partners to screen small diversions on the Sacramento River and Delta.

5.12.4.4.1 Egg to Larvae (March – July)

No egg to larvae North American Green Sturgeon would be benefited by fish screens under the proposed action since they remain in the stream substrate and would not be exposed to fish screens. Therefore, there would be no effects from fish screen construction for this life stage.

Few if any North American Green Sturgeon in the egg-to-larvae life stage are expected to be exposed to the effects of construction of screens on water diversion intakes based on the seasonal occurrence of this life stage in the Sacramento River. This period follows spawning, which generally occurs between March and July, with peak spawning believed to occur between April and June (Adams et al. 2002). The embryos incubate for a period seven to nine days before hatching as larvae (Van Eenennaam et al. 2001; Poytress et al. 2012).

5.12.4.4.2 Larvae to Juvenile (April – August)

The operation of fish screens on water diversions would have a beneficial effect on larvae to juvenile North American Green Sturgeon in the Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse impacts to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens under the proposed action would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

North American Green Sturgeon in the larvae to juvenile life stage may be exposed to the effects of construction of screens since they are present in the Sacramento River throughout the year (Table 5.12-1). After hatching, larvae and juveniles migrate downstream toward the Sacramento-San Joaquin Delta and estuary, where they may encounter work area of these projects; however, these work areas are localized and the number of fish is expected to be low. Potential short-term adverse impacts may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.12.4.4.3 Juvenile to Subadult/Adult

Southern DPS Green Sturgeon are expected to be present in the Delta during the main irrigation period for small diversions (late spring-fall). Diversion screening under the proposed action could reduce entrainment of individual Green Sturgeon. However, there is currently no information on the proportion of juvenile Green Sturgeon that are entrained into small unscreened diversions. North American Green Sturgeon in the juvenile to subadult/adult life stage may be exposed to the effects of construction of screens since they are present in the Sacramento River year-round (Table 5.12-1). Effects are the same as described above for juveniles. AMMs would minimize risk.

5.12.4.4.4 Adult to Spawning Adult (May - October)

Few, if any Adult North American Green Sturgeon are expected to be exposed to the effects of operation of screens on diversion intakes under the proposed action. Spawning Green Sturgeon inhabit deep pools in large, turbulent, freshwater river mainstems (Moyle et al. 1992), and thus, they are not likely to encounter the small screen diversions. Few, if any Adult North American Green Sturgeon are expected to be exposed to the effects of construction of screens. The timing of the adult upstream migration for spawning (February–July; Figure 5.12-4) largely avoids the July 15 – October 15 in-water construction work window as described avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. AMMs would minimize risks.

5.12.4.4.5 Spawning Adult to Egg and Post-Spawn Adult

Effects are the same as for Adult to Spawning Adult, above.

5.12.4.5 *Adult Rescue*

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Green Sturgeon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of Green Sturgeon of all life stages in the Sacramento River.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Green Sturgeon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Green Sturgeon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Green Sturgeon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*).

Juvenile Green Sturgeon larvae could be incidentally captured by gear used to rescue adult salmonids and sturgeon during implementation of adult rescue activities. The number of juvenile Green Sturgeon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Green Sturgeon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance or swimming ability in juveniles, thereby adversely impacting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make juveniles more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Green Sturgeon would be expected to be offset by benefits associated with increased numbers of adult Green Sturgeon returning to spawning grounds.

5.12.4.6 *Juvenile Trap and Haul*

Green Sturgeon larvae metamorphose into juveniles at lengths of 62 to 94 mm (Deng et al. 2002). Therefore, larger Green Sturgeon larvae in the vicinity of temporary juvenile collection weirs could be incidentally captured by gear used to trap juvenile salmonids during implementation of juvenile trap and haul activities. The number of Green Sturgeon larvae that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trap location and efficiency at collecting Green Sturgeon larvae, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.12-1). Because gear

type and location would be focused on trapping juvenile salmonids, and not Green Sturgeon, few Green Sturgeon individuals would be expected to be collected in the traps. Individual Green Sturgeon larvae exposed to juvenile trapping activities would be at risk of increased stress, injury, and/or mortality during capture and subsequent handling. The risk of these effects to this life stage could be greater for smaller (younger) larvae which may be more susceptible to injury and stress than larger (older) larvae. In addition, larvae collected later in the season when water quality conditions [e.g., water temperature] may be more stressful for larvae and may make larvae more susceptible to injury and stress-related effects associated with capture and handling than larvae captured and handled earlier in the season when water quality conditions generally are more suitable. However, the risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Because Green Sturgeon larvae and juveniles spend an extended period rearing in the river before migrating to the Delta, it is assumed that any larval Green Sturgeon trapped during juvenile trap and haul activities would be returned to the Sacramento River rather than be transported to the Delta and released.

Juvenile Green Sturgeon larvae in the vicinity of temporary juvenile collection weirs could be incidentally captured by gear used to trap juvenile salmonids during implementation of juvenile trap and haul activities. The number of juvenile Green Sturgeon that would be expected to be exposed to the effects of juvenile trap and haul activities would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trap location and efficiency at collecting juvenile Green Sturgeon, and the typical seasonal occurrence of this life stage in the Sacramento River (Table 5.12-1). Because gear type and location would be focused on trapping juvenile salmonids, and not Green Sturgeon, few juvenile Green Sturgeon individuals would be expected to be collected in the traps. Individual Green Sturgeon juveniles exposed to juvenile trapping activities would be at risk of increased stress, injury, and/or mortality during capture and subsequent handling. The risk of these effects to this life stage could be greater for smaller (younger) juveniles which may be more susceptible to injury and stress than larger (older) juveniles. In addition, juveniles collected later in the season when water quality conditions [e.g., water temperature] may be more stressful for juveniles and may make juveniles more susceptible to injury and stress-related effects associated with capture and handling than juveniles captured and handled earlier in the season when water quality conditions generally are more suitable. However, the risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). Because juvenile Green Sturgeon rear in-river for an extended period before migrating to the Delta, it is assumed that any juvenile Green Sturgeon trapped during juvenile trap and haul activities would be returned to the Sacramento River rather than be transported to the Delta and released.

Because of their large size and benthic behavior, adult Green Sturgeon are not expected to be vulnerable to capture during implementation of juvenile trap and haul activities.

5.12.4.7 American River Spawning and Rearing Habitat

Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar - North, El Manto, Sacramento Bar - South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction. As green sturgeon are broadcast spawners in deep pools, adding spawning gravel would not benefit Green Sturgeon. Addition of rearing habitat could provide benefits to green sturgeon juveniles.

Construction of spawning and rearing habitat could affect Green Sturgeon larvae in the river. Based on the proposed in-water work windows for the American River (see AMM2 *Construction Best Management Practices and Monitoring* in Appendix E, *Avoidance and Minimization Measures*), Green Sturgeon would be subject to potential adverse effects from proposed spawning (e.g. gravel augmentation) and rearing habitat (e.g., side channel) restoration projects in the American River associated with the proposed action. Construction activities could result in mortality of larvae or juveniles by crushing if heavy equipment enters the stream channel or otherwise disturbs larvae or juveniles during in-water activities. Larvae and juveniles could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality (e.g., reduced flow and dissolved oxygen from increases in sediment deposition) or direct impacts from sublethal and lethal exposures to contaminants. Exposure of the Green Sturgeon population to construction effects would be low based on the limited extent of proposed restoration projects relative to the overall distribution of spawning adults, and the implementation of other AMMs described in Appendix E, *Avoidance and Minimization Measures*. These measures include AMM1, which requires worker awareness training, AMM2, which specifies monitoring oversight by a qualified biologist, and AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment.

5.12.4.8 Tracy Fish Collection Facility

Upgrades to the TFCF under the proposed action will aim to minimize the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon. Salvage improvements will improve survival of salvaged fish, and potentially allow reduction of the expansion factors used to extrapolate take estimates from observed salvage.

5.12.4.9 Suisun Marsh Salinity Control Gates Operation

Under the proposed action, Reclamation would operate the Suisun Marsh Salinity Control Gate more frequently to provide freshwater to Suisun Marsh for Delta Smelt. This action could increase food in Suisun Marsh, which could have food web effects that benefit Green Sturgeon juveniles. Operation of the SMSCG from June through September under the proposed action coincides with a portion of the downstream migration of juvenile southern DPS Green Sturgeon, as well as adult southern DPS Green Sturgeon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators. Adult Green Sturgeon are strong swimmers and therefore the operation of the Suisun Marsh Salinity Control Gate is unlikely to affect adult or juvenile Green Sturgeon.

5.12.4.10 Clifton Court Predator Management

Predator control efforts under the proposed action can reduce predation on listed fish species, following their entrainment into Clifton Court Forebay. This could also reduce pre-screen loss of juvenile southern DPS Green Sturgeon. It is unknown what proportion of juvenile Green Sturgeon are entrained into CCF but individuals are salvaged infrequently.

5.12.4.11 Sacramento Deepwater Ship Channel Study

5.12.4.11.1 Larvae to Juvenile (April – August)

This study would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018). Juvenile southern DPS Green Sturgeon are

present in the Delta in every month of the year with a similar frequency (Table 5.12-1). Juvenile Green Sturgeon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of Green Sturgeon survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough. This would provide a benefit if survival rates are similar between the SDWSC and the Sacramento main stem.

5.12.4.11.2 Juvenile to Subadult/Adult

As described above, juvenile Green Sturgeon may potentially be entrained into the DWSC. Fish entering the SDWSC would not, however, be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar between the SDWSC and the Sacramento main stem

5.12.4.12 *Suisun and Colusa Basin Food Subsidies*

Provision of north Delta or Suisun Marsh food subsidies by routing drain water would occur in summer/fall and therefore could provide food benefits to Green Sturgeon juveniles, who are in the Delta in the fall.

5.12.4.13 *Tidal Habitat Restoration*

5.12.4.13.1 Juveniles

A large proportion of juvenile southern DPS Green Sturgeon are expected to be exposed to continuing to implement the 8,000 acres of tidal habitat restoration in the Delta under the proposed action. Tidal habitat restoration is expected to benefit juvenile Green Sturgeon in several aspects represented by the Green Sturgeon juvenile conceptual model (Figure 5.12-3) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta.

5.12.4.13.2 Adults

The timing of the adult Green Sturgeon upstream migration for spawning (February–July; Figure 5.12-5) avoids the August–October in-water construction work window for tidal and channel margin restoration under the proposed action. Benefits would be the same as described for juvenile Green Sturgeon.

5.12.4.14 *Predator Hot Spot Removal*

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids. It is currently unknown if predation on juvenile Green Sturgeon in the Delta is limiting their productivity. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the rearing and migratory corridors of juvenile Green Sturgeon.

5.12.4.15 *Delta Cross Channel Gate Improvements*

Little is known about the migratory behavior of juvenile Green Sturgeon in the Sacramento River basin. It is likely that juvenile Green Sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. It is likely that these fish will enter the

Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta. More information is required to accurately assess the migratory movements of juvenile Green Sturgeon in the river system, as well as their movements within the Delta during their rearing phase in estuarine/Delta waters. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.12.4.16 Tracy Fish Facility Operations and Improvements

5.12.4.16.1 Larvae to Juvenile (April – August)

Upgrades to the TFCF will aim to minimize the effects of the salvage process on listed fishes, in particular juvenile salmonids and Green Sturgeon. Salvage improvements will improve survival of salvaged fish and potentially allow reduction of the expansion factors used to extrapolate take estimates from observed salvage.

As previously described, juvenile Green Sturgeon can occur in the Delta year-round (Table 5.12-1; Figure 5.12-3) and, therefore, have the potential to be exposed to the effects of construction of the CO₂ injection device proposed for the Tracy Fish Facility Improvements. If construction affects the efficiency of Green Sturgeon salvage (which is an element of entrainment risk; Figure 5.12-3), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.12.4.16.2 Adult to Spawning Adult (May - October)

As with other proposed construction in the Delta under the proposed action, the timing of adult Green Sturgeon occurrence in the Delta could overlap with CO₂ injection device construction as part of Tracy Fish Facility Improvements. Application of AMMs and the small scale of the in-water construction would minimize the potential for any effects to individual adult Green Sturgeon. As adult sturgeon are not salvaged, no benefits of this action are expected for this life stage.

5.12.4.16.3 Spawning Adult to Egg and Post-Spawn Adult

As previously described for tidal habitat restoration, the timing of the adult Green Sturgeon upstream migration for spawning (February–July; Figure 5.12-5) avoids the in-water work window (August to October) for CO₂ injection device construction for the Tracy Fish Facility Improvements under the proposed action.

5.12.4.17 Skinner Fish Facility Improvements

Skinner Fish Facility improvements under the proposed action, which involve predator control efforts, can reduce predation on listed fish species, following their entrainment into Clifton Court Forebay. This could also reduce pre-screen loss of juvenile southern DPS Green Sturgeon. It is unknown what proportion of juvenile Green Sturgeon are entrained into CCF but individuals are salvaged infrequently. Thus, the proposed action is not likely to negatively impact juvenile Green Sturgeon.

5.12.4.18 Delta Fish Species Conservation Hatchery

None of the Green Sturgeon life stages would benefit from the Delta Fish Species Conservation Hatchery under the proposed action. As with the other proposed construction activities in the Delta, the year-round occurrence of juvenile Green Sturgeon in the Delta (Table 5.12-1; Figure 5.12-3) means that this life

stage, as well as the timing of the adult Green Sturgeon occurring in the Delta during May to October, could be exposed to Delta Fish Species Conservation Hatchery construction under the proposed action. The in-water work constructing the hatchery intake and outfall could result in a small number of individuals experiencing effects such as temporary loss of habitat leading to predation, degraded water quality, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas. The risks from these potential effects would be minimized with through the application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.12.4.19 Effects of Monitoring

Population estimates for Green Sturgeon also remain outstanding in the Central Valley. Similar to steelhead, the existing monitoring programs very rarely catch green sturgeon because most monitoring programs are not designed to capture them. Similar to steelhead, it is unlikely the monitoring programs have an effect to the population.

Table 5.12-4. Monitoring Programs – Green Sturgeon

| Species | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Chippis Island Trawl | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Trawl | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DJFMP Beach Seine Survey | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CDFW Mossdale Trawl | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EDSM KDTR Trawls | | | | | | | | | | | | | | | | | |
| Green Sturgeon | na | na | na | na | na | na | na | na | na | na | na | na | na | na | 0 | 0 | na |
| CDFW Bay Study Trawls | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 3 | 1 | 2 | 0 | 1 | 2 | 2 | 0 | 0 | 3 | 4 | 1 | 0 | 1 | na |
| CDFW SKT Study | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | | | | | | | | | | | | | | | | | |
| Green Sturgeon | 0 | 0 | 3 | 1 | 2 | 0 | 1 | 2 | 2 | 0 | 0 | 3 | 4 | 1 | 0 | 1 | na |
| RBDD Rotary Trap or Juvenile Production Estimate (JPE) | | | | | | | | | | | | | | | | | |
| Green Sturgeon | | | | | | | | | | | | | | | | | |

5.13 North American Green Sturgeon, Southern DPS Critical Habitat

Critical habitat for the southern DPS of North American Green Sturgeon, was designated in 2008 and includes the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays. Critical habitat includes stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line or bankfull elevation (defined as the level at which water begins to leave the channel and move onto the floodplain, and generally corresponds with a discharge that occurs every 1 to 2 years on an annual flood series). For bays and estuarine areas, critical habitat includes the lateral extent of the mean higher high water (MHHW) line. (73 FR 52084).

The designated critical habitat includes PBFs that are essential for the conservation of Green Sturgeon, southern DPS. The critical habitat designation includes separate list of PBFs for riverine and estuarine habitat.

The specific PBFs essential for the conservation of the Southern DPS freshwater riverine systems include:

1. *Food resources.* Abundant prey items for larval, juvenile, subadult, and adult life stages. Food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, subadult and adult Green Sturgeon may forage during their downstream post-spawning migration, while holding within deep pools, or on non-spawning migrations within freshwater rivers. Subadult and adult Green Sturgeon in freshwater rivers most likely feed on benthic prey species similar to those fed on in bays and estuaries, including shrimp, clams, and benthic fishes.
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 flow conditions), and subadults and adults (e.g., substrates for holding and spawning).
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. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development. Sufficient flow is needed to reduce the incidence of fungal infestations of the eggs. In addition, sufficient flow is needed to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in (and potentially suffocating the eggs and to maintain surfaces for feeding. Successful migration of adult Green Sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is associated with water flow and water temperature. Post-spawning downstream migrations are triggered by increased flows.
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. Suitable water temperatures would include stable water temperatures within spawning reaches. Suitable salinity levels range from fresh water for larvae and early juveniles to brackish water for juveniles prior to their transition to salt water. Adequate levels of dissolved oxygen are needed to support oxygen consumption by fish in their early life stages. Suitable water quality would also include water

containing acceptably low levels of contaminants that may disrupt normal development of embryonic, larval, and juvenile stages of Green Sturgeon. Water with acceptably low levels of such contaminants would protect Green Sturgeon from adverse impacts on growth, reproductive development, and reproductive success.

5. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of southern DPS fish 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). Safe and timely passage requires that no human-induced impediments, either physical, chemical or biological, alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach their spawning habitat in time to encounter con-specifics and reproduce). Unimpeded migratory corridors are necessary for adult Green Sturgeon to migrate to and from spawning habitats, and for larval and juvenile Green Sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries.
6. *Water depth.* Deep (≥ 5 m) 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. This includes sediments free of elevated levels of contaminants (e.g., selenium, polyaromatic hydrocarbons (PAHs), and organochlorine pesticides) that may adversely impact Green Sturgeon.

The specific PBFs essential for the conservation of the southern DPS Green Sturgeon in estuarine areas include:

1. *Food resources.* Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages. Prey species for these life stages within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing thalassinidean shrimp (particularly the burrowing ghost shrimp), amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult Green Sturgeon within the bays and estuaries.
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. Sufficient flows are needed to attract adult Green Sturgeon to the Sacramento River to initiate the upstream spawning migration.
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. Suitable water quality includes water with acceptably low levels of contaminants (e.g., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.
4. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats. Within the bays and estuaries adjacent to the Sacramento River, unimpeded passage is needed for juvenile Green Sturgeon to migrate from the river to the bays and estuaries and eventually out into the ocean.

Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean.

5. *Water depth.* A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult Green Sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. Juveniles occur primarily in shallow waters for rearing and foraging. Thus, a diversity of depths is important to support different life stages and habitat uses for Green Sturgeon within estuarine areas.
6. *Sediment quality.* Sediment quality (*i.e.*, chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (*e.g.*, selenium, PAHs, and organochlorine pesticides) that can cause adverse impacts on all life stages of Green Sturgeon.

5.13.1 Freshwater Riverine Systems

5.13.1.1 Food Resources

Availability of food resources for Green Sturgeon in the Sacramento River would potentially be affected by changes in flow and water temperature, although the nature of the effects is difficult to predict. Higher flow generally produces greater habitat complexity, potentially resulting in greater diversity and density of prey, although higher flow can also reduce foodweb productivity. Increased water temperature potentially stimulates foodweb productivity, leading to higher densities of prey species, but large temperature increases may physiologically stress prey species, ultimately leading to reduction in food resources. Larval and juvenile Green Sturgeon are more vulnerable to reductions in food resources than adults. Sturgeon larvae and juveniles typically feed on insect larvae, amphipods, mysids and other benthic invertebrates (Muir et al. 2000). Differences in flow and water temperatures between the proposed action and COS would be too small to cause any important differences in food resources for Green Sturgeon. In contrast, the differences in flow and water temperatures between the proposed action and the WOA would be sufficiently large to produce substantial changes in food resources. However, the nature of these changes and how they would impact the different life stages of Green Sturgeon feeding in the Sacramento River is highly uncertain. Probably the most significant environmental change resulting from the WOA scenario, would be the much higher late spring, summer and early fall water temperatures, as described throughout Section 5.15, *North American Green Sturgeon, southern DPS*. The period of high water temperatures overlaps with the period of maximum occurrence of Green Sturgeon larvae and juveniles in the river (Figure 5.12-1). The predicted increases in temperature are potentially large enough to result in major changes in the prey species that would dominate the benthic invertebrates on which the Green Sturgeon feed. However, while these changes would potentially reduce growth and survival of the Green Sturgeon larvae and juveniles, this conclusion is uncertain. Overall, the impacts of the proposed action relative to COS and the WOA scenario on food resources in Green Sturgeon critical habitat are expected to have no impact, but this conclusion is uncertain.

5.13.1.2 Substrate Type or Size

The proposed action includes adaptive management projects to improve spawning habitat for Chinook Salmon in the upper Sacramento River, and these projects would likely benefit substrate type or size in Green Sturgeon spawning habitat. River substrate type and size can also be affected by changes in flow. Very high flows scour bottom sediments, potentially creating the types of deep holes that Green Sturgeon favor for spawning, although such flows could also remove suitable spawning gravels from spawning

habitat. High, but less extreme flows flush sediments from gravels, which may improve Green Sturgeon spawning and egg incubation habitat. Overall, high flows are expected to improve river substrates for Green Sturgeon. Differences in flow between the proposed action and COS would generally be minor, as described throughout Section 5.15, *North American Green Sturgeon, Southern DPS*, and would not be large enough to effect meaningful changes in substrate type or size. The differences in flow between the proposed action and the WOA would often be large, but only the wet-year winter and spring flows would be high enough to scour sediments. WOA flows during such years are generally higher than proposed action flows and would therefore be more likely to result in improved Green Sturgeon spawning habitats. However, proposed action flow during the late spring and summer months, when Green Sturgeon spawn, is much higher than WOA flow, and likely high enough to flush sediments from the gravel substrates, thereby improving conditions for incubating embryos. These results indicate that, relative to the WOA, the proposed action would adversely impact Green Sturgeon substrate type and size in Green Sturgeon spawning habitat during winter and early spring, but benefit the suitability of the substrate for incubating embryos during summer. However, this conclusion is uncertain.

5.13.1.3 Water Flow

As described throughout Section 5.15, *North American Green Sturgeon, Southern DPS*, differences in Sacramento River flow between the proposed action and COS would generally be minor, but differences in flow between the proposed action and the WOA would be large enough to potentially affect all life stages of Green Sturgeon. Proposed action flow is generally higher than WOA flow during late spring, summer and early fall, when Green Sturgeon spawn, the eggs incubate, and the larvae and juveniles rear, disperse and migrate downstream. Post-spawn adults also emigrate during this period. Proposed action flow is generally similar or lower than WOA flow during late fall, winter, and early spring. Juveniles and adults continue emigrating through December, and by February adults enter the river and begin migrating upstream to holding and spawning habitat. The higher proposed action flows during late spring, summer and early fall would potentially benefit spawning, eggs, larvae, and juveniles in a number of ways, including increased water depth for holding and spawning habitat, reduced fine sediment deposition on incubating eggs, greater dispersion of larvae and juveniles, reduced crowding and competition, improved migration habitat and migration cues, reduced entrainment risk, and lower contaminant concentrations in the river. There is evidence that abundance of Green Sturgeon larvae and juveniles is positively related to annual outflow (Heublein et al. 2017a [*SAIL model*]). WOA flow in the middle Sacramento River is predicted to be low enough in many years during summer to adversely impact emigrating juveniles and adults. Reduced flows under the proposed action during winter and early spring would potentially have adverse impacts on immigrating adults, but the flows would consistently be high to prevent passage problems. Overall, the proposed action is not expected to adversely impact flow conditions in Green Sturgeon critical habitat.

5.13.1.4 Water Quality

In the critical habitat designation final rule for Green Sturgeon (October 9, 2009, 74 FR 52300), the Water Quality PBF includes “temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages”. These factors could potentially be affected by changes in flows and increases in water temperatures in the Sacramento River. As described throughout Section 5.15, *North American Green Sturgeon, Southern DPS*, differences in Sacramento River flow and water temperature would generally be minor between the proposed action and COS, but would be large enough between the proposed action and WOA to potentially impact all life stages of Green Sturgeon. Differences in flow are described above in Section 5.16.2.1.3, *Water Flow* and differences in water temperature are described in Section 5.16.2.1.3, *Water Temperature*. Higher spring, summer and fall flows under the proposed action would dilute contaminants present in the Green

Sturgeon critical habitat, reducing their adverse impacts. Water temperatures under the proposed action would be much lower than WOA temperatures during spring, summer and early fall, when the presence of Green Sturgeon eggs, larvae, and young juveniles peaks in the river. High water temperatures result in reduced DO. The young life stages of Green Sturgeon are especially vulnerable to high water temperatures and low DO. During June and July, predicted water temperatures in many years reach levels that are likely lethal to Green Sturgeon embryos. Overall, the proposed action is expected to have no impact on water quality of the Green Sturgeon critical habitat relative to the COS, and to substantially benefit water quality relative to the WOA.

5.13.1.5 Migratory Corridor

The middle Sacramento River is the main migratory corridor for Green Sturgeon critical habitat upstream of the Delta. Principal potential impacts of the proposed action on this corridor are instream flow and water temperature. Flow may affect upstream and downstream passage of migratory adults, dispersal and emigration rates of juveniles, and concentration of contaminants. Water temperature potentially affects growth and survival of adult and juvenile sturgeon in the migratory corridor. As described above in Section 5.16.2.1.3, *Water Flow*, flow in the middle Sacramento River under the proposed action is generally similar to COS flow, but is reduced relative to WOA flow during many years in winter and spring, when adult Green Sturgeon migrate upstream to holding and spawning areas in the middle and upper river. The flow under both scenarios are high enough to eliminate passage problems. Flow in the middle river is much higher under the proposed action than under WOA conditions during summer through fall, when larvae are dispersed downstream in the migratory corridor and juveniles and post-spawned adults migrate downstream. Adequate flow is essential to quickly move larvae and juveniles to critical rearing habitats before they starve (Muir et al. 2000). Flow in the middle river under the WOA scenario is often low enough to interfere with downstream passage of emigrating adults. The low flow may also concentrate contaminants in the river, which are likely to be highest in the late spring through early fall because this is the primary season for treating croplands with fertilizer and pesticides.

Predicted water temperatures in the middle Sacramento River migratory corridor of Green Sturgeon differ little between the proposed action and the COS scenarios, but proposed action temperatures are much lower than WOA temperatures during the late spring through early fall, and are much higher during late fall through early spring. The potential impact of water temperature is much greater during late spring to early fall than in the late fall to early spring because temperatures in the latter period under both scenarios are below levels that are stressful to Green Sturgeon. Temperatures in late spring to early fall regularly exceed critical thresholds for Green Sturgeon under the WOA scenario but rarely do so under the proposed action.

Overall, the proposed action would have no negative impact relative to COS on migratory corridor habitat in Green Sturgeon's Sacramento River critical habitat, and would have largely beneficial effects relative to the WOA scenario.

5.13.1.6 Depth

The proposed action would potentially have two different types of effects on depths for Green Sturgeon critical habitat in the Sacramento River: 1) the proposed action would potentially reduce the number and depth of pools suitable for Green Sturgeon holding and spawning by reducing unregulated high discharge scouring flows and 2) the proposed action could increase the depth of water in these pools by increasing the level of more moderate flows in the river. The proposed action is not expected to have either of these effects relative to the COS scenario. However, relative to the WOA scenario, the proposed action would potentially reduce the number and/or depth of pools suitable for Green Sturgeon holding and spawning

and would increase the depth of water in the pools. The main difference between the WOA scenario and the proposed action, is that Sacramento River flow is not regulated under the WOA scenario and the river would therefore experience a more natural flow regime, including a higher frequency of pulse flows strong enough to scour deep holes in portions of the river bottom. In contrast, the river is regulated under the proposed action scenario, including high flow releases from Shasta Reservoir during summer and early fall when most Green Sturgeon hold and spawn, which results in deeper water levels in the spawning pools. The higher flows would potentially improve water quality in the pools as well, by more effectively flushing out fine sediments, metabolic wastes and other contaminants. Therefore, the proposed action would potentially adversely impact the availability of deep pools for Green Sturgeon holding and spawning, but would benefit the quality of the pool habitats available.

5.13.1.7 Sediment Quality

High levels of fine sediments in the Sacramento River upstream of the Delta can adversely impact Green Sturgeon by smothering spawning substrates, which may increase mortality of embryos (Kock et al. 2006. *Effects of Sediment Cover on Survival and Development of White Sturgeon Embryos. Nor. Am. J. Fish. Manag.* 26: 134-141). However, more moderate levels provide essential habitat for small burrowing invertebrate organisms, such as chironomid larvae and other benthic invertebrates that may be important prey of Green Sturgeon larvae and young juveniles (Muir et al. 2000). Sacramento River flow is predicted to be much higher under the proposed action than the WOA scenario during the late spring and summer when most Green Sturgeon spawning occurs, which would likely improve spawning habitat. The availability of habitat with fine sediment deposits for burrowing benthic invertebrate prey is presumably related to the overall sediment supply, which depends mostly on stormwater runoff and imports from unregulated tributaries during major flows. The proposed action would have little effect on imports from tributaries, but it potentially would reduce inundation flows and subsequent stormwater runoff because unregulated pulse flows from upstream of Shasta Dam would potentially be larger and more frequent under the WOA scenario. Also, it is possible that imports of fine sediments from upstream of Shasta Dam would be higher under the WOA scenario because more of the fine sediment that currently deposits in Shasta Lake might be carried through the reduced reservoir and the fully open Shasta Dam. Overall, the proposed action is expected to improve conditions regarding fine sediment in Green Sturgeon spawning habitat, but may adversely impact fine sediment habitat for prey organisms of larval and juvenile Green Sturgeon. Both of these conclusions are uncertain.

5.13.2 Estuarine Habitats

Young-of-the-year Green Sturgeon juveniles emigrate from the Sacramento River into the Bay/Delta several months after hatching. They disperse to all parts of the Bay/Delta and rear there for a year or more before entering the ocean as subadults (Heublein et al. 2017b). Adults and subadults visit the Bay/Delta sporadically, and are most commonly found in summer and fall. Spawning Green Sturgeon enter the Bay/Delta from the ocean from late winter to spring and ascend the Sacramento River with minimal staging and feeding in the estuary (Heublein et al. 2009).

The principal potential effects of the proposed action on southern DPS Green Sturgeon in the Bay/Delta are changes related to flow, flow routing, and entrainment.

5.13.2.1 Food Resources

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. When juvenile Green Sturgeon enter the estuary from the Sacramento River, their diet shifts to larger benthic food items, though they remain generalists and opportunists.

Mysid shrimp and amphipods (*Corophium*) were observed to be the primary food items in juvenile (Israel et al. 2008). Adult and subadult Green Sturgeon in the Columbia River estuary, Willapa Bay, and Grays Harbor feed on crangonid shrimp, burrowing thalassinidean shrimp, amphipods, clams, juvenile Dungeness crab (*Cancer magister*), anchovies, sand lances (*Ammodytes hexapterus*), lingcod (*Ophiodon elongatus*), and other fishes. It expected that the diet of adult and subadult Green Sturgeon in the Bay/Delta would be similar.

Changes in Delta inflow resulting from the proposed action potentially impact prey of Green Sturgeon in the Bay/Delta Green Sturgeon critical habitat. Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green Sturgeon juveniles, subadults and adults, would be higher under the proposed action than under the WOA during many months, but particularly during July and August of all but the wettest years (e.g., Figures 5.13-1 and 5.13-2). The increased flow would result in greater depths and would likely lead to greater diversity in habitats, both factors that would potentially increase the diversity and productivity of Green Sturgeon food resources.

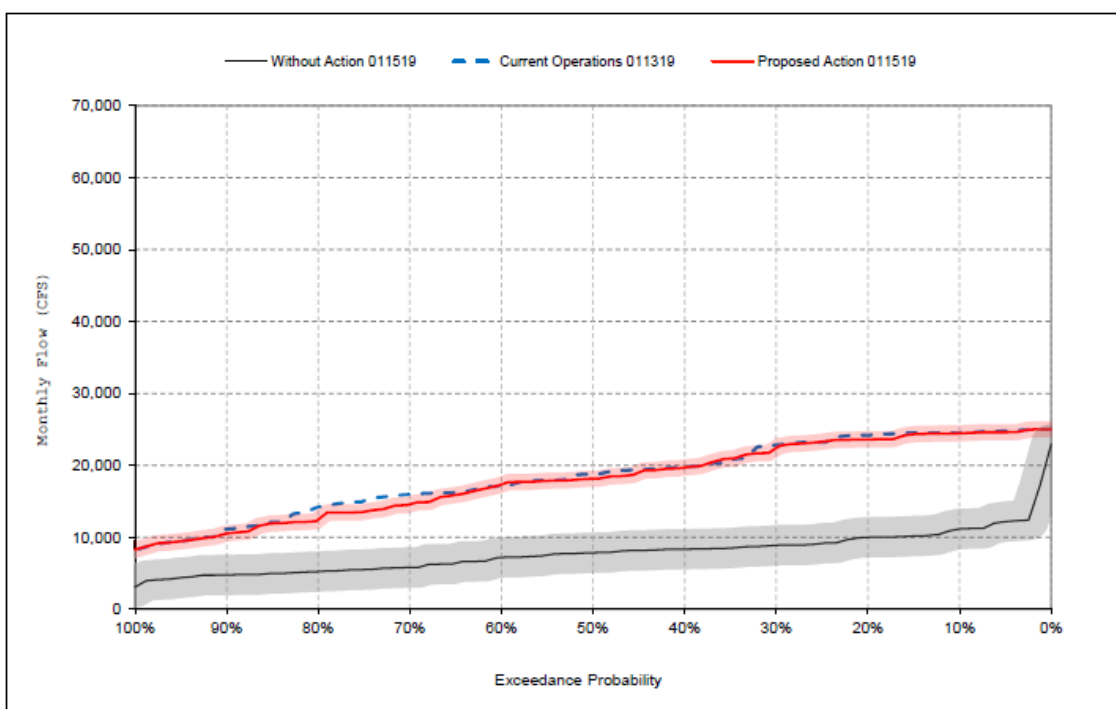


Figure 5.13-1. CalSim II Sacramento River Flows at Freeport, July

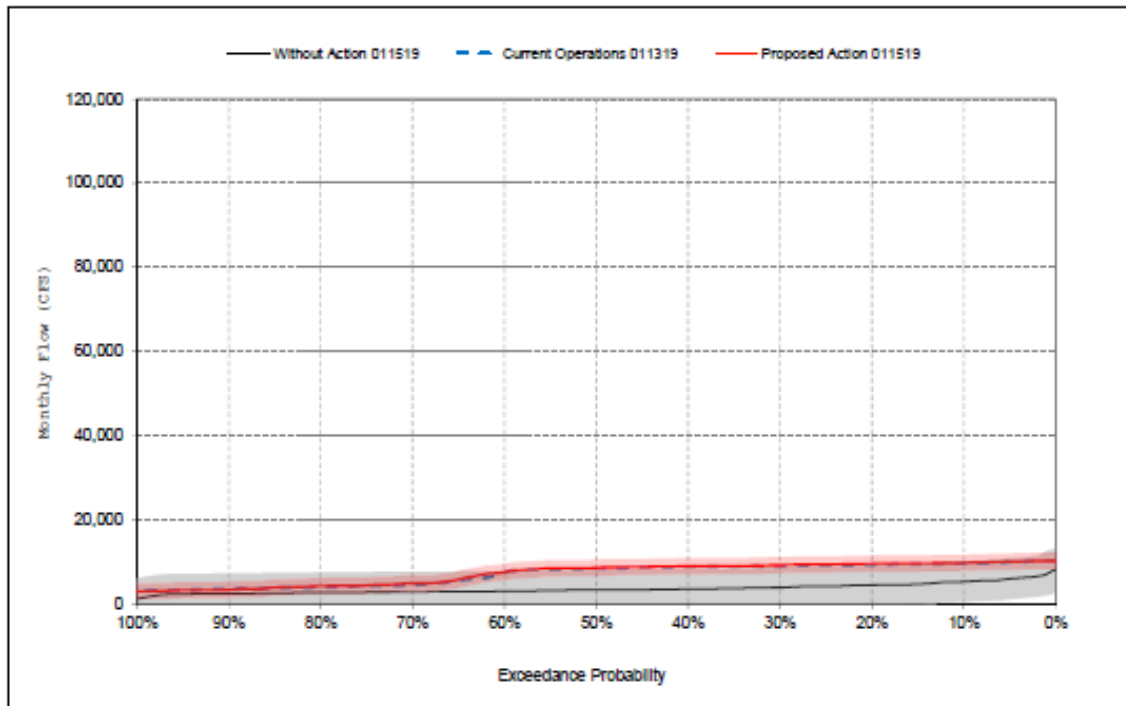


Figure 5.13-2. CalSim II Sacramento River Flows at Rio Vista, August

However, operation of the proposed action's proposed SMSCG operations during June to September of above normal and below normal water years (reducing salinity to improve habitat conditions in the relatively food-rich Suisun Marsh, the proposed action's proposed tidal restoration, and various programmatic actions would potentially enhance foodweb productivity in the Bay/Delta and result in greater food resources for Green Sturgeon.

5.13.2.2 Water Flow

Little is known about the relationship between survival of juvenile Green Sturgeon and Delta hydrology. Green sturgeon juveniles are thought to reside in the Delta for 1-3 years, so they encounter a variety of hydrological conditions. The juveniles are present in the Delta all year and sub-adults are most abundant from June-November (Table 5.12-1).

The effects of the proposed action on flow in Green Sturgeon estuarine critical habitat were evaluated by analyzing the effects of flow changes on Delta hydrodynamics, with potential effects on how fish are routed through Delta channels. The results indicate that routing into the interior Delta, where Green Sturgeon would be at higher risk from entrainment and reduced water quality (NMFS 2009), would be higher under the proposed action and the COS relative to the WOA, but the difference was likely not high enough to substantially impact Green Sturgeon. The proposed action on through Delta survival of juvenile Green Sturgeon has no impact, so the proposed action is not expected to adversely impact water flow for Green Sturgeon in the Delta.

Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green Sturgeon juveniles, subadults and adults, would be higher under the proposed action than under the WOA during many months, but particularly during July and August of all but the wettest years (e.g., Figures 5.13-1 and 5.13-2). As noted above, the higher flows would potentially improve Green Sturgeon

food resources. They would also potentially improve water quality and depth conditions in the Green Sturgeon critical habitat (see below).

Potential negative impacts on river flow could occur as a result of tidal restoration effects on channel hydrodynamics, although modeling and design of restoration would be done so as to minimize such impacts.

5.13.2.3 Water Quality

In the critical habitat designation final rule for Green Sturgeon (October 9, 2009, 74 FR 52300), the Water Quality PBF includes “temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages”. The proposed action is expected to have no impact on water temperature and DO in the estuarine critical habitat for Green Sturgeon. As described throughout the analysis of the effects to the species, these water quality parameters are major discriminators for comparing potential impacts of the proposed action and the WOA on Green Sturgeon in the Sacramento River upstream of the Delta. In the Bay/Delta, however, flow and water temperature of reservoir releases are generally considered to have little effect on water temperatures (Wagner et al. 2011, USFWS 2017b). This assessment, however, has been based on experience with smaller flow and water temperature differences than those expected between the proposed action and WOA (USFWS 2017b), so the conclusion that the proposed action would have no impacts on water temperature in the Bay/Delta is uncertain. Other than downstream of major effluents, DO in the Bay/Delta is primarily determined by water temperature. Juvenile Green Sturgeon have developed a tolerance for a wide range of salinities by the time they move into the Bay/Delta, so this water quality parameter is not expected to impact estuarine critical habitat for Green Sturgeon (Heublein et al. 2017b).

The proposed action has the potential to positively and negatively affect other water quality factors in the Green Sturgeon estuarine critical habitat relative to the WOA conditions. Higher summer flows under the proposed action at Freeport and Rio Vista (e.g., Figures 5.13-1 and 5.13-2) would dilute contaminants present in the mainstem Sacramento River, reducing their adverse impacts. Impacts of flows on contaminants in other parts of the Delta are uncertain. The increase in high unregulated Sacramento River flows, including pulse flows, expected during winter and spring under the WOA, would potentially increase loading of contaminants related to runoff from inundated croplands. However, the increase in high flows under the WOA would also flush contaminated sediments downstream from the Bay/Delta, potentially increasing water quality and sediment quality in the critical habitat. Thus, the proposed action has both positive and negative potential impacts with respect to water quality in Green Sturgeon estuarine critical habitat and the overall impact is uncertain.

Relative to the WOA, reduced winter-spring inflow to the Delta under the proposed action (e.g., Figures 29-9 through 29-14 in the CalSim II Flows summary in Appendix D, *Modeling*) has the potential to reduce sediment supply and therefore turbidity during winter to spring, as well as during summer and fall when resuspension of sediment supplied in the winter and spring produces turbidity. Impacts of turbidity on Green Sturgeon, if any, are unknown.

The year-round occurrence of juvenile Green Sturgeon in the Delta means that this life stage could be exposed to Delta Fishes Conservation Hatchery operations. Any water discharged from the facilities into the Sacramento River would be treated and subject to regular monitoring of water quality within the FTC for fish health, so there are not likely to be impacts on water quality associated with discharges from the FTC

The Delta Fishes Conservation Hatchery including marinas would house a number of boats. Boat motors introduce metals, hydrocarbons, and other pollutants into the Sacramento River. These compounds can have a negative effect on the water quality for Green Sturgeon in the system, including affecting pH and DO. These increased pollutants have been associated with the impaired development and survival of juveniles (Soule et al. 1991; Von Westerhagen et al. 1987). In some instances, motorboat traffic can increase turbidity and nutrients in the water column, decreasing water quality. Increased boat traffic may negatively impact the designated Green Sturgeon critical habitat by disturbing sediment and decreasing water quality and food resources, and possibly limiting space and access for rearing or resident fish. Safe passage through critical habitat might also be compromised for migrating Green Sturgeon. The potential sites currently have very high boating and shipping traffic and the relatively small output from the ERS marina would not dramatically increase the amount of pollutants, turbidity, and nutrients to which Green Sturgeon would be exposed. Furthermore, the proposed action would not change the overall number of boats in the region, only their harbor location. Therefore there would be no negative impacts on juvenile Green Sturgeon critical habitat.

During summer/fall, there is the potential for impacts to flow, flow velocity, and water clarity under the proposed action to negatively impact water quality in the critical habitat relative to the WOA by increasing the potential for harmful algal blooms, although this is uncertain. Reclamation and DWR's proposal includes programmatic adaptive management elements that could limit potential negative impacts from harmful algal blooms.

5.13.2.4 Migratory Corridor

The effects of combined exports present an entrainment issue that could delay migration or decrease survival or population viability through entrainment into the South Delta facilities.

As discussed in Section the analysis of entrainment, impacts to the migratory corridor function of juvenile and sub-adult Green Sturgeon critical habitat from south Delta exports are less clear than for juvenile salmonids because Green Sturgeon spend one to three years rearing in the Delta environment before transitioning to their marine subadult life stage. During this Delta rearing phase, Green Sturgeon are free to migrate throughout the Delta. Estimating entrainment risk from raw salvage data is hamstrung by a lack of information on the number of juvenile Green Sturgeon potentially exposed to salvage. However, it can be inferred that higher rates of exports will result in higher rates of entrainment.

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. Average total exports for months when Green Sturgeon juveniles are present in the Delta indicate zero entrainment risk for the WOA scenario. In the June through September period, the proposed action has an average total export rate slightly higher than COS (Figure H-27 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed for the proposed action in September through November (Figure H-28 – Appendix H, *Bay-Delta Aquatics Effects Figures*) will only slightly increase entrainment risk relative to COS. Therefore, the proposed action would potentially adversely impact entrainment of Green Sturgeon in the Delta relative to the WOA, but would have a minor impact relative to the COS.

5.13.2.5 Depth

Juvenile southern DPS Green Sturgeon are present in the Delta all year and sub-adults are most abundant from June through November. One of the PBFs for Green Sturgeon estuarine critical habitat is a diversity of depths for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Sacramento River flow at Freeport and Rio Vista, which are important rearing and migratory habitat areas for Green

Sturgeon juveniles, subadults and adults, would be much higher under the proposed action than under the WOA during most months, but particularly during July and August of all but the wettest years (e.g., Figures 29-16 and 32-17 in the CalSim II flow section of Appendix D). These differences would likely afford the three Green Sturgeon life stages a greater diversity of depth. Therefore, the proposed action is expected to benefit Green Sturgeon critical habitat in the Bay/Delta relative to the WOA with respect to depth.

5.13.2.6 Sediment Quality

Fine sediments provide essential habitat for burrowing invertebrate organisms such as shrimp, clams, amphipods, worms, and insect larvae that are important prey of Green Sturgeon juveniles, subadults and adults. The availability of habitat with fine sediment deposits is presumably related to the overall sediment supply, which depends mostly on stormwater runoff and imports from unregulated tributaries during major flows. The proposed action would have little impact on imports from tributaries, but it potentially would reduce inundation flows and subsequent stormwater runoff because unregulated pulse flows from upstream of Shasta Dam would potentially be larger and more frequent under the WOA scenario. Also, it is possible that imports of fine sediments from upstream of Shasta Dam would be higher under the WOA scenario because more of the fine sediment that currently deposits in Shasta Lake might be carried through the reduced reservoir and the fully open Shasta Dam. Therefore, the proposed action may adversely impact fine sediment habitat for prey organisms of Green Sturgeon in their estuarine critical habitat. These conclusions are uncertain. Implementation of tidal and channel margin restoration through adaptive management would provide additional sand substrate for Delta Smelt spawning habitat (USFWS 2017, p.111), which would contribute to offsetting the potential negative impact of the proposed action on sediments for Green Sturgeon prey habitat.

5.14 Killer Whale, Southern Resident DPS

Ford et al. (2016) confirmed the importance of Chinook Salmon to Southern Residents in the summer months using DNA sequencing from whale feces. The researchers found that more than 90 percent of the whale's inferred diet consisted of salmonids; almost 80 percent was Chinook Salmon. Bellinger et al. (2015) estimated that Central Valley Chinook Salmon made up about 22 percent of the Chinook Salmon sampled off the Oregon coast and about 50 percent of those sampled off the California coast (south to Big Sur). While this apex predator certainly eats a variety of other species as well, Central Valley Chinook Salmon (all runs) can be estimated to make up approximately 40% of the killer whale diet when killer whales are off the California coast, and 18% of the killer whale diet when the killer whales are off the Oregon coast.

As discussed by NMFS (2017, p.831), individual-level effects to killer whale from changes in Chinook Salmon prey could include changes in areas searched for prey and consequent changes in energy expended for such searches, resulting in changes in energy intake and the risk of nutritional stress. Changes in energy consumption and nutritional stress could lead to changes in body size, condition, and growth; and changes in reproductive and survival rates for adults (NMFS 2017, p.831).

The southern distinct population segment of killer whales is thought to move with the seasonal abundance of salmonids returning to natal rivers to spawn from early summer through fall. There are correlations between the occurrence of southern residents and commercial and sport Salmon fishery catches in US waters off southeastern Vancouver Island and in Puget Sound (Heimlich-Boran, 1986). This population of

killer whales is commonly found off southeastern Vancouver Island and in Puget Sound, Washington, from late spring to late fall (Ford, 2006, Osborne 1999). The winter distribution of Southern Resident Killer Whales is poorly known. K and L pods have been observed off the mouth of the Columbia River and in Monterey Bay, California, associated with local production of Chinook Salmon (Wiles 2004; Balcomb 2006).

The reduced flows in the spring of the proposed action, as compared to the WOA, are likely to affect rearing and migrating Fall-run Chinook Salmon, which could possibly reduce juvenile production. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows. To reduce these effects, Reclamation has included a variety of conservation measures including fall and winter refill and redd maintenance, spawning and rearing habitat restoration on the Sacramento, American, Stanislaus, and lower San Joaquin rivers, tidal habitat restoration, and predator hot spot removal. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action on Killer Whale prey as compared to WOA. In addition, as discussed above, Chinook Salmon from the Central Valley are a relatively small portion of the killer whale diet, between 18 – 40%.

5.14.1 Effects of Operation

The proposed action relative to WOA has potential beneficial and negative effects on Chinook Salmon stocks which form part of the diet of SRKW. Potential beneficial effects of the proposed action to killer whale prey relative to the WOA would occur because reservoir storage under the proposed action allows summer/fall releases to maintain favorable water temperature conditions for early life stages, as exemplified for Winter-run Chinook salmon in the Sacramento River below Keswick Dam. Potential negative effects to killer whale prey generally could occur during winter and spring, particularly the latter, which coincides with the main period of juvenile downstream migration and is when flow is often appreciably lower under the proposed action compared to the WOA, which could increase the duration of juvenile travel time and decrease survival.

Conservation measures under the proposed action generally would be expected to have overall beneficial effects on Chinook Salmon stocks from the Central Valley relative to WOA, although some temporary negative effects are also possible, as discussed in Chinook Salmon effects sections.

Studies have suggested that most Chinook salmon in the coastal ocean off California appear to be of hatchery origin (Barnett-Johnson et al. 2007; Johnson et al. 2016). The potential effects of the proposed action on Central Valley Chinook Salmon stocks would be expected to be zero to minimal on hatchery-origin juvenile Chinook Salmon released downstream of the Delta. The percentage of hatchery-origin fish released downstream of the Delta has been variable over time. For example, from the mid-1980s to 2012, the proportion of hatchery Fall-run Chinook Salmon juveniles released downstream of the Delta by state and federal hatcheries varied from around 20% to 60% (Huber and Carlson 2015). Similarly, from 2013 to 2017, the percentage of juvenile Fall-run and Spring-run Chinook Salmon released by state Central Valley hatcheries downstream of the Delta varied between 24% (2016) and 60% (2013) (California Department of Fish and Wildlife 2018).

While the proposed action is likely to negatively impact individual Central Valley Chinook salmon from operation of the export facilities, this reduction is not expected to result in decreased overall ocean abundance or availability of prey for killer whale, when weighed against hatchery production. The proposed action is expected to be beneficial to Central Valley Chinook salmon due to flow and temperature management as compared to without the operation of the CVP and SWP.

Due to the generally medium priority (18-41% of the diet, only when off the coast of California and Oregon) of the Central Valley stocks that could be affected by proposed action among many stocks contributing to the SRKW diet, and the contribution of hatchery-origin Chinook Salmon released downstream of the potential influence of proposed action, population-level effects of the proposed action to SRKW prey species are not expected.

5.14.2 Effects of Maintenance

Implementation of the species avoidance and take minimization steps under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Chinook Salmon stocks from maintenance activities.

5.14.3 Effects of Conservation Measures

Construction components of the proposed action have the potential to affect Chinook Salmon stocks, which form part of the diet of SRKW. The various proposed construction activities would generally benefit Chinook salmon stocks in the long-run, through increased operational flexibility and habitat restoration. The conservation measures potentially could also result in negative effects to individual fish such as: temporary loss of aquatic and riparian habitat leading to increased predation 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 (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), 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. These potential effects would be minimized through restriction of in-water work to windows limiting exposure by reducing potential for spatiotemporal overlap, and implementation of other AMMs to minimize the potential for effects when species do overlap with in-water work.

5.14.4 Effects of Monitoring Activities

Monitoring activities described in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation* would result in capture of individual juvenile Chinook salmon that otherwise could have reached the ocean and become prey for SRKW. However, the extent of this capture is limited relative to the overall abundance of juvenile Chinook salmon. In addition, the priority of the Chinook salmon stocks is low to moderate relative to other stocks for the SRKW diet.

5.14.5 Chinook Salmon, Central Valley Fall-run/Late Fall-run ESU

The reduced spring flows of the proposed action, compared to the WOA, are likely to affect rearing and migrating Fall-run Chinook Salmon, which could possibly reduce juvenile production and affect Killer Whale prey. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, and reduced emigration flows.

Reclamation has included fall and winter refill and redd maintenance as well as smoothing rice decomposition, to consider keeping flows higher in the fall for avoiding Fall-run redd dewatering when Shasta Reservoir storage allows.

In addition to the fall and winter redd maintenance and smoothing of rice decomposition, several conservation measures for Winter-run Chinook salmon, Spring-run Chinook salmon, or steelhead would incidentally minimize impacts on Fall-run Chinook Salmon. These include spawning and rearing habitat restoration on the Sacramento, American, Stanislaus, and lower San Joaquin rivers, tidal habitat restoration, and predator hot spot removal. OMR management establishes protective criteria to minimize and avoid entrainment based on historical salvage. Additional protective measures occur when environmental criteria indicate that entrainment is more likely and allow for more flexible operations when entrainment is less likely. The proposed action also includes conservation measures such as improvements at fish collection facilities to improve facility survival and reduce impacts of the proposed action on Killer Whale prey as compared to WOA.

5.14.5.1 Life stage Timing and Location

General life stage timing and location information for Fall-run and Late Fall-run Chinook Salmon is provided in Tables 5.14-1 and 5.14-2. Additional detail regarding juvenile life stage timing at various monitoring locations is provided in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Timing Summary from SacPAS*.

Table 5.14-1. The Temporal Occurrence of Adult and Juvenile Fall-run Chinook Salmon at Locations in the Central Valley (DWR and Reclamation 2016, p.11A-103).

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----|-----|------------|-----|-----|---------|-----|-----|-----|-----|-----|
| Adult | | | | | | | | | | | | |
| Delta ¹ | | | | | | | | | | | | |
| Sacramento River Basin ² | | | | | | | | | | | | |
| San Joaquin River ² | | | | | | | | | | | | |
| Juvenile | | | | | | | | | | | | |
| Sacramento River at Red Bluff ³ | | | | | | | | | | | | |
| Delta (beach seine) ⁴ | | | | | | | | | | | | |
| Mossdale (trawl) ⁴ | | | | | | | | | | | | |
| West Sacramento River (trawl) ⁴ | | | | | | | | | | | | |
| Chipps Island (trawl) ⁴ | | | | | | | | | | | | |
| Knights Landing (trap) ⁵ | | | | | | | | | | | | |
| Relative Abundance: | ■ = High | | | ■ = Medium | | | ■ = Low | | | | | |
| Note: Darker shades indicate months of greatest relative abundance. Sources: ¹ State Water Project and Federal Water Project fish salvage data 1981-1988. ² Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991. ³ Martin et al. 2001. ⁴ U.S. Fish and Wildlife Service 2001b. ⁵ Snider and Titus 2000. | | | | | | | | | | | | |

Table 5.14-2. The Temporal Occurrence of Adult and Juvenile Late Fall-run Chinook Salmon at Locations in the Central Valley (DWR and Reclamation 2016, p.11A-104).

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----|-----|-----|------------|-----|-----|-----|---------|-----|-----|-----|
| Adult | | | | | | | | | | | | |
| Delta ¹ | | | | | | | | | | | | |
| Sacramento River Basin ² | | | | | | | | | | | | |
| Juvenile | | | | | | | | | | | | |
| Sacramento River at Red Bluff ³ | | | | | | | | | | | | |
| West Sacramento River (trawl) ⁴ | | | | | | | | | | | | |
| Delta (beach seine) ⁴ | | | | | | | | | | | | |
| Chipps Island (trawl) ⁴ | | | | | | | | | | | | |
| Knights Landing (trap) ⁵ | | | | | | | | | | | | |
| Relative Abundance: | ■ = High | | | | ■ = Medium | | | | ■ = Low | | | |
| Note: Darker shades indicate months of greatest relative abundance. Sources: ¹ Moyle 2002. ² Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991. ³ Martin et al. 2001. ⁴ U.S. Fish and Wildlife Service 2001b. ⁵ Snider and Titus 2000. | | | | | | | | | | | | |

5.14.5.2 Conceptual Model Linkages

Central Valley Fall-run/Late Fall-run Chinook Salmon populations occur in several Central Valley streams. The SAIL conceptual model (Figure 5.6-1) was prepared specially for Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams apply equally well to the Fall-run and Late Fall-run races in Sacramento River. The primary differences in the habitat requirements between the Fall-run/Late Fall-run Chinook Salmon and Winter-run Chinook Salmon are the duration and the time of year that the different life stages use their habitats, as well as spawning locations within the Sacramento River (see Chapter 2, Species Accounts). Releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, dissolved oxygen level (DO), and other habitat attributes that influence the timing, condition and survival of eggs and alevins in the spawning redds. The proportion of eggs surviving to emerge as fry depends largely on the quality of conditions in the redd (Windell et al. 2017). Redd quality is affected by substrate size and composition, flow velocity, temperature, DO, contaminants, sedimentation, and pathogens and diseases. Flow affects sedimentation and gravel composition of the redds and may cause redd scour, stranding or dewatering (Windell et al. 2017). Flow also affects the surface area of river bed available for redd construction.

Fall-run adults spawn in the Sacramento River and eggs and alevins are in the gravel primarily between September and December with a peak during October through December (Table 5.14-1). Spawning

occurs between Keswick Dam to Red Bluff Diversion Dam primarily, although spawning occurs as far down as Princeton (Reclamation 2017).

Late Fall-run Chinook Salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between December and June with a peak during January through March (Table 5.14-1). Spawning occurs between Keswick Dam and Red Bluff Diversion Dam, with the majority of spawning between Keswick Dam and Red Bluff (Reclamation 2017).

Fry emergence occurs up to 3.5 months after eggs are spawned (Moyle 2002), so effects of flow in the upper Sacramento River on incubating fall-run eggs and alevins potentially occur from September through April and on incubating Late Fall-run Chinook Salmon eggs and alevins potentially occur from December through August.

As indicated by the SAIL conceptual model (Figure 5.6-2), releases from Keswick Dam and the resulting flows in the upper Sacramento River, combined with other environmental drivers, affect water temperature, DO, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of rearing juvenile Fall-run/Late Fall-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the upper Sacramento River depends largely on habitat conditions, including instream flow (Windell et al. 2017). Instream flow affects other factors through dilution (e.g., toxicity and contaminants), water temperatures (which also affects DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially affects cues that stimulate outmigration (Windell et al. 2017, Moyle 2002).

Fall-run/Late Fall-run Chinook Salmon juveniles rear in and emigrate from the upper Sacramento (Keswick to Red Bluff) year-round, with a peak rearing period during January through April and, for Late Fall-run Chinook Salmon only, a secondary peak in August through November (Table 5.14-1; Table 5.14-2). Flows during summer, fall and winter of dry and critically dry years generally have the greatest potential to negatively impact the juvenile life stage in the upper Sacramento River because reservoir storage and cold water pool in these seasons and water year types may be insufficient to provide suitable flow and water temperature conditions in the rearing habitats.

Many of the factors that affect rearing and emigrating Fall-run/Late Fall-run Chinook Salmon juveniles in the middle Sacramento River are similar to those described above for the upper Sacramento River. As indicated by the SAIL conceptual model (Figure 5.6-3), flows from the upper Sacramento River and tributaries of the middle Sacramento, combined with other environmental drivers such as floodplain connectivity, food production and retention, and water diversions, affect water temperature, DO, food availability, stranding, outmigration cues and other habitat attributes that influence the timing, condition and survival of rearing juvenile Fall-run/Late Fall-run Chinook Salmon. The proportion of juveniles surviving to emigrate from the middle Sacramento River depends largely on growth and predation, which are greatly affected by habitat conditions, including instream flow (Windell et al. 2017).

Juvenile Fall-run/Late Fall-run Chinook Salmon spend varying amounts of time rearing in the upper Sacramento River following emergence before migrating to the middle River. They use the middle Sacramento River as rearing habitat and a migratory corridor to the Delta. Fall-run/Late Fall-run Chinook Salmon-sized juveniles occur in the middle Sacramento River at Knights Landing primarily from November through May (Table 5.14-1), with two separate peak occurrences for Late Fall-run Chinook Salmon: November through February and April and May (Table 5.14-2). The two peaks may reflect differences in the timing of emigration from different Sacramento River tributaries.

Inundated floodplains of the middle Sacramento River, such as the Yolo and Sutter Bypasses, have proven successful habitats for juvenile salmon growth (Katz, 2017). This success has been attributed to optimum water temperature, lower water velocity, and higher food quality and food density relative to the main channel. Reduced predator and competitor density also likely contribute to high growth rates observed for juvenile salmon rearing in floodplains (Windell et al. 2017).

Continuing their upstream migration from the Delta, Fall-run Chinook Salmon adults migrate through the middle and upper Sacramento River between July and December and Late Fall-run enter the middle Sacramento River between October and April. The adults typically spawn soon after reaching their spawning habitats, but some hold for a month or two in the upper river before spawning (Satterthwaite et al. 2017; California Natural Resources Agency 2016. Appendix 5E Essential Fish Habitat Assessment). The holding period for Fall-run Chinook Salmon in the Sacramento River is August to October (California Natural Resources Agency 2016. Appendix 5E Essential Fish Habitat Assessment). No information has been found regarding the period that Late Fall-run Chinook Salmon hold, but it is assumed that they hold during October and November (Satterthwaite et al. 2017).

As indicated by the SAIL conceptual model (Figure 5.6-6), flows from Keswick Dam releases affect water temperature, DO, and other habitat attributes that influence the timing, condition, distribution and survival of adult Fall-run/Late Fall-run Chinook Salmon during their upstream migration, holding and spawning in the upper Sacramento River.

5.14.5.3 *Effects of Operation*

5.14.5.3.1 Seasonal Operations

Under the WOA conditions, there would be 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 (other than upstream hydropower operations not under Reclamation control), where Fall-run spawn. Reservoir gates and river valves would be kept open, resulting in minimal storage (Figure 5.6-7). The seasonal flows modeled under the WOA scenario in the Sacramento River at Keswick Dam, show low summer and fall flows and high winter and spring flows (Figures 5-15 through 5-18 in the HEC5Q Temperatures section of Appendix D, *Modeling*). Other locations in the Sacramento River would show similar seasonal flow patterns (See figures in the HEC-5Q Temperatures section of Appendix D, and Figures 5.14-1 and 5.14-2).

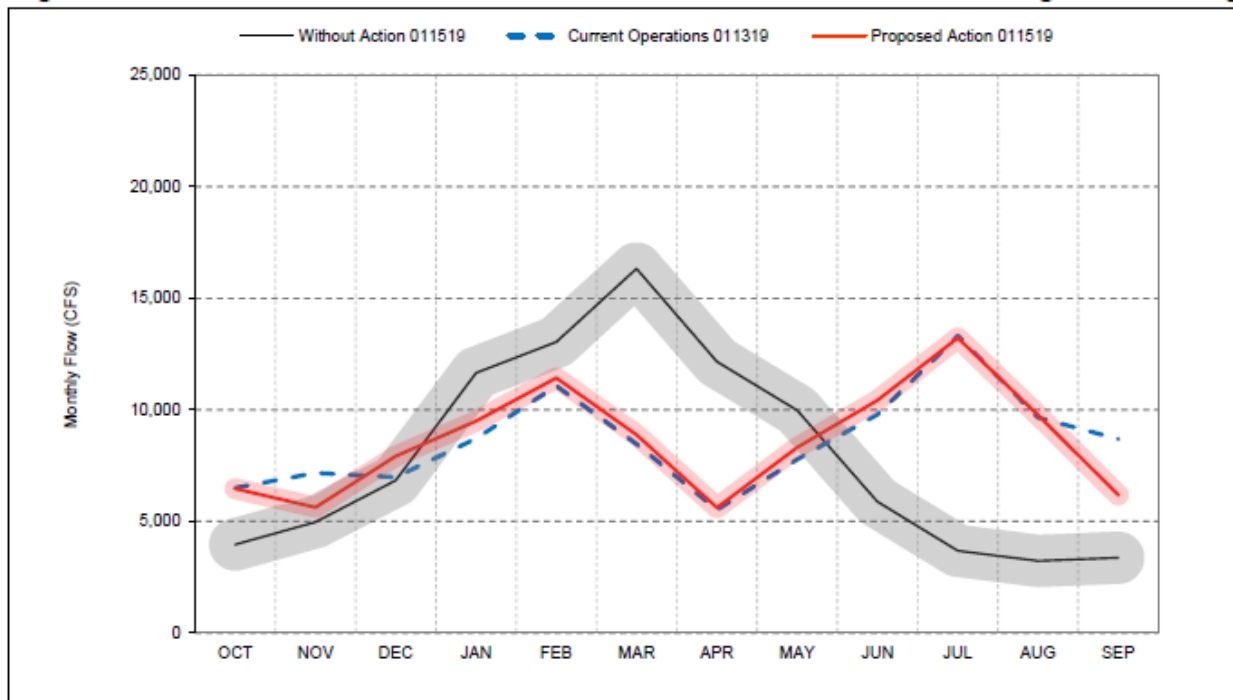


Figure 5.14-1. Mean Modeled Flows in the Sacramento River Below Keswick Dam

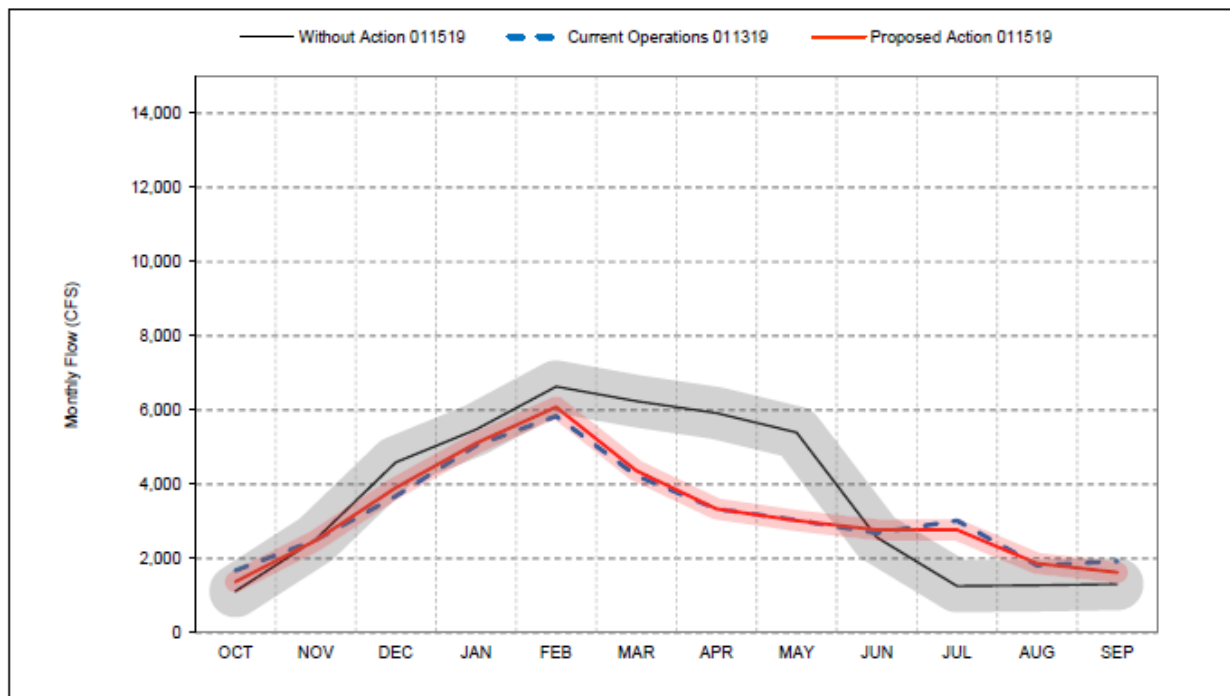


Figure 5.14-2. Mean Modeled Flows in the American River Below Nimbus Dam

Higher flows may negatively impact spawning and egg/alevin incubation. If flows are sufficiently high, they result in excessive depths and flow velocities for constructing redds, and redds that were previously built are at risk of being scoured from the bed (NMFS 2017 – CWF BO). In addition, under high flows, adults may build redds in areas that are later dewatered or isolated from the main river channel when the flows decline. High flow events with rapid flow fluctuations are likely to occur more frequently in rivers with uncontrolled flows, like the Sacramento River under the WOA conditions.

In the spawning reaches of Fall-run/Late Fall-run Chinook Salmon in the upper Sacramento River, flows under WOA during the October through April (Fall-run) and December through July (Late Fall-run) spawning, egg incubation, and alevin periods are highly variable. Flows under WOA are modeled as approximately 4,000 cfs from July through October in most water year types. The low flows would have a number of negative effects on spawning, egg incubation, and alevins of both Fall-run and Late Fall-run Chinook Salmon. As described by Windell et al. 2017, potential adverse effects of the low flows on eggs and alevins include:

- An insufficient area of river bed with suitable attributes to accommodate redds for all spawning-ready Fall-run/Late Fall-run adults.
- Inadequate flow velocities to flush sediments from the redds.
- Insufficient flow to maintain adequate levels of DO in contact with eggs and alevins in the redds and to flush metabolic wastes from the redd.
- Insufficient water depths for redds, such that minor reductions in flow result in redd stranding and dewatering.

5.14.5.3.2 Sacramento River Cold Water Pool Management

5.14.5.3.2.1 Eggs to Fry Emergence

5.14.5.3.2.1.1 Flow

Under the WOA, flows are approximately 4,000 cfs from July through October in the Sacramento River in most water year types, as inflow to Shasta Reservoir is minimal after snowmelt runoff in the late spring and summer and flows are maintained by constant spring fed sources of around 3,000 cfs upstream of Shasta in the Pit and McCloud rivers. Lower flows could limit spawning habitat, result in higher water temperatures, and dissolved oxygen for Fall-run Chinook Salmon eggs and alevin. Under COS flows during the October through February egg incubation period are usually above 6,000 cfs. The proposed action flows are similar to the COS flows at the lower end of the flow range where spawning habitat generally is most plentiful.

Differences in flows between COS and the proposed action are small in most months, but flows are moderately higher for the proposed action in June and substantially higher for the COS scenario in September and November (15-14 and 15-in the CalSim II Flows section of Appendix D). In these three months, the flow differences are expected for years with relatively wet hydrologies and, therefore, are not expected to have a meaningful effect on most Fall-run/Late Fall-run growth and survival factors. However, the Weighted Usable Area (WUA) of fall-run spawning habitat declines substantially over this range of flows (~6,000 cfs to 12,000 cfs [proposed action] or 17,000 [COS]) (Figure 15.4-3; USFWS 2003).

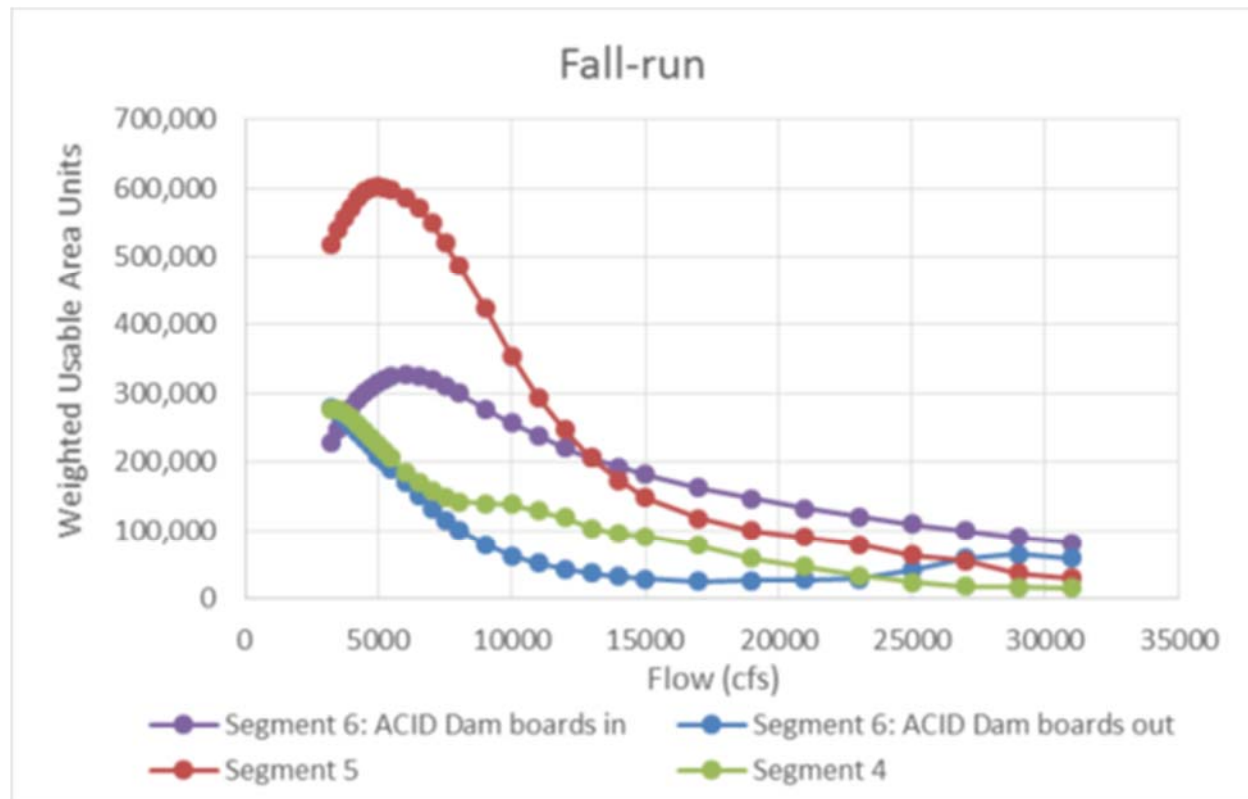


Figure 5.14-3. Spawning Habitat WUA Curves for Fall-run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

Flows under the proposed action and COS scenarios are consistently well above the WOA flows in June through October, but not during November through April (Figures 15-3 through 15-18 in the CalSim II Flows section of Appendix D). In November, there is little difference in flow between the WOA and proposed action scenarios, except in the highest flow years, when the proposed action flows tend to be higher, but the COS flows are well above the WOA flows under most of the flow range. In December and February, proposed action and COS flows are generally below WOA flows for years with dry hydrologies, and are generally higher in wet years, except for the wettest Decembers. In January, proposed action and COS flows are moderately lower than the WOA flows in almost all years, and during March and April, they are consistently well below the WOA flows. In May, proposed action and COS flows are below WOA flows during the wettest 50 percent of years, and similar to or slightly higher than the WOA flows in the driest 50 percent of years (Figure 15-14 in the CalSim II Flows section of Appendix D). Therefore, during the first two months of the fall-run spawning and incubation period (September through October), all the potential negative effects of low flows on Fall-run/Late Fall-run spawning and incubation listed above are expected to be less under the proposed action scenarios than under the WOA scenario. But during January through April, the potential negative effects of low flows are expected to be greater under the proposed action.

5.14.5.3.2.1.2 Water Temperature

Critical water temperatures thresholds for Fall-run/Late Fall-run Chinook Salmon vary by life stage, with eggs and alevins the most sensitive to elevated temperatures. Under the proposed action, Reclamation

would operate to new water temperature management measures that include a water temperature maximum of 53.5 degrees Fahrenheit in the Sacramento River above the Clear Creek confluence.

In the upper Sacramento River, where most Fall-run/Late Fall-run spawning occurs, the WOA monthly mean water temperatures (HEC-5Q WOA scenario) during the September through April (Fall-run) and December through July (Late Fall-run) spawning and egg/alevin incubation periods would be variable. Between November and March, water temperatures would be consistently under the 53.5 and 56 degree Fahrenheit thresholds (see Appendix D, *Modeling*). Approximately 20 percent of Aprils would be above 53.5 degrees Fahrenheit but all would be below 56 degrees Fahrenheit (Figure 5.6-30). Between May and October, aside from the coldest ~5 percent of Mays and ~35 percent of Octobers, water temperatures under the WOA scenario would always be higher than 53.5 degrees Fahrenheit and 56 degrees Fahrenheit, reaching as high as 73 degrees Fahrenheit in the warmest years (Figures 5-14 through 5-18 in the HEC-5Q Temperatures section of Appendix D). Such warm summer conditions would adversely affect survival of early incubating Fall-run and later incubating Late Fall-run eggs and alevins under the WOA scenario in the upper Sacramento River during those months.

The presence of a large cold water pool and the flexibility afforded by the TCD make possible the provision of much colder water under the proposed action in the upper Sacramento River during May through October than would be possible under the WOA conditions. Under the proposed action, monthly mean water temperature outputs from HEC 5Q at Keswick range from about 46 to 66 degrees Fahrenheit during May through October (Figures 5-14 through 5-19 in the HEC-5Q Temperatures section of Appendix D). During November through April, water temperatures range from about 43 to 58 degrees Fahrenheit (Figures 5-8 through 5-13 in the HEC5Q Temperatures section of Appendix D)(). While the HEC-5Q model provides 6-hour data, the results presented here are monthly averages, which should reasonably estimate daily average water temperatures near the dam because operations at Shasta and Keswick dams create relatively stable summer flow and water temperature conditions. Variable weather conditions and travel time of water result in greater fluctuations around the mean further downstream of the dam.

There is little difference in water temperatures at Keswick Dam between the proposed action and COS scenarios during the Fall-run/Late Fall-run spawning and egg/alevin incubation period, except for in October, when the proposed action is two degrees Fahrenheit colder than the COS in the middle of the exceedance plot range (90% to 20% exceedance; Figures 5-10 through 5-12, 5-13, and 5-14 through 5-18 in the HEC-5Q Temperature section of Appendix D). It is expected that the Proposed Action would be more protective of Fall-run/Late Fall-run than Current Operations.

With the proposed improvements in water temperature management, adverse impacts on Fall-run/Late Fall-run individuals are expected to lessen under the proposed action. Therefore, benefits of the CVP include fall temperature management for Fall-run and Late Fall-run Chinook Salmon.

5.14.5.3.2.2 Rearing to Outmigrating Juveniles

5.14.5.3.2.2.1 Flows

The low fall flows under the WOA conditions would likely result in degraded conditions in juvenile rearing habitats in the upper Sacramento River for any juvenile Late Fall-run that remain in the river in the fall, as Shasta Dam is still a passage barrier under WOA. The low flows under WOA conditions during June through October would have adverse impacts on rearing habitat of Late Fall-run juveniles. These degraded habitat conditions would lead to reduced growth rate and higher mortality of the individual juveniles and a potentially reduced population abundance.

CalSim modeling indicates that upper Sacramento River flows during the year-round Fall-run/Late Fall-run juvenile rearing and emigration period in the upper Sacramento River are generally similar between the proposed action and COS (Figures 15-7 through 15-18 in the CalSim II Flows section of Appendix D) except, as described previously, for higher flows under the proposed action during December and January and higher flows during September and November under the COS scenario. These differences in flow between proposed action and COS scenarios could potentially affect juvenile habitat attributes of Fall-run and Late Fall-run juveniles both positively and negatively depending on the underlying habitat attribute (Figure 5.6-2).

From January through April, WOA flows would often be nearly twice as high as the proposed action and COS flows during years with dry hydrologies. The proposed action and COS flows in such years would generally be at the required minimum of 3,250 cfs per WRO 90-5. The WUA for rearing habitat of both Fall-run and Late Fall-run Chinook Salmon juveniles is at or near its maximum at 3,250 cfs (e.g., Figure 5.14-4) (USFWS 2005). This flow was the lowest flow included in the USFWS study. Depending on the reach sampled in the study, flow of approximately 6,000 cfs, which is the most frequent flow level for dry hydrologies under the WOA scenario, was estimated to have similar to much lower juvenile rearing habitat WUA than the 3,250 cfs flow (USFWS 2005). Although the WUA analyses indicate potentially greater juvenile rearing habitat WUA in dry years under the proposed action and COS scenarios than under the WOA scenario, the reductions in flow predicted for these scenarios would potentially affect other rearing habitat attributes of Fall-run/Late Fall-run juveniles than those measured for the WUA analyses.

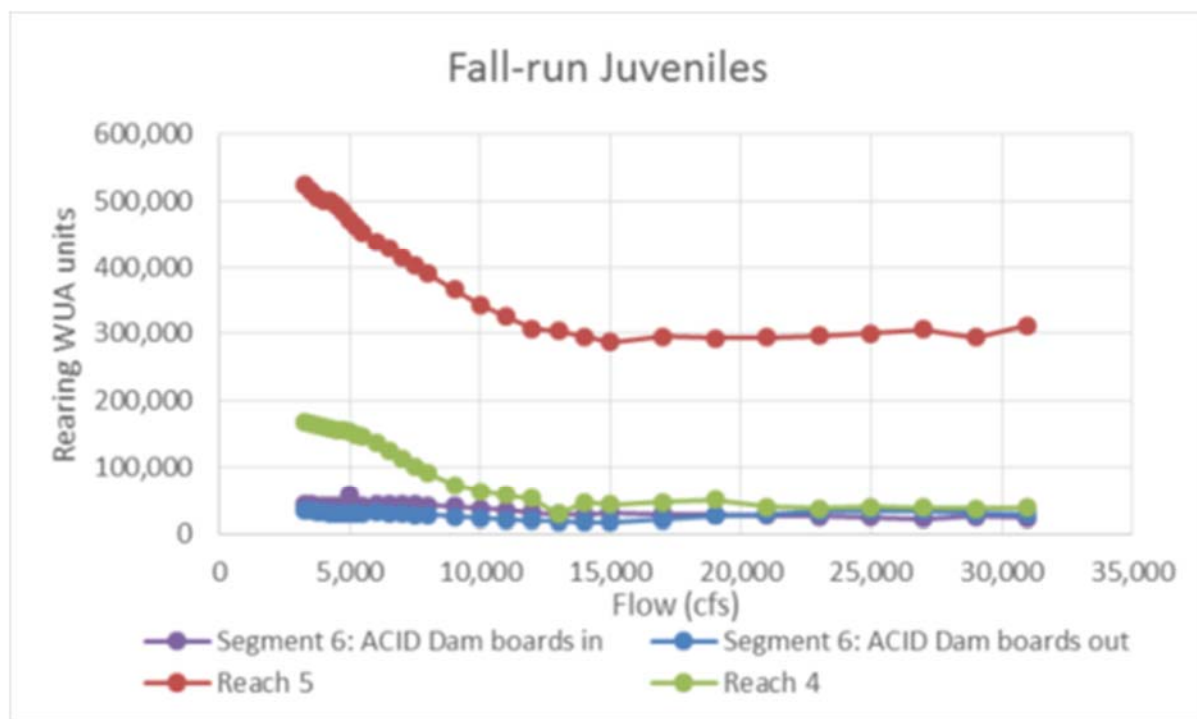


Figure 5.14-4. Rearing Habitat WUA Curves for Fall-run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

Lower winter and spring flows under the proposed action and COS relative to WOA could have both negative and positive effects on rearing juvenile Fall-run/Late-Fall run Chinook Salmon. Potential

impacts include less inundation of floodplain and side-channel habitat, degraded feeding conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows, while benefits include lower stranding risk because of decreased use of flood plains and lower flow fluctuations. On balance, given the USFWS (2005) results, the effect of lower winter and spring flows during most years under the proposed action relative to the WOA scenario on Fall-run/Late Fall-run Chinook Salmon juveniles and their rearing habitat is uncertain.

5.14.5.3.2.2.2 Water Temperature

In the upper Sacramento River, the WOA scenario monthly mean water temperatures at Keswick Dam during October through April would be below the 61 degree Fahrenheit rearing juvenile threshold (USEPA, 2003) in 99-100 percent of years (Figures 5-7 to 5-9, 5-10-5-12, and 5-13 in the HEC-5Q Temperatures section of Appendix D), but would frequently be above 61 degrees Fahrenheit from May to September. The frequent exceedances of the 61 degrees Fahrenheit threshold that would occur during May through September in the upper Sacramento River would impact rearing Fall-run/Late Fall-run Chinook Salmon juveniles with greater effect to Late Fall-run.

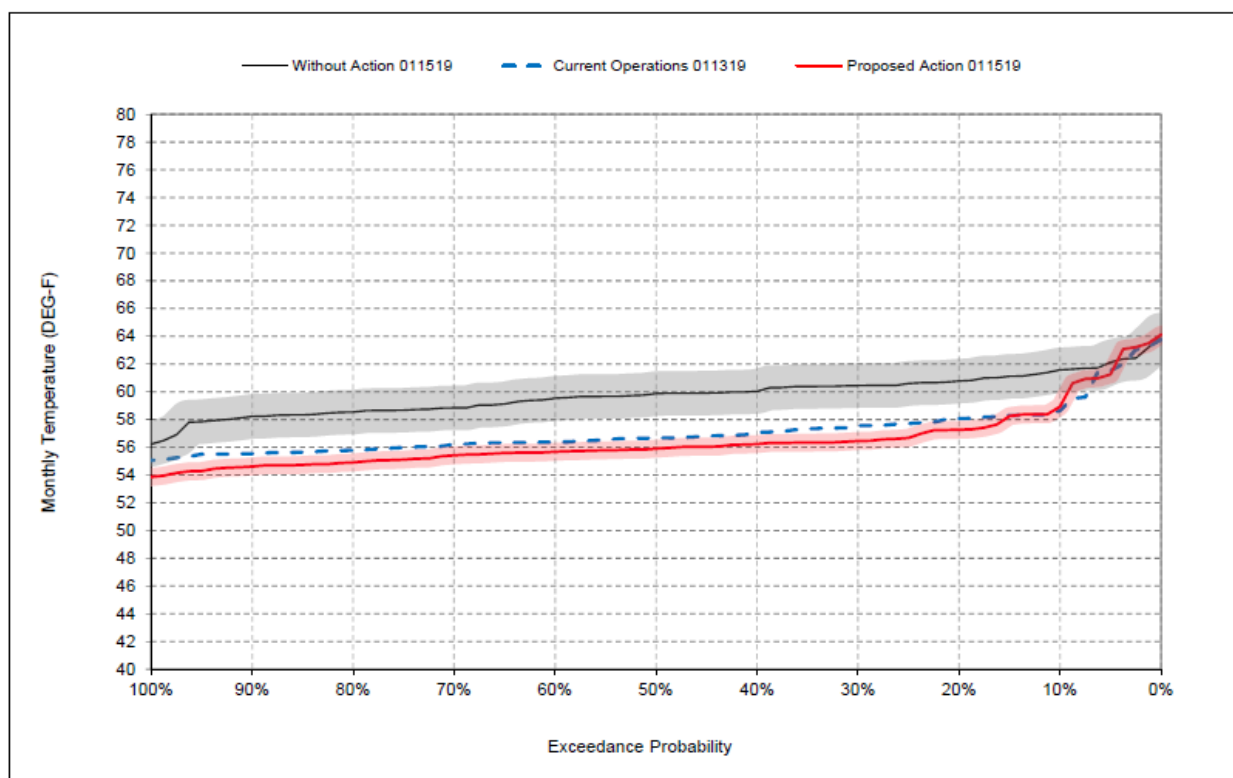


Figure 5.14-5. HEC-5Q Sacramento River Water Temperatures at Red Bluff under the WOA, proposed action and COS scenarios, October

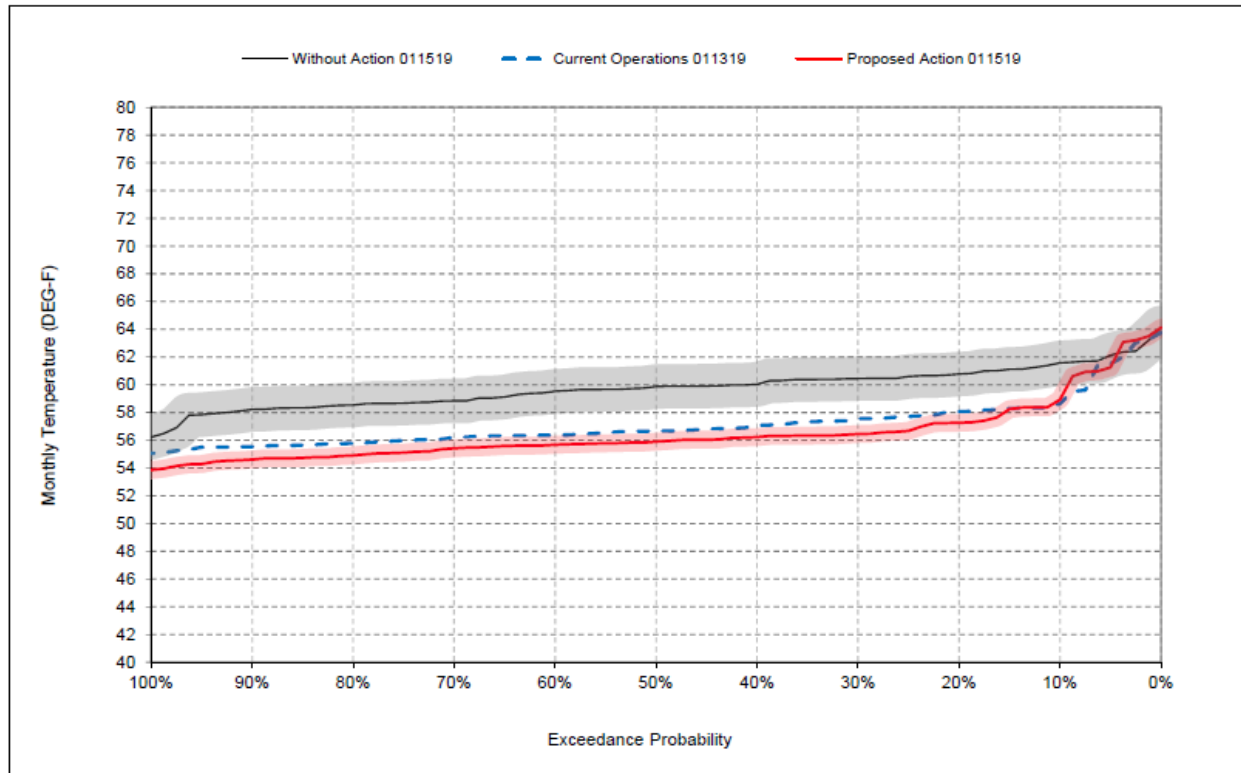


Figure 5.14-6. HEC-5Q Sacramento River Water Temperatures at Red Bluff under the WOA, proposed action and COS scenarios, May

Water temperatures at Keswick under the proposed action and COS scenarios are higher than those under the WOA scenario during November through February, are similar in March, and are lower than those under the WOA scenario in April through September (Figures 5-12 to 5-12, 5-13, and 5-14 through 5-18 in the HEC-5Q Temperatures section of Appendix D). In October, temperatures under proposed action and COS are lower than those under the WOA except in the warmest 10 percent of years (see Figure 5-7 in the HEC-5Q Temperatures section of Appendix D). A similar pattern is observed for Red Bluff, although March water temperatures under proposed action and COS would be higher than those under the WOA and April water temperatures would be similar among the three scenarios (e.g., Figure 5.14-6, Figure 10-16, and Figure 10-6 in the HEC-5Q Temperatures section of Appendix D). All water temperatures under proposed action and COS scenarios during the Fall-run/Late Fall-run juvenile rearing period are consistently below the 61 degrees Fahrenheit threshold, except for June through October. However, during June through October, water temperatures under the WOA in almost every year would be substantially higher (~10 to 20 degrees Fahrenheit) than those under the proposed action and COS. Therefore, water temperature conditions under proposed action would provide benefits relative to the WOA conditions to juvenile Fall-run/Late Fall-run Chinook Salmon rearing in the upper Sacramento River.

5.14.5.3.2.3 Rearing to Outmigrating Juveniles in the Middle Sacramento River

5.14.5.3.2.3.1 Flow

CalSim modeling indicates that middle Sacramento River flows during November through May are generally similar between the proposed action and COS, except during November of above normal and wet years, for which the mean flows under the COS scenario are higher (Tables 17-3 in the CalSim II Flows section of Appendix D). The November reductions in flow under the proposed action scenario are predicted for the middle ranges of the exceedance curves (roughly 6,000 cfs to 13,000 cfs) (Figure WRF_LS3_Wsnov): flows in this range would provide generally comparable rearing habitat Weighted Usable Area (WUA) for Fall-run and Late Fall-run Chinook Salmon juveniles (USFWS 2005), although this study is not applicable to the middle and lower river.

As was true for the upper Sacramento River, the CalSim modeling shows large seasonal changes in the differences in middle Sacramento River flow between the WOA scenario and the proposed action and COS scenarios. In November, there are small to moderate differences in flow between the WOA and proposed action scenarios, with higher flows under the WOA scenario in the middle-high range of flow years, and lower flows under the WOA scenario in the lower flow years, but the COS flows are consistently above the WOA flows in all but the highest flow years (Figure 19-8; Tables 17-1, 18-1, and 19-1 in the Flows section of Appendix D). In December through February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years (Figures 19-9 through 19-11; Tables 17-1, 18-1, and 19-1 in the Flows section of Appendix D), and in March and April, the WOA flows are consistently higher than the proposed action and COS flows (Figures 19-12 and 19-13 in the Flows section of Appendix D). In May, the WOA flows are substantially higher than the proposed action and COS flows for the 60 percent of highest flow years and are substantially lower for the 25 percent of lowest flow years (Figure 19-14 in the Flows section of Appendix D).

The higher November and May flows under the COS relative to WOA during years with drier hydrologies would likely result in enhanced conditions in juvenile rearing habitats, including more habitat complexity, side channel habitat structure and refuge habitat, and reduced disease potential. The lower proposed action flows in December through April could have both negative and positive effects on rearing juvenile Fall-run/Late Fall-run Chinook Salmon. Potential impacts include less floodplain and side-channel habitat, worse feeding conditions, increased competition and predation, higher water temperatures and lower DO, and degraded emigration flows, while potential benefits include lower stranding risk because of decreased use of flood plains and lower flow fluctuations, and lower contaminants loading from stormwater runoff. The potential impacts of lower winter and early spring flows under the proposed action are presumed provide an overall impact to the population through lesser juvenile productivity. The proposed action addresses the impact to juvenile productivity of the change in flows and water temperatures through conservation measures.

5.14.5.3.2.3.2 Water Temperature

The USEPA (2003) gives 64 degrees Fahrenheit as the critical 7 day average daily maximum (7DADM) water temperature for Chinook Salmon juveniles rearing, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, which is close to Knights Landing. The WOA scenario monthly mean water temperatures remain below the 64 degrees Fahrenheit threshold from November through March (14-8, 14-9, 14-10 through 14-13 in the HEC 5Q Temperatures section of Appendix D), but exceed the threshold during the warmest 5 percent of years in April and the warmest 85 percent of years in May,

with a maximum water temperature of 75 degrees Fahrenheit (Figures 14-13 and 14-14 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures under the proposed action and COS scenarios are substantially or moderately above the WOA scenario water temperatures during most years in November through April (Figures 14-8, 14-9, 14-12, 14-13 in the HEC 5Q Temperatures section of Appendix D), and are moderately below the WOA scenario water temperatures during most years in May (Figure 14-14 in the HEC 5Q Temperatures section of Appendix D). Water temperatures during most years in the November through April period are suitable for juvenile Fall-run/Late Fall-run Chinook Salmon that rear in and emigrate from the middle Sacramento River under the WOA and the proposed action and COS scenarios, therefore, adverse impacts on the Fall-run/Late Fall-run Chinook Salmon juveniles are not expected for these months. Under all three scenarios during May, however, the 64 degrees Fahrenheit threshold would be exceeded in most years, with the WOA scenario having greater exceedances than the proposed action and COS scenarios, especially in warmer years (Figure 14-14 in the HEC 5Q Temperatures section of Appendix D). These results indicate that water temperature conditions would be too warm for juvenile Fall-run/Late Fall-run rearing and emigrating in the middle Sacramento River during May under WOA conditions, the proposed action and COS and that conditions would be worse under the WOA conditions. It should be noted that May is the last month during spring or summer that Fall-run/Late Fall-run juveniles are abundant in the middle river (Table 5.14-1), and it is likely that when water temperatures are too high they emigrate to the ocean before May. Water temperatures in the middle and lower river cannot be efficiently managed with Shasta Reservoir releases so are predominantly dependent on ambient conditions.

5.14.5.3.2.4 Adult Migration from Ocean to Rivers

5.14.5.3.2.4.1 Flow

Under WOA, CalSim modeling indicates that during the July through December fall-run Chinook salmon immigration period, the lowest flows at Keswick Dam during July through October are low enough to create potential passage problems for immigrating fall-run Chinook salmon adults, and this is even more true at Wilkins Slough, where flows reach 0 cfs in some years. The low flows under WOA would have major adverse impacts on adults migrating upstream in the middle Sacramento River and for adults holding in the upper river.

During the July through December Fall-run Chinook salmon immigration period and the October through April Late Fall-run immigration period, flows are similar between the proposed action and COS scenarios at Wilkins Slough and at Keswick, except for much higher flows during September under the COS scenario (up to ~7,000 cfs higher) at Wilkins Slough and Keswick for flows in the range from about 8,000 cfs to 16,000 cfs (Figures 19-18 and 15-18 in the Flows section of Appendix D) and higher flows during November under the COS scenario (~3,500 cfs higher at Keswick and ~4,000 cfs higher at Wilkins Slough) for flows from about 6,000 cfs to 13,000 cfs (Figure 19-8 and 15-8 in the Flows section of Appendix D). These flow differences occur primarily for flows greater than 5,000 cfs, which are likely high enough to present no passage problems for upstream migrating adults.

The CalSim modeling shows large seasonal changes in the differences in middle and upper Sacramento River flow between the WOA scenario and the proposed action and COS scenarios. In November through February, the WOA flows are generally similar to or slightly higher than the proposed action and COS flows for most years at both Wilkins Slough and Keswick Dam. The main exception is November, when there is little difference in flow between the WOA and proposed action scenarios, except for higher proposed action flows in the highest flow years at Keswick, but the COS flows are well above the WOA flows under most of the flow range (Figures 19-8 and 15-8 in the Flows section of Appendix D). In

March and April, the WOA flows are generally higher than the proposed action and COS flows at both locations (Figures 19-12 and 19-13 and 15-12 and 15-13 in the Flows section of Appendix D). For the remainder of the months included in the Fall-run and Late Fall-run Chinook Salmon adult immigration periods (July through October), the proposed action and COS flows are generally higher or much higher than the WOA flows at both locations (Figures 19-16 through 19-18 and 19-7; 15-16 through 15-18 and 15-7 in the Flows section of Appendix D). The higher flows during July through October in years with dry hydrologies at Wilkins Slough and Keswick under the proposed action relative to the WOA scenario would likely benefit Fall-run/Late Fall-run adults migrating in the middle and upper Sacramento River by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks (Windell et al. 2017).

5.14.5.3.2.4.2 Water Temperature

Under WOA conditions there would be no control of flow or water temperature in the Sacramento River, Shasta storage levels would be very low (see Shasta Lake Storage figures in the CalSim Storage section of Appendix D) and, assuming stratification developed, the cold water pool would be small and would not be managed.

The USEPA (2003) gives 68 degrees Fahrenheit as the critical 7DADM water temperature for Chinook Salmon adults migrating and 61 degrees Fahrenheit as the critical 7DADM for holding adults, although this is based on Pacific Northwest fish and hydrology and does not consider the operational feasibility of 7DADM. In the middle Sacramento River below the Colusa Basin Drain, WOA water temperatures exceed the water temperature threshold for migrating adults in summer, but not in the winter. During almost all years in July and August, the WOA water temperatures exceed the threshold by at least 10 degrees Fahrenheit. Therefore, water temperatures would be highly stressful to Fall-run Chinook Salmon adults migrating upstream during the first months of their July through December immigration period, whereas they would be moderately stressful in some years to Late Fall-run migrating upstream during October.

In the upper Sacramento River at Keswick, the WOA scenario monthly average water temperatures are consistently below the 61 degrees Fahrenheit threshold for holding Fall-run/Late Fall-run adults from October through December, when the Late Fall-run adults are expected to hold, but exceed the threshold by over 15 degrees Fahrenheit in every year during the July and August holding period of fall-run adults (Figures 5-16 and 5-17 in the HEC 5Q Temperatures section of Appendix D). Therefore, water temperatures under the WOA conditions would be suitable for holding Late Fall-run adults, but would negatively impact holding Fall-run Chinook Salmon females and their unspawned eggs.

Under the proposed action and COS scenarios, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating adults from November through April and in almost all years during October (Figures 14-7, 14-8, 14-9 through 14-14, 14-13 in the HEC 5Q Temperatures section of Appendix D), but would exceed the threshold during July and August in all or almost all years (Figures 14-16 and 14-17 in the HEC 5Q Temperatures section of Appendix D). The much higher percentage of years exceeding the threshold under the proposed action than the COS scenario, indicates that conditions in the middle Sacramento River would be more stressful for the upstream migrating fall-run Chinook salmon adults under the proposed action than under COS. The reason for this difference in water temperatures under the two scenarios is that river flow is much higher under the COS scenario (see Figure 5-18 in the HEC 5Q Temperatures section of Appendix D) because of Fall X2 releases for Delta smelt protection. Upstream migrating fall-run Chinook salmon adults would also be exposed to water temperatures exceeding the 68 degrees Fahrenheit threshold during July and August, but Late Fall-run Chinook salmon would not be

exposed to water temperatures exceeding the threshold in any month during their October through April migration period, except for a few years (less than 5 percent) in October.

In the upper Sacramento River at Keswick, under the proposed action and COS scenarios, the average water temperatures would stay below the 61 degrees Fahrenheit threshold for holding adults during November through July of all years (Figures 5-8, 5-9, 5-19 through 5-12, 5-13, 5-14 through 5-16 in the HEC 5Q Temperatures section of Appendix D) and from August through October in, at most, 4 percent of years (Figures 5-17 and 5-7 in the HEC 5Q Temperatures section of Appendix D).

In the middle Sacramento River downstream of the Colusa Basin Drain, water temperatures under the proposed action and COS scenarios are generally similar to the WOA scenario water temperatures during November and December (Figures 14-8 and 14-9 in the HEC 5Q Temperatures section of Appendix D), above the WOA scenario water temperatures from January through April (Figure 14-10 through 14-12, 14-13 in the HEC 5Q Temperatures section of Appendix D), below the WOA scenario water temperatures during July through October (Figures 14-16 through 14-18, and Figure 14-7 in the HEC 5Q Temperatures section of Appendix D). In the upper Sacramento River at Keswick, water temperatures under the proposed action and COS scenarios are similar to WOA water temperatures during March (Figure 5-12 in the HEC 5Q Temperatures section of Appendix D), well above the WOA scenario water temperatures during November through February (Figures 5-8 through 5-11 in the HEC 5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in all years during April through September, and all but 7 percent of years in October (Figures 5-13, 5-14 through 5-7 in the HEC 5Q Temperatures section of Appendix D).

Water temperatures are suitable for Late Fall-run Chinook salmon immigration during their October through April migration period under all three scenarios in the middle Sacramento River as well as for holding in the upper river. However, water temperatures during July through September, the first three months of the fall-run Chinook salmon immigration and holding period, exceed the 68 degrees Fahrenheit threshold below the Colusa Basin Drain during every year under the WOA scenario and in most years under the proposed action and COS scenarios, but the exceedances are typically much greater under the WOA scenario (Figures 14-16 through 14-18 in the HEC 5Q Temperatures section of Appendix D). In October, the threshold is exceeded in much lower percentages of years, but the water temperatures are consistently higher for the WOA scenario (Figure 14-7 in the HEC 5Q Temperatures section of Appendix D).

At Keswick, the 61 degrees Fahrenheit threshold for holding adults is not exceeded in any years during November through April under any of the scenarios (Figures 5-8, 5-9, 5-10 through 5-12, 5-13 in the HEC 5Q Temperatures section of Appendix D). In July through September, the threshold is exceeded in every year under the WOA scenario, but in only a few years under the proposed action and COS scenarios (5-16 through 5-18 in the HEC 5Q Temperatures section of Appendix D). In October, the threshold is exceeded in no years under the WOA scenario and in 4 percent of years under the proposed action and COS scenarios, although water temperatures under the proposed action and COS scenarios are lower than those under the WOA scenario, except in the warmest 7 percent of years (Figure 5-7 in the HEC 5Q Temperatures section of Appendix D). Water temperatures would be suitable for Late Fall-run Chinook salmon holding adults, except under the proposed action and COS scenarios in the warmest five percent of Octobers. During the summer months (July through September), when water temperatures are generally stressful for adult salmon in the Sacramento River, the water temperatures under the WOA conditions in both the middle and upper Sacramento River are almost always much higher than those under the proposed action or COS. It is unlikely that migrating adult fall-run Chinook salmon could survive the elevated water temperatures in the middle Sacramento River predicted for the summer months under tWOA or that eggs of the adult fall-run Chinook salmon holding in the upper Sacramento River

could survive the predicted high summer water temperatures. Water temperature conditions under the proposed action and COS are also unfavorable for fall-run adults migrating during July through September, but the temperatures are less than 5 degrees Fahrenheit above the 68 degree Fahrenheit threshold in at least 50 percent of years, while water temperatures under the WOA scenario are more than 10 degrees Fahrenheit above the threshold in almost every year during July and August, and are more than 5 degrees Fahrenheit above the threshold in most years during September. Water temperature conditions under the proposed action would be favorable for fall-run Chinook salmon adults holding in the upper Sacramento River in almost every year.

5.14.5.3.2.5 Adult Holding in Rivers

5.14.5.3.2.5.1 Flows

WOA's low flows in July and August would potentially increase exposure of holding fall-run Chinook salmon adults to poor water quality, pathogens and anglers. WOA flows are roughly similar to proposed action and COS flows during November and December, except for the higher COS flows during November noted above (Figures 15-8 and 15-9 in the Flows section of Appendix D), and are much lower than proposed action and COS flows during July, August and most years in October (Figures 15-16 and 15-17, and 15-7 in the Flows section of Appendix D 15-Kaug, and WSF_LS1_KWKoct). In general, higher flows are likely to benefit holding Fall-run/Late Fall-run adults by affording better water quality (including cooler water temperatures and higher DO), reduced exposure to pathogens, and lower risk from anglers (Windell et al. 2017). The proposed action and COS scenarios would have much higher flows than the WOA scenario during summer, when flow is often low. Therefore, the proposed action is expected to be more protective of Fall-run/Late Fall-run Chinook Salmon than the Without Action conditions.

5.14.5.3.2.5.2 Water Temperatures

In the upper Sacramento River at Keswick, water temperatures under the proposed action and COS scenarios are higher than WOA water temperatures during November and December (Figures 5-8 and 5-9 in the HEC 5Q Temperatures section of Appendix D), and well below the WOA scenario water temperatures in July, August and October, except for the warmest Octobers (Figures 5-16, 5-17 and 5-7 in the HEC 5Q Temperatures section of Appendix D). Water temperatures under the WOA scenario are predicted to exceed the 61 degrees Fahrenheit holding threshold in all years during July and August, and are predicted to exceed the 61 degrees Fahrenheit holding threshold under the proposed action and COS scenarios less than 5% percent of years in August and October. These results indicate that proposed action, relative to WOA, provide a clear benefit to adult Fall-run/Late Fall-run Chinook Salmon holding in the upper Sacramento River.

5.14.5.3.3 Spring Pulse Flows

5.14.5.3.3.1 Eggs to Fry Emergence

As described in the proposed action, Reclamation will release pulse flows in the spring if projected storage on May 1 in Shasta Reservoir is above 4 MAF. If Shasta Reservoir total storage on May 1 is projected to be greater than 4 MAF, Reclamation would make a Spring pulse release as long as the release would not cause Reclamation to drop into a lower Tier of the Shasta summer temperature management or interfere with the ability to meet other anticipated demands on the reservoir.

Spring pulse releases are not at the time of year of egg incubation, and rather would be timed to attract juvenile Fall-run Chinook salmon to move downstream. Spring pulses could benefit late redds by increasing dissolved oxygen in the water for eggs. Late eggs emerging from the gravel could be exposed to redd dewatering on the ramp-down side of a spring pulse.

5.14.5.3.3.2 Rearing to Outmigrating Juveniles

Spring pulse flows would benefit juvenile salmonids by triggering their outmigration (Kjelson et al., 1981), and possibly by increasing survival and reducing predation. Please see the Spring-run Chinook salmon effects analysis for more detail on mechanisms and benefits.

5.14.5.3.4 Fall / Winter Refill and Redd Maintenance

Under WOA, fall flows are low. Under the proposed action, Reclamation proposes to increase fall flows based on Shasta Reservoir storage to avoid dewatering Winter-run and Fall-run Chinook salmon redds. Higher flows than the WOA during this September – November period could benefit fall-run Chinook salmon redds. Currently, Reclamation lowers flows in the early fall period in order to conserve water for spring cold water pool. This can result in dewatering Fall-run Chinook salmon redds that were laid at higher flows when Reclamation was keeping flows high to avoid dewatering Winter-run Chinook salmon redds. Therefore, this action could potentially benefit Fall-run Chinook salmon in years where Reclamation ends the year with high storage in the reservoir.

5.14.5.3.5 Clear Creek Flows

5.14.5.3.5.1 Eggs to Fry Emergence

Fall-run/Late Fall-run Chinook salmon eggs and emerging fry would be exposed to the effects of Clear Creek geomorphic flows, and potentially spring attraction flows based on the proposed timing of these releases (after January 1 for geomorphic flows; April-June for spring attraction flows [Clear Creek Technical Team 2018]), and the seasonal occurrence of this life stage in Clear Creek (October – February; Table 5.14-1). Potential effects of these flows include increased gravel scour which could displace incubating eggs from redds, resulting in exposure to increased predation, mechanical shock and abrasion, and increased water temperature if transported out of suitable incubation habitat. Geomorphic flows could also temporarily increase suspended solids and turbidity, causing sediment deposition in redds that can reduce hydraulic conductivity through the redd and result in reduced oxygen delivery to eggs, reduced flushing of metabolic waste, and entombment of alevins via a sediment “cap” that prevents or impedes emergence (Everest et al. 1987, Lisle et al. 1989).

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Proposed geomorphic and attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse impacts associated with these releases are expected to be of low magnitude, compared to conditions created by existing storm peak discharges, and occur with low frequency.. If geomorphic flows under the proposed action were to achieve their intended effect (gravel mobilization), the total area and overall quality of egg incubation habitat would be increased.

Fall-run/Late Fall-run Chinook Salmon eggs and emerging fry would not be exposed to the effects of Whiskeytown water temperature controls in Clear Creek, based on the timing of these controls (60°F at

IGO gage June 1-September 15; 56°F at IGO gage September 15-October 31), and the seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.14-1). Therefore, temperature controls are anticipated to have no effect on this life stage.

5.14.5.3.5.2 Rearing to Outmigrating Juveniles

Rearing and outmigrating juvenile Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of geomorphic and spring attraction flows under the proposed action relative to WOA given the likely timing of spring attraction flows (May-June [Clear Creek Technical Team 2018]), geomorphic flows (contemporaneous with peak storm flows after January 1), and the peak timing of this life stage in Clear Creek (year-round; Table 5.14-1).

These flow releases have the potential to degrade water quality via increased suspended solids and turbidity, leading to direct physiological impacts on rearing and outmigrating juvenile health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility. The effects of this exposure could also include displacement of rearing fish from suitable habitat, leading to increased predation and exposure to increased water temperatures.

Studies on Clear Creek have shown that the sediment transport threshold generally occurs between 3000–3500 cfs (McBain and Trush 2001, Pittman and Matthews 2004). Events of this magnitude occurred in 50% (26 of 52) of years since Whiskeytown Dam was constructed, while daily average flows > 3000 cfs occur on 0.2% of days since WY 1965 (37 days total). Proposed geomorphic and spring attraction flows up to the safe release capacity (approximately 900 cfs) under the proposed action represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, adverse effects associated with geomorphic flow releases are expected to be of low magnitude, compared to conditions created by existing storm peak discharges, and occur with low frequency. Therefore, the potential for geomorphic and spring attraction flow releases to result in negative population-level effects on rearing and outmigrating Fall-run/Late Fall-run Chinook is anticipated to be low.

Some rearing and outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to the effects of Whiskeytown water temperature controls in Clear Creek given the timing of these controls (June 1-September 15 & September 15-October 31), and the peak timing of this life stage in Clear Creek (year-round; Table 5.14-1). However, this life stage of Fall-run/Late Fall-run Chinook typically utilizes rearing habitat during cooler winter and spring months, so a low number of individuals would be affected by water temperature controls from June-October. The oversummering Fall-run/Late Fall-run juveniles would benefit from the temperature management.

5.14.5.3.5.3 Adult Migration from Ocean to Rivers

Few, if any, migrating adults would be exposed to the effects of geomorphic and spring attraction flows under the proposed action given the likely timing of these flows (geomorphic flows contemporaneous with peak storm flows after January 1; spring attraction flows May-June [Clear Creek Technical Team 2018]) and the peak timing of this life stage in Clear Creek (October-December; Table 5.14-1). Therefore, this action is anticipated to have no effect on this life stage.

Under the proposed action relative to WOA, low numbers of migrating adults could be exposed to Whiskeytown Dam water temperature controls in Clear Creek, based on the timing of these controls (June

1-September 15 & September 15-October 31) and the seasonal timing of this life stage in Clear Creek (October-December; Table 5.14-1). Water temperature objectives during this period (56°F-60°F) are well within the acceptable range (38°F -56°F; Bell 1991) for this life stage of Fall-run/Late Fall-run Chinook and well below the levels that cause acute to chronic stress ($\geq 70^\circ\text{F}$; Lindley et al. 2004). In addition, effects of exposure to Whiskeytown Dam temperature controls in Clear Creek would result in a reduction in water temperatures in Clear Creek compared to the WOA, both at IGO and the creek mouth, by 5-13°F in the months of September and October at 50% exceedance probability.

5.14.5.3.5.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed under the proposed action to the effects of geomorphic and spring attraction flows given the likely timing of these flows (geomorphic flows contemporaneous with peak storm flows after January 1; spring attraction flows May-June [Clear Creek Technical Team 2018]) and the peak timing of this life stage in Clear Creek (July-December; Table 5.14-1). Therefore, this action is anticipated to have no effect on this life stage.

Holding adults would be exposed to Whiskeytown Dam temperature controls in Clear Creek, based on the timing of these controls (June 1-September 15 & September 15-October 31) and the seasonal timing of this life stage in Clear Creek (July-December; Table 5.14-1). Water temperature objectives during this period (56°F-60°F) are well within the acceptable range (38°F -56°F; Bell 1991) for this life stage of Fall-run/Late Fall-run Chinook and well below the levels that cause acute to chronic stress ($\geq 70^\circ\text{F}$; Lindley et al. 2004). In addition, effects of exposure to Whiskeytown Dam temperature controls in Clear Creek would be a reduction in water temperatures in Clear Creek compared to the WOA, both at IGO and the creek mouth, by 5-13°F (HEC 5Q Temperature Results) in the months of September and October at 50% exceedance probability.

5.14.5.3.6 Feather River

5.14.5.3.6.1 Eggs to Fry Emergence

5.14.5.3.6.1.1 Flow Effects

Eggs and emerging fry of Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of Oroville Dam releases and resulting flows in the High Flow Channel (HFC) of the Feather River downstream of the Oroville Complex FERC Project boundary, based on the seasonal occurrence of this life stage in the Feather River (January–April; Table 5.14-1 and Table 5.14-2, NMFS 2016), minimum instream flow requirements in the HFC (Table 5.14-3), and compliance with Water Rights Decision 1641 (D-1641).

As indicated by the Salmon and Sturgeon Assessment of Indicators by Life-stage (SAIL) Upper River conceptual model (CM1), these flows, combined with other environmental drivers, affect water temperature, DO levels, sedimentation, substrate composition, and other habitat attributes that influence redd quality, which in turn determines egg-to-fry survival (Johnson et. Al., 2016, Windell et. Al., 2017). Insufficient flow during this life stage may result in higher water temperatures, lower DO in redds, and redd dewatering, each of which may lead to elevated egg mortality. Insufficient flow may also limit the habitat area available for redd construction, thereby limiting available habitat for this life stage. Excessive flow during this life stage may scour redds, and higher flows upstream of the HFC may attract spawning adults further upstream into the Low Flow Channel (LFC), where spawning habitat is less abundant, and the effects of superimposition are greater (Sommer et. Al., 2001).

Table 5.14-3. Feather River High Flow Channel minimum instream flow requirements included in the NMFS BO and USFWS BO

| Preceding April – July runoff (Percent of Normal) | High Flow Channel Minimum Instream Flow (cfs) | | |
|---------------------------------------------------|-----------------------------------------------|-------|------------|
| | Oct-Feb | March | April-Sept |
| 55% or greater | 1,700 | 1,700 | 1,000 |
| Less than 55% | 1,200 | 1,000 | 1,000 |

Under WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Reservoir gates and diversion tunnels would be kept open, resulting in annual storage volumes less than 1,000 TAF (Figure 5.14-7). As a result, there would be limited control of flow or water temperature in the Feather River HFC, which provides habitat for this life stage. Oroville Dam under the WOA releases lower summer and fall flows and higher winter and spring flows compared to the proposed action and current operations (Figures 5.14-8 and 5.14-9).

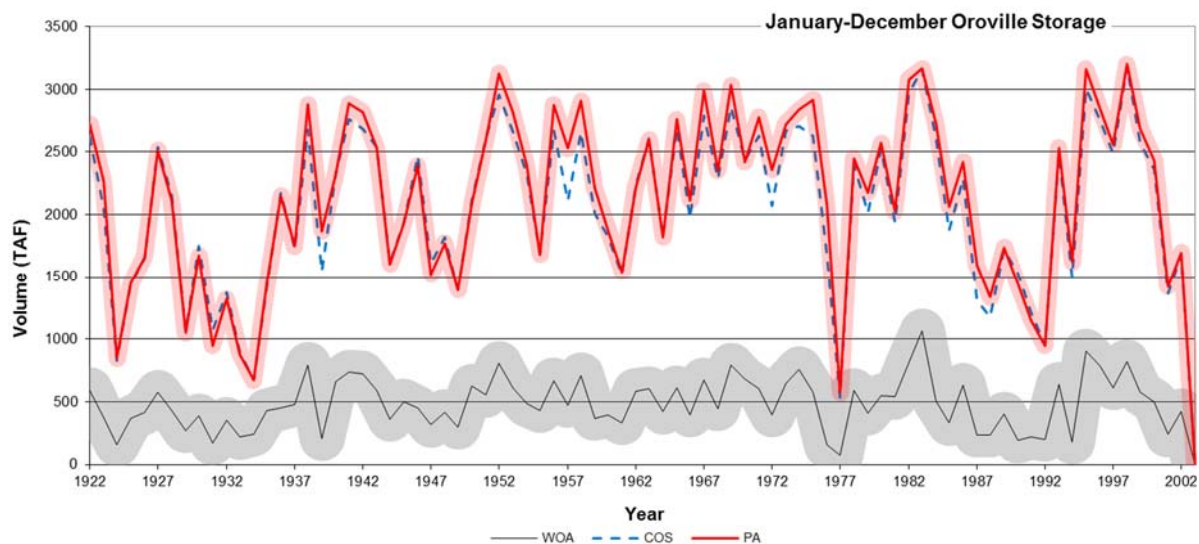


Figure 5.14-7. CalSim II estimates of mean Oroville storage (Thousand Acre-Feet [TAF]) for the period 1923–2002 under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

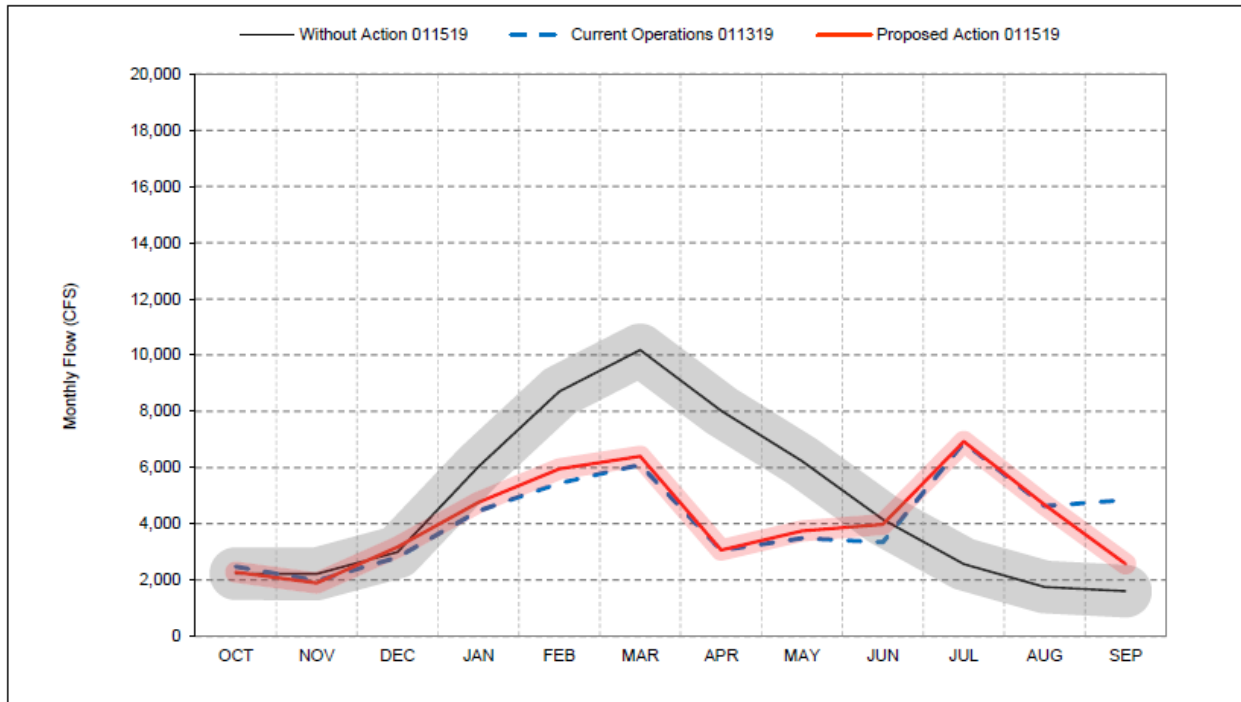


Figure 5.14-8. CalSim II estimates of Feather River long-term average streamflow below Thermalito Afterbay under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

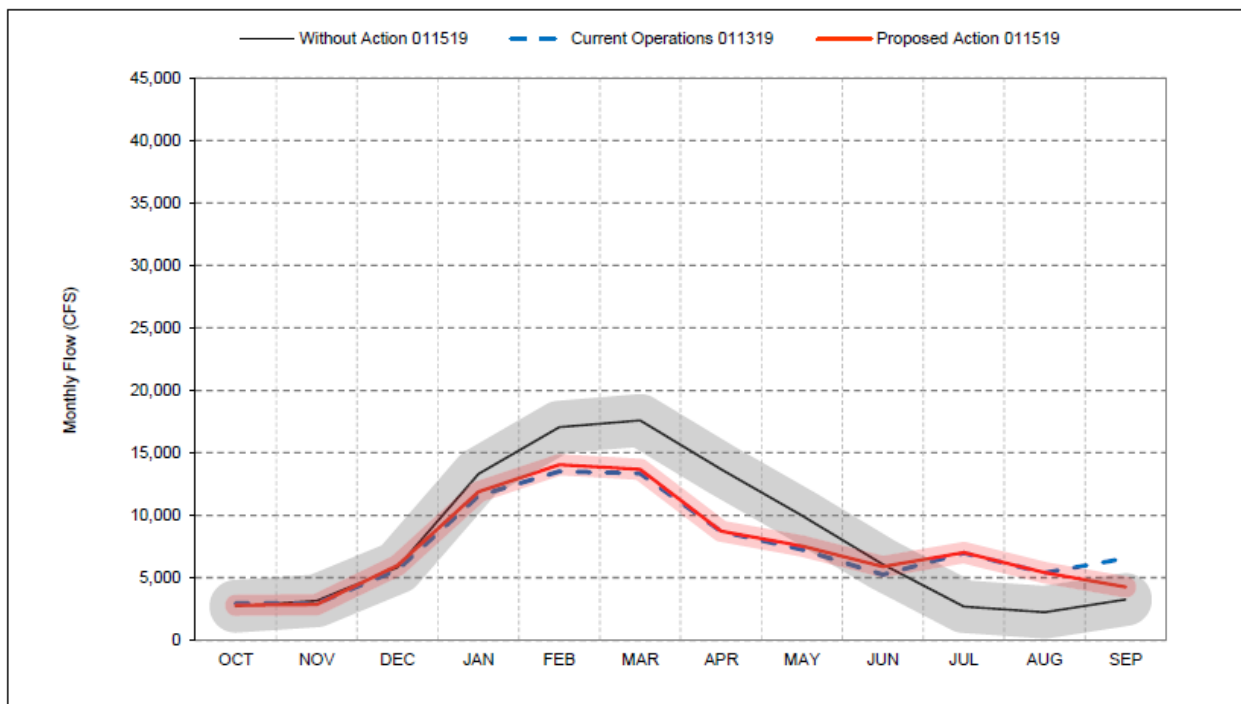
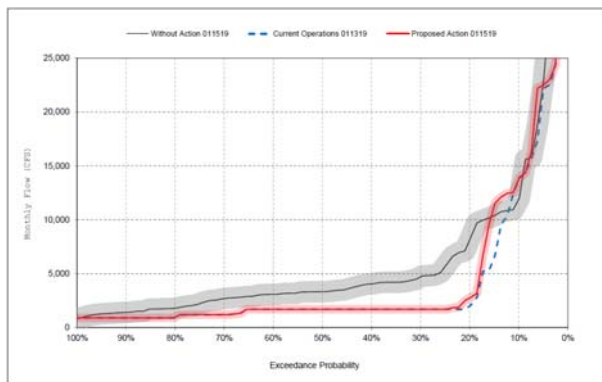


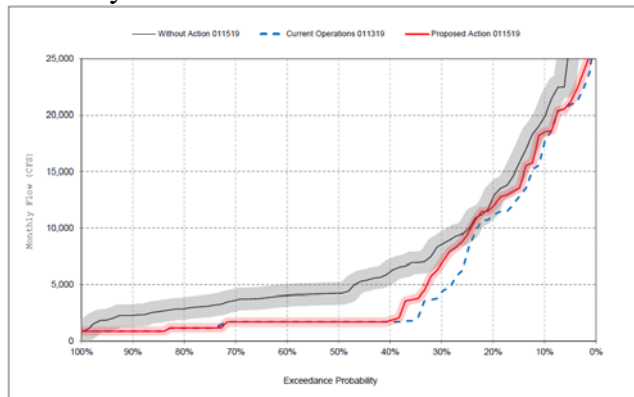
Figure 5.14-9. CalSim II estimates of Feather River mouth long-term average flow under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

Feather River flows below Thermalito Afterbay under the WOA would be similar to or higher than flows under the proposed action and COS during the peak seasonal timing of Fall-run/Late Fall-run Chinook salmon egg incubation and fry emergence (January–April) (Figure 5.14-10). Although flows under the proposed action and COS are lower, there is little to no risk falling below the required minimum flow for January and February (1,200–1,700 cfs, depending on preceding April–July runoff) and March and April (1,000–1,700 cfs, depending on preceding April–July runoff).

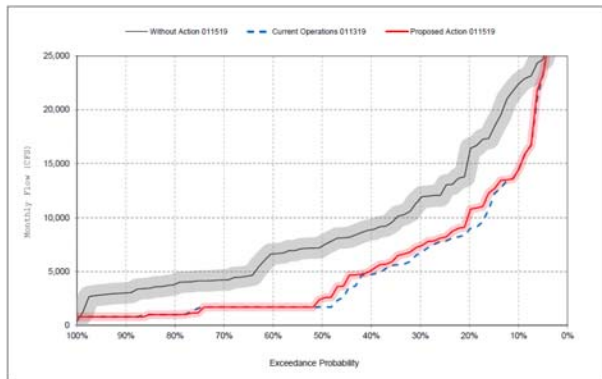
January



February



March



April

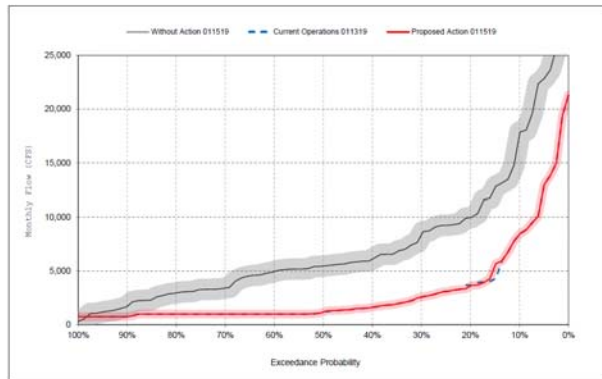


Figure 5.14-10. CalSim II estimates of Feather River flow below the Thermalito Afterbay in January–April under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action).

Flows in the Feather River HFC during the egg incubation to fry emergence period under the proposed action and COS would be lower than under WOA in below normal, dry, and critically dry year types (Figure 5.14-11). Importantly, CalSim II model output indicates projected flows under the proposed action and COS would increase the likelihood that flows in January–March would not meet the minimum instream flow criteria of 1,700 cfs for preceding April–July runoff of 55% or greater; an exception is February and March in below normal years. In years where the preceding April–July runoff is less than 55%, the minimum instream flow criteria would not be met in January of critically dry years (Figure 5.14-11).

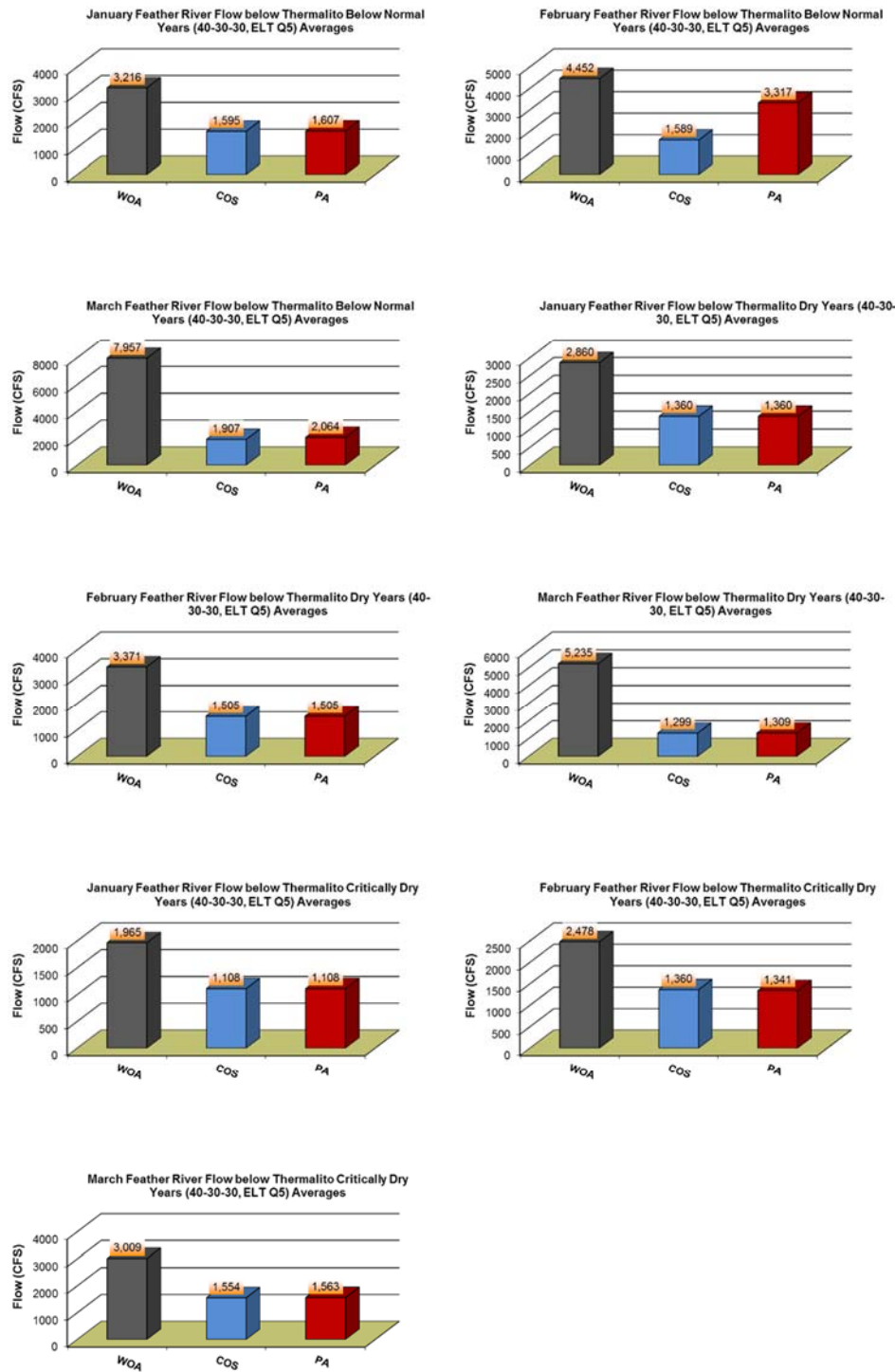


Figure 5.14-11. CalSim II estimates of Feather River flow below Thermalito Afterbay, January through February, for below normal, dry, and critically dry water years under the WOA (Without Action), COS (Current Operations), and PA (Proposed Action) scenarios.

5.14.5.3.6.1.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of Fall-run/Late Fall-run Chinook salmon eggs. Exposure to the effects of elevated water temperatures include an inability to satisfy metabolic demand, and acute to chronic physiological stress, eventually leading to egg mortality (Stillwater Sciences 2006, Anderson 2017, Martin et al. 2017). The highest survival rates for Fall-run/Late Fall-run Chinook eggs occur at < 54 °F; water temperatures are stressful to eggs above 56 °F, are lethal above 60 °F, and the upper lethal limit is 62 °F (Stillwater Sciences 2006).

Eggs and emerging fry of Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (January–April; NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-4). Under WOA, Lake Oroville would not be operated to control storage or flow releases and no conveyance of water to San Luis Reservoir via the Banks Pumping Plant would be made. Therefore, there would be no control of flow or water temperature in the Feather River HFC where Fall-run/Late Fall-run Chinook salmon egg incubation could occur. Resulting water temperatures under the WOA in the Feather River HFC at Gridley Bridge as modeled by the RecTemp temperature model are generally lower during the winter months, and higher during the summer and fall with peak annual water temperatures of approximately 78 °F occurring in July and August (Figure 5.14-12).

Table 5.14-4. Maximum Daily Mean Water Temperature for the HFC.

| Maximum Daily Mean Water Temperature Objectives for the HFC (measured at the downstream FERC project boundary) | |
|---------------------------------------------------------------------------------------------------------------------------|-------------|
| Period | Temperature |
| January 1 – March 31 | 56 |
| April 1 – 30 | 61 |
| May 1 – 15 | 64 |
| May 16 – 31 | 64 |
| June 1 – August 31 | 64 |
| September 1 – 8 | 61 |
| September 9 – 30 | 61 |
| October 1 – 31 | 60 |
| November 1 – December 31 | 56 |

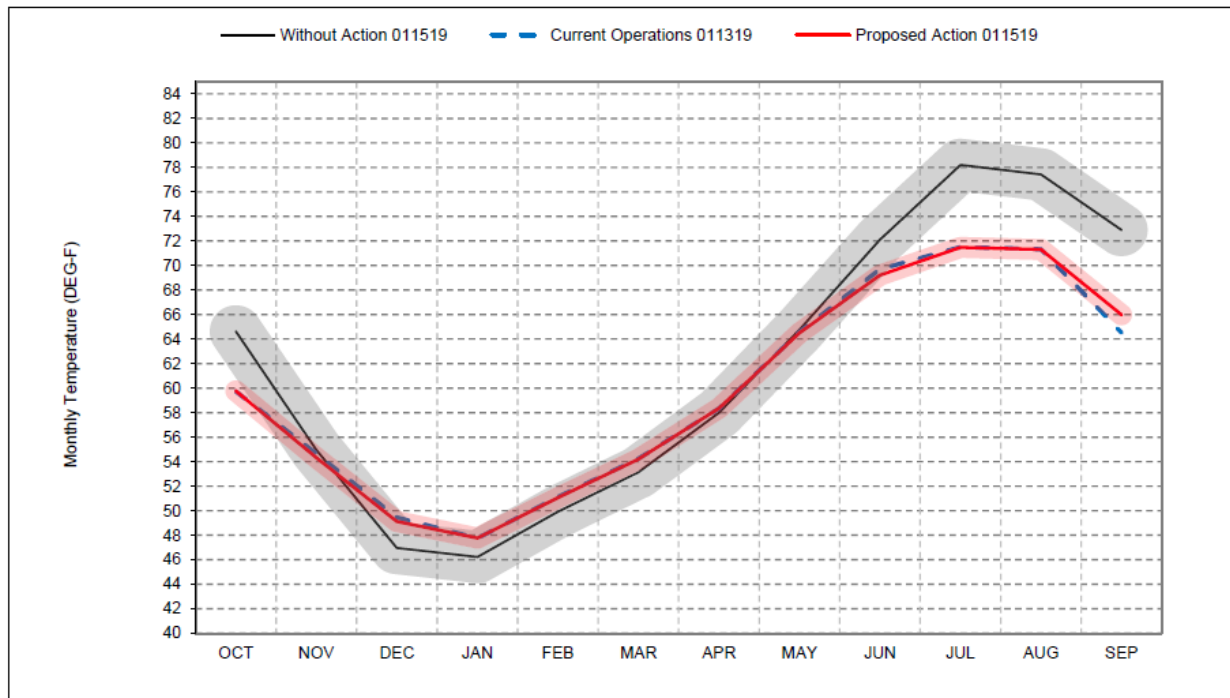
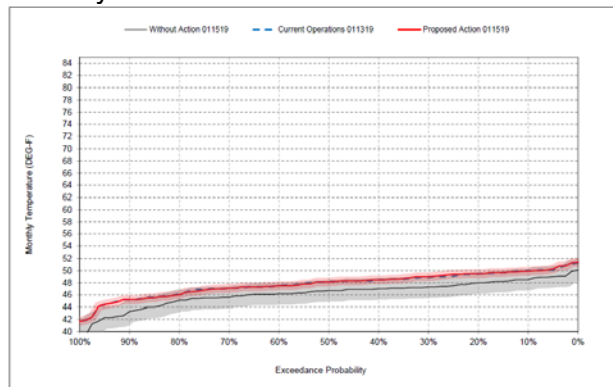


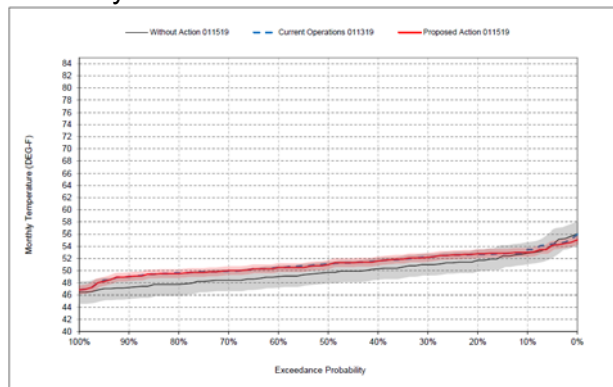
Figure 5.14-12. Long-term average RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA, COS, and proposed action.

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Temperatures at Gridley Bridge under the WOA are slightly lower than water temperatures under the proposed action and COS during January through March, and are roughly equivalent during the month of April (Figure 5.14-13).

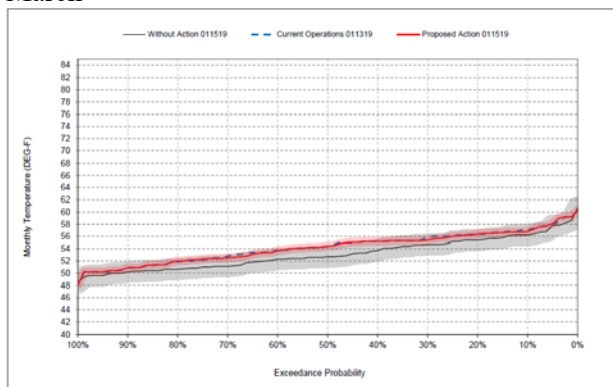
January



February



March



April

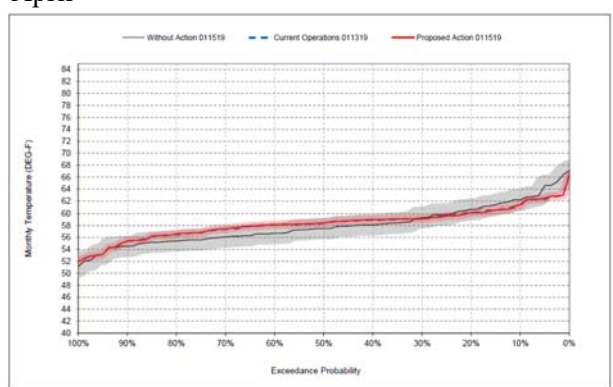


Figure 5.14-13. RecTemp estimates of Feather River water temperature at Gridley Bridge under the WOA, COS, and proposed action for January to April.

Water temperatures at Gridley Bridge under the WOA, COS, and proposed action could fall below 56 °F during the months of January–March, which is within the range of optimal egg development and survival. Water temperatures in April under all three scenarios would range from 56 °F to 60 °F, which is within the chronic to acute stress range. Water temperatures exceeding the objectives and the biological thresholds for this life stage of Fall-run/Late Fall-run Chinook would have adverse impacts on individuals, including acute to chronic physiological stress and increased likelihood of egg mortality. However, RecTemp model output indicates water temperatures projected under the proposed action and COS will increase the likelihood that the April water temperatures would remain below the lethal limit (62 °F) at low exceedance probabilities and that April water temperature objectives are met. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be minimized under the proposed action.

5.14.5.3.6.2 Rearing to Outmigrating Juveniles

5.14.5.3.6.2.1 Flow Effects

Rearing to outmigrating juvenile Fall-run/Late Fall-run Chinook salmon would be affected by Oroville Dam releases and resulting flows in the HFC of the Feather River downstream of the Oroville Complex FERC boundary, based on the seasonal occurrence of this life stage in the Feather River (year-round

possible with peak abundance January–April and August–November; Table 5.14-1 and Table 5.14-2, NMFS 2016), minimum instream flow requirements in the High Flow Channel of the Feather River (year-round requirements; Table 5.14 -1), and compliance with Water Rights Decision 1641 (D-1641).

Feather River flows below Thermalito Afterbay under – WOA generally approximate or are significantly higher than flows under the proposed action and COS during the peak seasonal timing of Fall-run/Late Fall-run Chinook juvenile rearing (January–April, Figure 5.14-10; August–November, Figure 5.14-11). In particular, flows are reliably higher under the WOA from January to May and in November (Figures 5.14-10 and 5.14-11), lower in August–October, a trend especially pronounced in wetter water year types. The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios. Differences in flows between the proposed action and COS are less pronounced than differences between the proposed action and WOA during the January to April and August to November periods.

Lower proposed action flows could have both negative and positive effects on rearing juvenile Fall-run/Late Fall-run Chinook Salmon. Flows can modulate water temperature and DO concentration leading to changes in contaminant toxicity, pathogen virulence, food availability, bioenergetics and disease susceptibility. In addition, river stage and flow velocity may affect habitat connectivity, and availability which in turn may influence food availability, predation, crowding, entrainment and stranding risk, and can potentially affect cues that stimulate outmigration (Windell et al. 2017, Moyle 2002). There can be positive effects of lower flows including lower stranding risk resulting from decreased use of floodplain habitat and lower flow fluctuations, and lower contaminant loading from stormwater runoff. The comparative magnitude of positive and negative effects of lower flows under the proposed action and COS compared to the WOA are difficult to quantify, however, potential adverse effects of the proposed action lower flows from January–April are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.14.5.3.6.2.2 Water Temperature Effects

Rearing Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (year-round possible with peak abundance January–April and August–November; Table 5.14-1 and Table 5.14-2, NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-8)..

Water temperatures under WOA in the Feather River HFC at Gridley Bridge are similar to the proposed action and COS water temperatures during the January–April period and significantly higher during the August–November period (Figure 5.14-12). Under the proposed action and COS, operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May (Figure 5.14-12). Water temperatures at Gridley Bridge under the WOA are the same or lower than water temperatures under the proposed action and COS from January to April, and higher than the proposed action and COS from August to November, which coincides with the peak seasonal timing of rearing Fall-run/Late Fall-run Chinook. The risk of water temperature-related stress and mortality are not present during the January–April period as water temperatures remain well within the optimal range (< 61°F) for this life stage and under the Feather River HFC temperature objectives for these months. The risk of water temperature-related stress under the proposed action and COS are present during the month of August, however water temperatures are significantly lower than under the WOA, which approach lethal levels in August. As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less

severe under the proposed action, especially during below normal, dry, and critically dry water year types (Figure 5.14-13).

5.14.5.3.6.3 Migrating Adults

5.14.5.3.6.3.1 Flow Effects

Feather River flows below Thermalito Afterbay under the WOA are generally somewhat lower than the proposed action and COS during October and are approximate or are significantly higher than flows under the proposed action and COS during November–March, the peak seasonal timing of Fall-run/Late Fall-run Chinook adult migration (Figure 5.14-10). The likelihood of flows occurring that are less than the minimum instream flow requirements during these months is very low under all scenarios, although some risk exists under the three scenarios in October, November, and January of critically dry years, when flows are less than or are approaching the minimum instream flow requirements (Figure 5.14-11).

Proposed action and COS flows during this period are lower than WOA flows, however, flows are not anticipated to decline below minimum instream flow standards or to a level that results in any increased passage or barrier issues in the Feather River HFC. These adverse impacts of lower flows are generally mitigated by flow increases, but there can be adverse effects of high flows including higher stranding risk resulting from increased use of flood plain habitat and greater flow fluctuations, and higher contaminant loading from stormwater runoff.

Significantly lower proposed action flows in February and March could result in both negative and positive effects on migrating adult Fall-run/Late Fall-run Chinook. Negative effects include a decrease in floodplain and side-channel habitat, degraded foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced immigration flows. Positive effects are anticipated to be a lower stranding risk resulting from decrease use of flood plain habitat and less flow fluctuations, and contaminant loading from storm water runoff. The comparative magnitude of positive and negative effects of lower flows under the proposed action and COS to the WOA are difficult to quantify, however, potential adverse effects of lower flows are anticipated to be minimal since projected flows during this period remain well in excess of all applicable minimum instream flows for the Feather River HFC.

5.14.5.3.6.3.2 Water Temperature Effects

Water temperatures, combined with other environmental drivers, have the potential to heavily influence condition and survival of migrating adults. Exposure to the effects of elevated water temperatures can include an increased susceptibility to disease, and physiological stress potentially leading to mortality and altered migration timing and speed. Migrating adult Fall-run/Late Fall-run Chinook require temperatures < 57°F for optimal survival (Marine 1992 as cited in Stillwater Sciences 2006).

Migrating adult Fall-run/Late Fall-run Chinook salmon would be exposed to the effects of water temperature objectives for the Feather River HFC, based on the seasonal occurrence of this life stage in the Feather River (July–April, peak abundance October–March; Table 5.14-1, Table 5.14-2, and NMFS 2016), and the timing of the water temperature objectives (year-round objectives; Table 5.14-3 -2).

Water temperatures in the Feather River from October to March are relatively less influenced by flow releases from Lake Oroville than in summer, given the larger flow volumes, and colder air temperatures during these months. Under the WOA water temperatures in the Feather River HFC at Gridley Bridge 1 are approximately similar to the proposed action and COS water temperatures from February and March,

with small differences projected in November to January and slightly larger differences projected in October (Figure 5.14-12).

Under the proposed action and COS operations and flow releases would be managed to achieve Feather River HFC water temperature objectives, resulting in water temperatures that are generally lower than those modeled under the WOA from June to October, and water temperatures that are roughly equivalent from November to May. Water Temperatures at Gridley Bridge under the proposed action and COS are the same or slightly higher than water temperatures under the WOA from November to March and lower than the WOA in October, which coincides with the peak seasonal timing of migrating adult Fall-run/Late Fall-run Chinook salmon. The risk of water temperature-related stress and mortality are low during this period as water temperatures are projected to be within the optimal range (<57 °F) for this life stage from November to March; water temperatures under the proposed action and COS are slightly above the optimal range in October, however, are significantly less than under the WOA (Figure 5.14-12). As a result, potential adverse effects of water temperature objectives on this life stage are anticipated to be less severe under the proposed action relative to WOA, especially during below normal, dry, and critically dry water year types (Figure 5.14-13).

5.14.5.3.7 American River Seasonal Operations (includes 2017 FMS and “planning minimum”)

5.14.5.3.7.1 Egg to Fry Emergence

For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in the 2017 Flow Management Standard (FMS) as part of the proposed action. The 2017 FMS includes a Minimum Release Requirement (MRR) with flows that range from 500 to 2000 cfs based on time of year and annual hydrology. The objective of the planned minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold water pool when possible and improve habitat conditions for steelhead and fall-run Chinook Salmon in the lower American River. In addition, redd dewatering protective adjustments were included in the 2017 FMS to limit potential redd dewatering due to reductions in the MRR during the January through May period coincident with the embryo incubation period for Fall-run/Late Fall-run Chinook Salmon.

The embryo incubation and alevin development period for Fall-run/Late Fall-run Chinook Salmon follows the October through March spawning period (peaking in Nov through September) (Table 5.14-1 and Table 5.14-2), with fry emerging from the gravel from late December to March. This period coincides with the timing of this proposed action, and would likely directly benefit this life stage. The implementation of the proposed 2017 FMS measures under the proposed action would provide suitable habitat conditions in the lower American River tailored for Chinook Salmon and Steelhead, particularly during drought conditions and improve conditions for this life stage relative to WOA.

5.14.5.3.7.2 Rearing to Outmigrating Juveniles

The 2017 FMS under the proposed action also includes the provision for spring pulse flows, with the purpose to provide a juvenile salmonid (fall-run Chinook Salmon and steelhead) emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring in the river, and downstream in the lower Sacramento River. The 2017 FMS should provide a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 time frame. Fall-run/Late Fall-run Chinook Salmon exhibit a stream-type life history where excessively high water temperatures have been identified as one of the factors

threatening Fall-run/Late Fall-run Chinook Salmon in the Central Valley and a factor for listing of the species (NMFS 2014). The 2017 FMS under the proposed action also includes water temperature objectives that would provide suitable temperatures for juveniles by maintaining water temperatures below 65°F from mid-May to mid-October. The implementation of the proposed 2017 FMS measures would provide suitable habitat conditions in the lower American River and for Fall-run/Late Fall-run Chinook Salmon, particularly during drought conditions and improve conditions for this life stage.

5.14.5.3.7.3 Adult Migration from Ocean to Rivers

Adult Fall-run/Late Fall-run Chinook Salmon enter freshwater beginning in July, peak in October through December, and are present until about February 1 (Table 5.14-1 and 5.14-2). Adults hold primarily in deep cold pools in proximity to spawning areas or below the dam or weir until they are sexually mature and ready to spawn (CDFG 1998; NMFS 2009). Excessively high water temperatures has been identified as one the factors threatening Fall-run/Late Fall-run Chinook Salmon and a factor for considering listing of the species, particularly in the adult immigration and holding life stage (NMFS 2014). In addition to the MRR flows, the 2017 FMS under the proposed action also includes the following water temperature objectives to provide suitable temperatures for salmonids:

- 60°F or less by October 1 to provide suitable conditions for fall-run Chinook holding and early spawning,

Although the Folsom coldwater pool is generally insufficient to meet water temperature objectives, the implementation of the 2017 FMS under the proposed action would provide more suitable habitat conditions in the lower American River for Fall-run/Late Fall-run Chinook Salmon relative to WOA, particularly during drought conditions.

5.14.5.3.7.4 Adult Holding in Rivers

Fall-run Chinook Salmon experience egg retention or pre-spawning mortality in the American River in most years when water temperatures in the fall holding period are sub-optimal. During 1993 to 2017 the proportion of unspawned adults ranged from 3% to 67% and averaged 20% and the proportion that retained some eggs (greater than 30% egg retention) ranged from 6% to 80% with an average of 33% (Figure 5.14-14). The American River has the highest level of pre-spawning mortality for Fall-run/Late Fall-run Chinook Salmon measured for any river in the Central Valley. Effects for adult holding would be the same as for migrating adults, discussed above. The proposed action strives to provide conditions more conducive to successful spawning and would benefit adults holding in the American River.

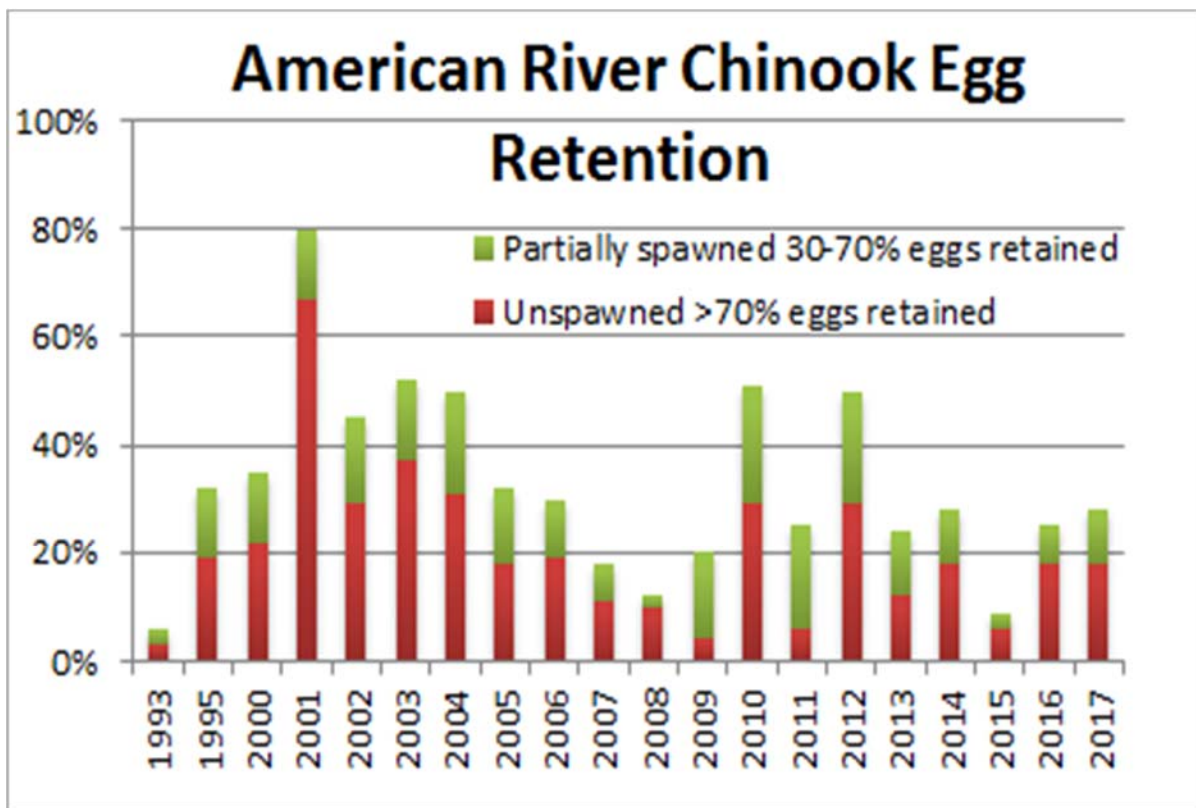


Figure 5.14-14. American River Chinook Salmon egg retention. Egg retention refers to eggs left unspawned in female carcasses.

5.14.5.3.8 Stanislaus River Stepped Release Plan

5.14.5.3.8.1 Eggs to Fry Emergence

Fall-run Chinook Salmon eggs, alevin and/or fry are found throughout most of the Stanislaus River from Goodwin Dam downstream to Oakdale. Under WOA conditions, the lower level river outlets of New Melones would be closed to preserve the integrity of the gate structure and the Flood Control and Industrial gate would be set fully open and assumed to pass a flow of approximately 8,000 cfs. Inflow exceeding this capacity would be stored in New Melones until the releases capacity could physically evacuate the water. If necessary, the spillway would be used to prevent overtopping of the New Melones Dam and protecting the structural integrity of the New Melones Dam and related facilities. This spillway is not gated and would naturally flow should the reservoir reach that height. This would result in Fall-run/Late Fall-run Chinook Salmon distribution being similar to current conditions as Goodwin Dam would still represent a total barrier to further upstream migration. Water temperatures under the WOA scenario within the Stanislaus River would represent those of uncontrolled flows coming off the western Sierra Nevada that travel through the CVP storage and conveyance facilities on the Stanislaus River that would be operated only to the extent necessary to fulfill non-discretionary duty to ensure their continued existence. Operations of non-CVP facilities would still occur as they are occurring today. Modeled flows associated with this scenario below Goodwin Dam are depicted below.

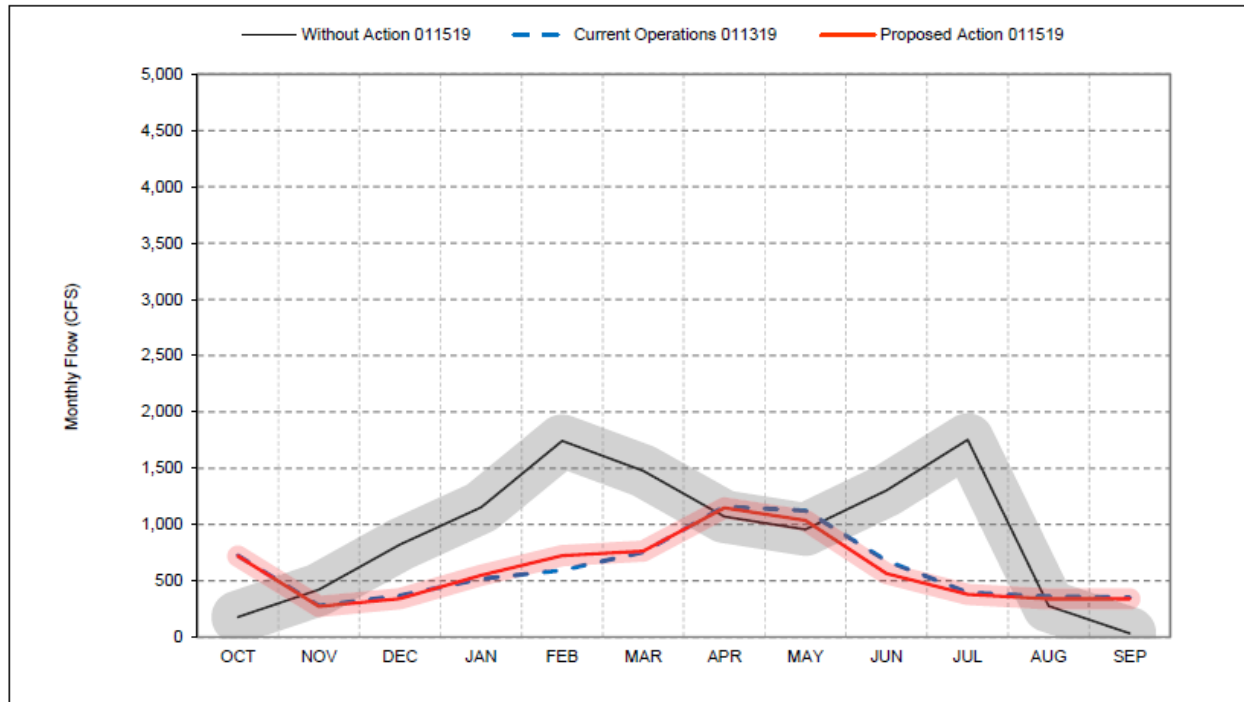


Figure 5.14-15. Stanislaus Modeled Flows. Long-Term-Average Modeled flows under WOA, COS and proposed action Scenario in the Stanislaus River Below Goodwin Dam

Current operations within the Stanislaus River are managed according to the 2008 USFWS BO, the 2009 NMFS BO, COA, and the New Melones Interim Plan of Operations (IPO).

Current operations of New Melones Dam under the IPO, which has been in effect since 1997, were developed prior to completion of current tools to understand hydrology in the Stanislaus River Basin, and the water delivered from New Melones was overallocated in many years and was not able to consistently meet requirements for fish flows, water temperature, water quality, dissolved oxygen, and water deliveries.

Under the proposed action, Reclamation proposes to implement the New Melones Stepped Release Plan to create a sustainable operation on the Stanislaus River that strives to meet requirements for fish flows, temperature, water quality, dissolved oxygen, and water deliveries. The Draft Stepped Release Plan incorporates up-to-date information about hydrology in the basin and is based on recent versions of CalSim modeling.

An attraction flow in October would be provided each year and assist in upstream migration of Fall-run Chinook Salmon. Attraction flows would be maintained at 200 cfs through the November-December spawning period. This is slightly less than the optimal 300 cfs spawning flow but would maintain Fall-run Chinook Salmon populations. Egg incubation during November to February would occur under suitable water temperature and flow conditions at most times. During dryer years water temperature in October and November would be above suitable at times but proposed action water temperatures would be cooler than WOA and COS so the proposed action would generally improve incubation success.

5.14.5.3.8.2 Rearing to Outmigrating Juveniles

The NMFS' *Recovery Plan for Central Valley Chinook Salmon and Steelhead* (NMFS 2014) identifies recovery actions on the Stanislaus River. These actions include managing flow releases to provide suitable water temperatures and flows for all steelhead life stages, and the Stepped Release Plan would improve the ability to manage water temperatures in droughts. The plan also identifies the need to evaluate whether pulse flows are beneficial to adult steelhead immigration and juvenile steelhead emigration.

The stepped operation plan under the proposed action includes spring flows during April and May intended to improve juvenile rearing and outmigration survival. These flows occur earlier than the natural flows under WOA. The earlier flows are beneficial in providing a way for juveniles to get out through the lower San Joaquin River and Delta before water temperatures become unsuitable later in the spring to summer.

5.14.5.3.8.3 Adult Migration from Ocean to Rivers

The attraction flows under the stepped release plan are timed to assist with Fall-run/Late Fall-run Chinook immigration. Flows of about 750 cfs or higher attract high numbers of Fall-run Chinook Salmon into the Stanislaus River, including many strays from other rivers. A partial barrier to Fall-run Chinook Salmon exists in Goodwin Canyon where early migrating Chinook hold over the summer. When the fall attraction flows occur Chinook are able to pass this area more quickly and reach habitats near Goodwin Dam. The area near Goodwin Dam provides cooler water earlier in the fall, conducive to successful spawning.

5.14.5.3.8.4 Adult Holding

Fall-run Chinook Salmon Adults hold in the Stanislaus River from summer for early running Chinook up until spawning in October. Generally water temperatures would be suitable most years in the upper portions of the river at Knights Ferry and above for the proposed action scenarios and the COS and unsuitable under WOA. A key holding location is in the Goodwin Canyon area for the early running Fall-run Chinook salmon and as noted above the fall pulse flow provides a cue and ability for the fish to distribute to suitable spawning areas. The proposed action is generally cooler than COS which as a benefit to adult survival during holding prior to spawning.

5.14.5.3.9 Alteration of Stanislaus River Dissolved Oxygen Requirement

5.14.5.3.9.1 Eggs to Fry Emergence

Fall-run Chinook Salmon eggs, alevin and/or fry are found throughout most of the Stanislaus River from Goodwin Dam downstream to Oakdale. Under WOA, flow would be uncontrolled through the CVP project facilities and fish distribution would be similar to current operations as Goodwin Dam would represent a significant barrier to further upstream migration but the warm fall water temperatures would not be conducive to high survival. Current operations are required to meet a year-round dissolved oxygen minimum of 7 mg/L, which was introduced in an effort to protect salmon, steelhead, and trout in the river (CDFW 2018). However, maintaining dissolved oxygen concentrations above 7 mg/L in the Stanislaus River at Ripon is challenging during drought conditions, and, based on studies of juvenile distribution and abundance, does not appear to be warranted to protect salmonids in the Stanislaus River (Kennedy and Cannon 2005, Kennedy 2008).

Reclamation currently operates to a 7.0 mg/L dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation proposes to move the compliance location to Orange Blossom Bridge, where

the species (steelhead) are primarily located at that time of year. Based on multi-year observations of salmonid abundance in the River Kennedy and Cannon (2005) and Kennedy (2008) found that over-summering juvenile salmonids are primarily found upstream of Orange Blossom Bridge, which is approximately 31 miles upstream from Ripon. Dissolved oxygen monitoring at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) indicates that dissolved oxygen concentrations can be 0.5-1 mg/L higher at this location than those measured at Ripon (Cramer Fish Sciences 2006a-d). Because the fish are located primarily at least twice this distance upstream from Ripon, the dissolved oxygen concentration is likely to be at this level or higher where the majority of these fish occur. The majority of Fall-run Chinook Salmon eggs, alevin and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L, although no eggs, alevin, or fry are present in the river in the summer.

5.14.5.3.9.2 Rearing to Outmigrating Juveniles

As discussed above, as the majority of juvenile Fall-run Chinook Salmon are found in locations where summer dissolved oxygen levels would be expected to be maintained at or above 7 mg/L.

Additionally, as juvenile fall run Chinook are outmigrating from January through the end of June (Zerg et al, 2014), there would be no individual- or population-level effects from this element on this life stage.

5.14.5.3.9.3 Adult Migration from Ocean to Rivers

Based on the typical seasonal occurrence of this life stage in the River (July to October), adult migrating Chinook Salmon would be expected to be exposed to the effects of the relaxation of dissolved oxygen requirements at Ripon. During low flow periods in the Stanislaus River there could be delay of adults migrating up the Stanislaus River if dissolved oxygen is too low.

5.14.5.3.10 Delta Seasonal Operations including OMR Management

Hydrodynamic changes associated with river inflows and South Delta exports under the proposed action have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) “near-field” mortality associated with entrainment to the export facilities, 2) “far-field” mortality resulting from altered hydrodynamics.

5.14.5.3.10.1 Entrainment

Zeug and Cavallo (2014) analyzed > 1000 release groups representing, more than 28 million coded wire tagged juvenile fish including winter, Fall-run/Late Fall-run Chinook Salmon. The average proportion Sacramento River-origin Fall-run Chinook salvaged over a 15-year period was 0.0001 and the proportion of mortality accounted for by entrainment averaged 0.0003 (Zeug and Cavallo 2014). Salvage increased with increasing exports but loss never exceeded 1% regardless of export rate. Late Fall-run Chinook Salmon juveniles were salvaged at a higher rate than any other race (0.02% of each release group) and entrainment related mortality accounted for almost 1% of total mortality on average (Zeug and Cavallo 2014). Proportional loss of Late-Fall Chinook salmon remained low until exports exceeded ~9,000 cfs when proportional loss could approach 8% (Zeug and Cavallo 2014). Average total exports for months when Fall-run/Late-Fall run Chinook Salmon juveniles are present in the Delta indicate zero entrainment risk for WOA. In the December through February period when Late-Fall run are most abundant, the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will therefore have a similar entrainment risk. Total exports proposed for the proposed action in March-June (1,699 cfs higher than COS; Figure H-2 –

Appendix H, *Bay-Delta Aquatics Effects Figures*) when juvenile Fall-run/Late Fall-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS, but entrainment losses for Fall-run/Late Fall-run Chinook Salmon will be low relative to total population. Entrainment risk will also increase for Late-Fall run and losses will likely be higher relative to Fall-run Chinook salmon.

Zeug and Cavallo (2014) analyzed salvage of 313 releases totaling more than 7,000,000 San Joaquin River-origin juvenile Fall-run juvenile Chinook Salmon. Salvage of Fall-run Chinook originating from the San Joaquin River averaged 1.4% and increased with export rate at the CVP and SWP (Zeug and Cavallo 2014). However, there were few observations at export rates greater than 3,000 cfs. Average mortality at the facilities represents < 5% total juvenile mortality for San Joaquin River-origin populations but can range as high as 17.5% (Zeug and Cavallo 2014). Average total exports for months when Fall-run Chinook Salmon juveniles are present in the Delta indicate zero entrainment risk for WOA. In the December through February period the proposed action proposes an average total export rate slightly higher than COS (366 cfs; Figure H-1 – Appendix H, *Bay-Delta Aquatics Effects Figures*) and will, therefore, have a similar to slightly higher entrainment risk. Total exports proposed for the proposed action in March-June (1,699 cfs higher than COS; Figure H-2 – Appendix H, *Bay-Delta Aquatics Effects Figures*) when juvenile Fall-run Chinook Salmon are most abundant in the Delta, will increase entrainment risk relative to COS. Recent acoustic studies of juvenile Fall-run Chinook Salmon in the San Joaquin River revealed that when the HORB is out, >60% of fish detected at Chipps Island came through CVP, indicating that salvage is a higher survival route than volitional migration.

As shown by the following figures, CVP and SWP Fish Facilities salvage between 0 and 140,000 Fall-run Chinook salmon annually, and between 0 and 450 Late Fall-run Chinook salmon annually. As indicated above, under the proposed action exports are expected to increase compared to both WOA and COS, and so salvage and entrainment would also be expected to increase. However, salvage may be a higher survival route than through the San Joaquin River.

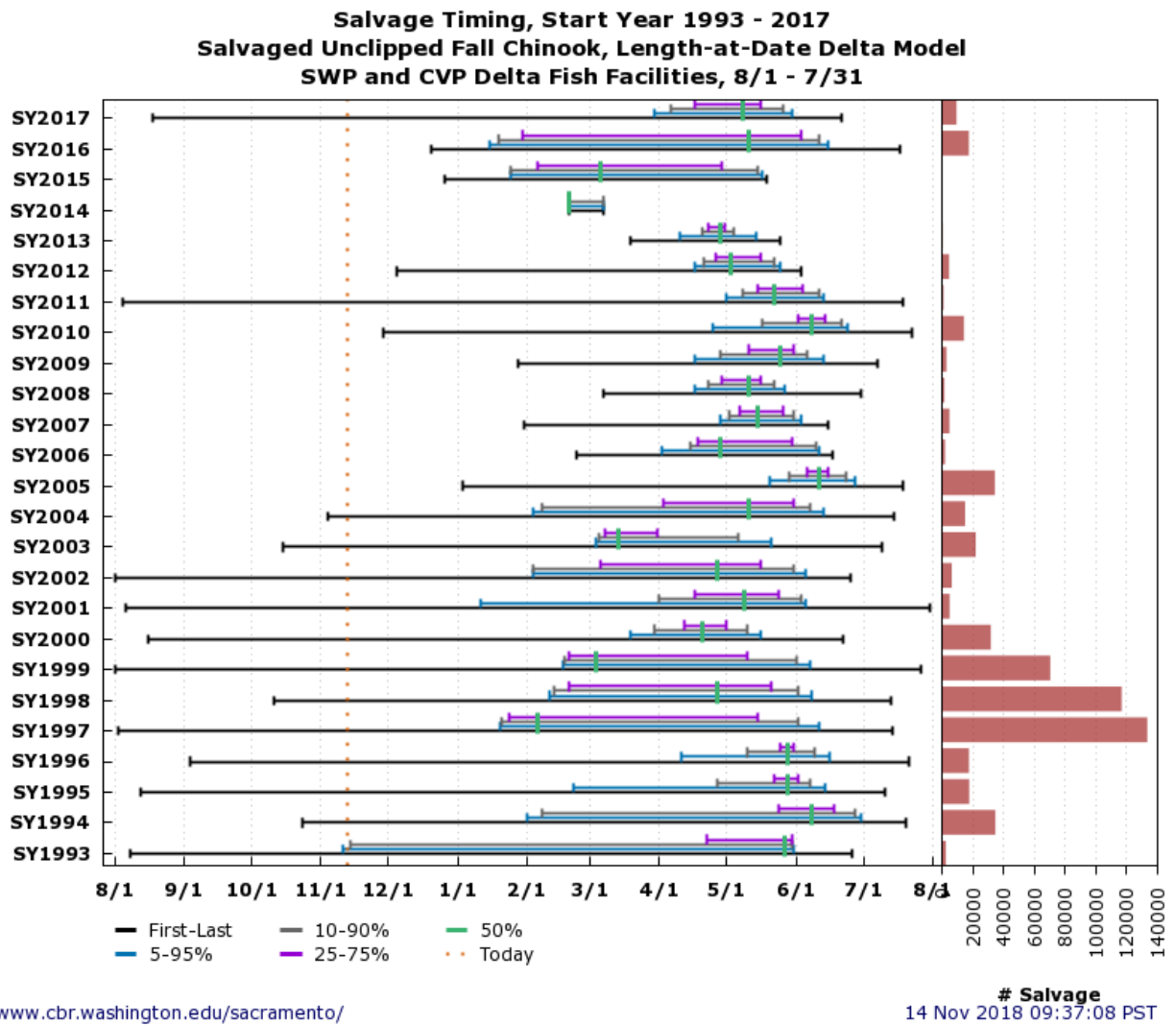
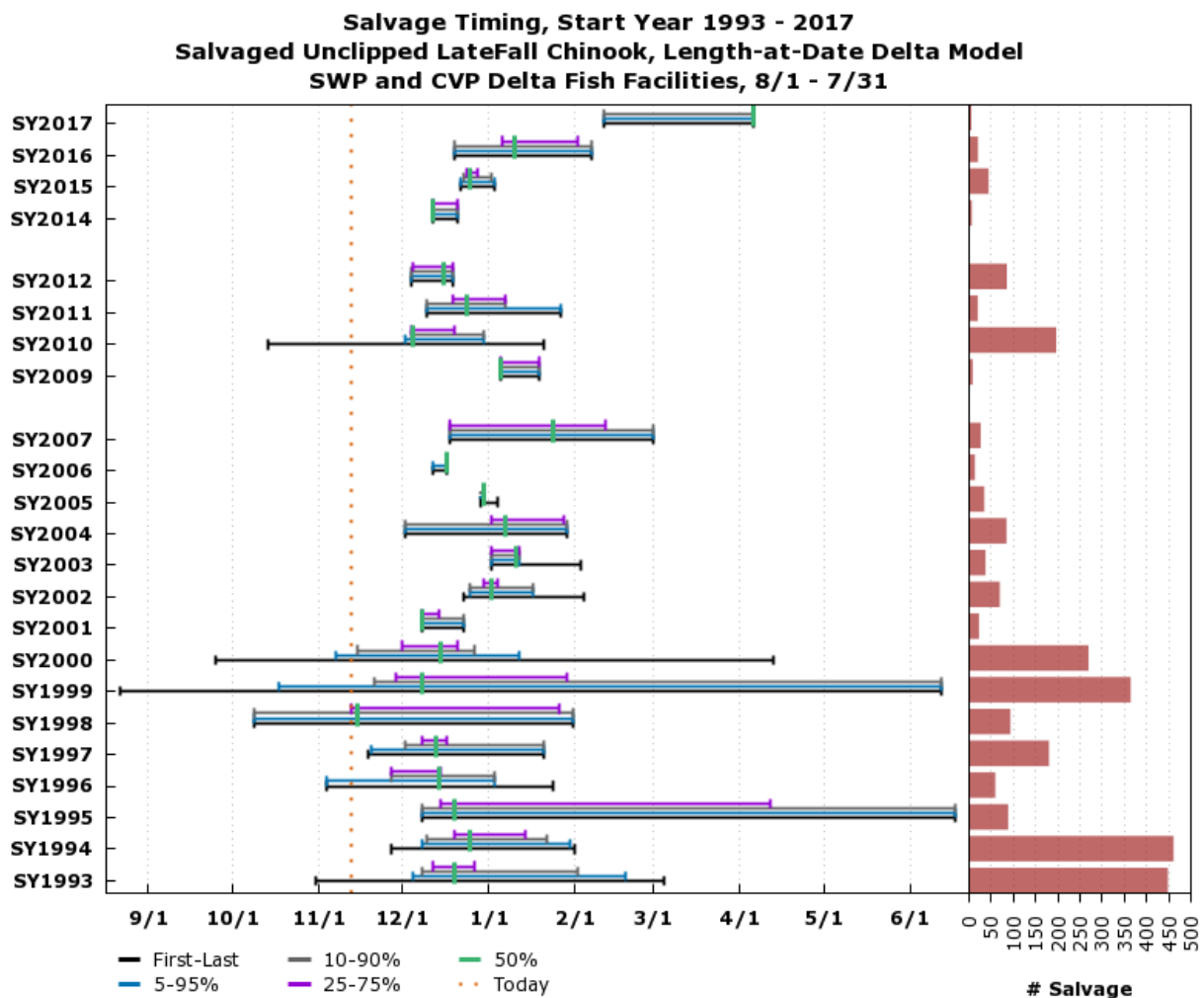


Figure 5.14-16. Fall-run Chinook Salmon Salvage, 1993-2017



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Figure 5.14-17. Late Fall-run Chinook Salmon Salvage, 1993-2017

5.14.5.3.10.2 Routing

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2 as described above. Juvenile Fall-run Chinook Salmon abundance in the Delta is greatest between February and May and Late-Fall run are present in the Delta between November and July with peaks in January-February and April-May (Tables 5.14-1 and 5.14-2). In the December through February period, velocity overlap between the proposed action and COS in the Sacramento River main stem between the Sutter-Steamboat and DCC/Georgiana Slough Junctions, was >50% in Critical, Dry, Below Normal and Above Normal Years (Figure H-3 – Appendix H, *Bay-Delta Aquatics Effects Figures*). In Wet years, velocity overlap in this reach was ≤ 50%. Velocities were higher under the proposed action in all water year types indicating routing into the interior Delta would be lower relative to COS (Perry et al. 2015). Comparing the proposed action to WOA in the Dec-Feb period revealed low velocity overlap in Dry, Above Normal and Wet years with higher velocities in the WOA (Figure H-4 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were more similar in Critical and Below Normal years; however, velocities were still higher in the WOA

scenario. This pattern indicates routing into the interior Delta would be lower under WOA relative to the proposed action or COS (Perry et al. 2015). In the March to May period comparison of the proposed action and COS revealed similar patterns of velocity overlap as described for the December-February period (Figure H-5 – Appendix H, *Bay-Delta Aquatics Effects Figures*) indicating routing into the interior Delta would be lower under the proposed action during March-May. Comparing the proposed action with the WOA in March-May revealed low overlap in Sacramento main stem velocities between the Steamboat-Sutter Junction and the DCC-Georgiana Slough junction (Figure H-6 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA indicating routing into the interior Delta under WOA would be lower than the proposed action or COS.

Fall-run and Late-Fall run juveniles originating from the Sacramento River that enter the interior Delta via Georgiana Slough and the Delta Cross Channel can be exposed to hydrodynamic project effects that could affect routing. Once these fish arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Routing of juvenile Chinook Salmon into alternative migration routes is closely related to hydrodynamics (Perry et al. 2015; Cavallo et al. 2015; Steel et al. 2012). Changes to hydrodynamics in Delta channels resulting from the proposed action were evaluated using DSM2 as described above. When Fall-run Chinook salmon juveniles originating from the Mokelumne River arrive at the junction of the Mokelumne River and the San Joaquin River, they can move south toward the export facilities or west toward the ocean. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junction of the Mokelumne and San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Juvenile Fall-run Chinook Salmon are present in the Mossdale Trawl between January and June with a peak between February and May (Table 5.14-1). Early studies using coded wire tags indicated that survival of San Joaquin River-origin juvenile Chinook Salmon was lower in the Old River Route relative to the San Joaquin main stem (Newman 2008). This finding led to strategies designed to keep larger proportions of fish in the San Joaquin River main stem including the Head of Old River rock barrier and non-physical barriers. Recent studies using acoustic technology have indicated that differences in survival among the two routes are not significant (Buchanan et al. 2013; Buchanan et al. 2018). Thus, fish that enter Head of Old River are unlikely to experience reduced survival. In the December-February period, velocity overlap between proposed action and COS at the Head of Old River was high in Critical water years and moderate in Dry, Below Normal and Wet years (Figure H-7 – Appendix H, *Bay-Delta Aquatics Effects Figures*). The lowest overlap occurred in Above Normal years (Figure H-7 – Appendix H, *Bay-Delta Aquatics Effects Figures*). When proposed action was compared to WOA in the December-February period, velocity overlap was high in critical years and moderate to low in all other water year types (Figure H-8 – Appendix H, *Bay-Delta Aquatics Effects Figures*). In the March-May period, velocity overlap patterns were similar to comparisons in the December-February period (Figures H-9 and H-10 – Appendix H, *Bay-Delta Aquatics Effects Figures*).

Fall–run Chinook Salmon originating from the San Joaquin River that remain in the San Joaquin River main stem at the Head of Old River are exposed to additional junctions that lead into the interior Delta including; Turner Cut, Columbia Cut, Middle River, Old River, Fisherman’s Cut and False River. In the December-February period analysis of DSM2 data indicates that there is little change to velocities in the region of the junctions with San Joaquin Rivers between the proposed action and both the COS and the WOA scenarios (Figures H-7 and H-8 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Similar results were obtained when comparing the proposed action to COS and WOA in the March to May period (Figures H-9 and H-10 – *Appendix H, Bay-Delta Aquatics Effects Figures*).

5.14.5.3.10.3 Through Delta Survival

Comparing between proposed action and WOA (Figure H-12 – *Appendix H, Bay-Delta Aquatics Effects Figures*), overlap in changes in velocity distributions were lower for each water year type (43.9 – 74.1%) with higher velocities under WOA relative to proposed action. At Steamboat Slough, when the proposed action was compared to WOA, overlap was moderate to high with values between 45.0 and 76.6 % (Fig X14 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Velocities were higher under the WOA in all water year types (Figure H-14 – *Appendix H, Bay-Delta Aquatics Effects Figures*).

In the March through May period at Walnut Grove, when proposed action was compared to WOA in the March through May period, velocity overlap was variable among water year types from a low of 18.7% in Wet years to 63.5% in Critical years (Figure H-16 – *Appendix H, Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were greater under the WOA relative to the proposed action. At Steamboat Slough in the March through May period, velocity overlap was lower when proposed action was compared to WOA (Figure H-18 – *Appendix H, Bay-Delta Aquatics Effects Figures*). The lowest value occurred in Wet years (23.2%) and highest in Critical years (74.9%).

A recent study by Perry et al. (2018) found that the effect of flow on survival is not uniform throughout the Delta. Relationships between flow and survival were significant only in reaches where flow changes from bi-directional to unidirectional when discharge increases. During the December to February period at the San Joaquin River at Highway 4, velocity distributions for proposed action relative to WOA exhibited velocity overlap decrease in all water year types, with higher velocities under WOA (Figure H-20 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Overlap values ranged from a low of 58.8% in Wet years to 79.6% in Critical years (Figure H-20 – *Appendix H, Bay-Delta Aquatics Effects Figures*). At the Head of Middle River during the December-February period, overlap was low between the proposed action and WOA in Below Normal, Above Normal and Wet water years ($\leq 25.1\%$) with higher velocities under WOA (Figure H-22 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Overlap was higher in Critical and Dry years and velocities remained higher under WOA (Figure H-22 – *Appendix H, Bay-Delta Aquatics Effects Figures*).

In the March-May period in the San Joaquin River at Highway 4, there was high overlap in Critical years (91.7%) between the proposed action and WOA. In other water year types, overlap ranged between 54.9% in Wet years to 78.3% in Dry years with higher velocities under the WOA (Figure H-24 – *Appendix H, Bay-Delta Aquatics Effects Figures*). Comparison of the proposed action with WOA in March-May at Head of Middle River revealed high overlap in in Critical years and low to moderate overlap in all other water year types (Figure H-26 – *Appendix H, Bay-Delta Aquatics Effects Figures*). In all water year types, velocities were higher under the WOA relative to the proposed action.

5.14.5.3.11 Delta Cross Channel

5.14.5.3.11.1 Rearing to Outmigrating Juveniles in the Bay-Delta

The Delta Cross Channel may be closed for up to 45 days from November through January for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days from May 21 through June 15 for fishery protection purposes.

The peak migration of juvenile Fall-run Chinook Salmon in the Sacramento River past West Sacramento, which is near the DCC, occurs from February through May (Table 5.14-1). Therefore, the DCC is closed for the majority of the juvenile Fall-run Chinook migration period in the Sacramento River and as such, the proportion of fish exposed to an open DCC would be low. Juvenile Fall-run which are entrained into an open DCC and transported to the interior Delta have reduced survival (Perry et al. 2010). Since the proportion of juvenile Fall-run Chinook salmon exposed to an open DCC would be low the potential negative effects of DCC operation would be low.

5.14.5.3.11.2 Adult Migration

The status of the DCC gates, open or closed, affects ability of Fall-run and Late Fall-run Chinook Salmon to migrate to their river of origin. Attraction flows from the Mokelumne River are often low, resulting in an open DCC path allowing salmon to stray to the Sacramento River and spawn in Sacramento River tributaries. This is hypothesized to result in lower Mokelumne escapement than would otherwise occur and increased homogenization of Fall-run Chinook salmon. No change in DCC operations in the Fall-run or Late Fall-run Chinook salmon adult migration season (August-October) are planned so effects would be unchanged from the current condition. Reclamation proposes to improve the DCC gates to enable a more real time operation to occur. This has potential to improve conditions for migrating adults in the future.

5.14.5.3.12 Agricultural Barriers

Under the proposed action, Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

The proportion of juvenile Fall-run Chinook salmon exposed to the agricultural barriers depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the agricultural barriers. The peak relative abundance of juvenile Fall-run Chinook salmon in the Delta at Mossdale is February through May (Table 5.14-1). If the agricultural barriers are operating as early as April 15 then they have the potential to expose a large proportion of the juvenile Fall-run Chinook salmon migrating down the San Joaquin River. When the Head of Old River barrier is not in place, which it is not under the proposed action, acoustically tagged juvenile Chinook Salmon have demonstrated a high probability of selecting the Old River route (Buchanan 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Fall-run Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). Flap gates tied up on agricultural barriers from May 16 to May 31 would help to reduce the negative effect of the barriers during this period. However, juveniles migrating before or after this period could be exposed to the agricultural barriers with flaps down which apparently decreases passage success and survival (DWR 2018). Therefore, the potential negative effects of the agricultural barriers depends on when they are installed and whether the flap gates are down or tied up but overall would be medium to high.

The figure below shows Chinook Salmon survival from the Head of Old River between 3 different routes: San Joaquin River to Turner Cut, CVP via the Old River, or SWP via the Old River. As can be shown on the graph below, Chinook Salmon survival is higher through the Old River and the CVP for flows below 3900 cfs at Vernalis than through the San Joaquin River. This figure was generated from a slightly revised meta analysis from route-specific survival estimates from published juvenile Chinook tagging studies completed between 2008 and 2015 (e.g. Buchanan et al. 2016), are generally 100-120 mm parr / smolts. As can also be seen on the figure, flows at Vernalis are less than approximately 3900 cfs nearly 80% of the time. Finally, DWR cannot install the Head of Old River barrier at flows above 5,000 cfs. Therefore, Chinook salmon survival (and, presumably, steelhead, although steelhead data has not shown a difference between the San Joaquin River and Old River) is higher through Old River the majority of the time. Therefore, while agricultural barriers with tidal flap gates down may cause some decline in passage and reach survival, overall survival is expected to increase in the proposed action, which does not include the Head of Old River Barrier, especially with flap gates tied up from May 16 to May 31.

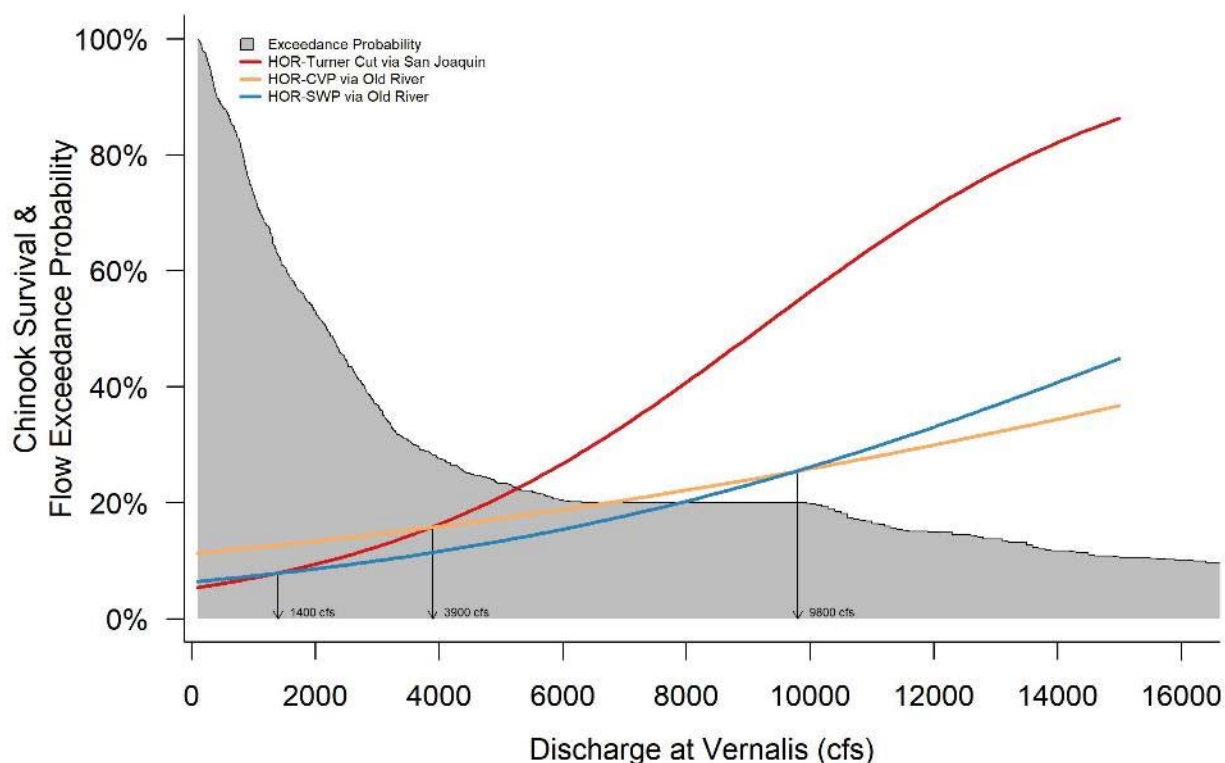


Figure 5.14-18. Chinook Salmon survival from the Head of Old River between 3 different routes: San Joaquin River to Turner Cut, CVP via the Old River, or SWP via the Old River

5.14.5.3.13 Contra Costa Canal Rock Slough Intake

As discussed in Section 4.9.5, CCWD’s operations in the proposed action are consistent with the operational criteria specified in separate biological opinions and permits that govern operations at CCWD’s intakes and Los Vaqueros Reservoir (NMFS 1993; NMFS 2007; NMFS 2010; NMFS 2017; USFWS 1993a; USFWS 1993b; USFWS 2000; USFWS 2007; USFWS 2010; USFWS 2017; CDFG

1994; CDFG 2009). Therefore, the operation of the Rock Slough Intake for the Proposed Action remains unchanged from the COS.

The Contra Costa Canal Rock Slough Intake is located on a dead-end slough, far from the main migratory route for Fall-run/Late Fall-run, approximately 10 miles from the San Joaquin River and 18 miles from the Sacramento River via the shortest routes. Three life stages (fry, juveniles, and adults) of Fall-run/Late Fall-run Chinook Salmon can be present in the Delta at various times. A portion of the Fall-run Chinook salmon fry population (length-40 to 50 mm) migrates downstream soon after emergence where they rear in the lower Delta river channels and Suisun Bay during the spring. These Fall-run Chinook salmon fry enter the estuary in January and peak in abundance in February and March. Juvenile Fall-run Chinook Salmon (length-80 to 90 mm long) can be in the Delta from April–early June and adult Fall-run Chinook Salmon are in the Delta during late summer and fall (approximately late June–early December). Late Fall-run juveniles can be in the Delta Rock Slough from April–June and adults migrate from October–April (Reclamation 2016).

Fish monitoring prior to the construction of the RSFS indicates the timing and magnitude of CV Fall-run/Late Fall-run presence near the Rock Slough Intake. From 1999-2009, the 11 years prior to construction of the RSFS, CCWD's Fish Monitoring Program collected a total of 18 CV Fall-run/Late Fall-run near the Rock Slough Intake (Reclamation 2016). Since construction of the RSFS, operation of the hydraulic rake cleaning system has been shown to trap and kill adult Chinook Salmon and other non-listed fish (Reclamation 2016). From 2011-2018 47 Chinook salmon were recovered at the RSFS (Reclamation 2016, Appendix A; Tenera 2018a). Approximately 60 percent were of hatchery origin; the CWTs revealed that all were Fall-run/Late Fall-run Chinook Salmon released from either Mokelumne River (53 percent), Merced River (6 percent) or Nimbus (2 percent) fish hatcheries.

5.14.5.3.13.1 Juveniles

Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, juvenile CV Fall-run/Late Fall-run are not likely to be in the vicinity of the Rock Slough Intake. However, according to NMFS (2017), juvenile salmon can be “drawn” into the south Delta under reverse flows and high CVP and SWP pumping rates. However, the water diversions at the Rock Slough Intake when combined with diversions at CCWD's Old River Intake and Middle River Intake have a negligible effect on velocity along the migratory path for juvenile Fall-run/Late Fall-run Chinook Salmon and are not likely to impact the movement of juvenile salmonids. Please see the Winter-run Chinook Salmon section for additional details.

5.14.5.3.13.2 Adults

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is poor habitat with relatively high water temperature and a prevalence of aquatic weeds. Due to the location of the Rock Slough Intake near the end of a dead-end slough, far from the main migratory routes, and due to the poor quality of habitat within the slough, adult Fall-run/Late Fall-run Chinook Salmon are not likely to be in the vicinity of the Rock Slough Intake. However, if some adults stray into Rock Slough, the water exiting the Contra Costa Canal on ebb tide may create a false attraction to adult salmon that are migrating upstream (NMFS 2017).

NMFS has advised Reclamation that salmonids will likely be less attracted to the area near the intake if tides can be reduced (Reclamation 2016). It is worth noting that the ebb tidal flow in Rock Slough will be substantially reduced when the Contra Costa Canal is encased in a pipeline. This ongoing, multi-phased

project (the Canal Replacement Project) is being conducted as a separate action by CCWD and has undergone separate environmental review. Completion of the Canal Replacement Project will result in tidal flows being significantly reduced at the Rock Slough Intake. Modeling of the area indicates that with only the first two phases complete, ebb flows reach up to 160 cfs, but with the Contra Costa Canal fully encased, ebb flows would be greatly muted to about 10 cfs.

5.14.5.3.14 North Bay Aqueduct

Fall-run Chinook Salmon may be present in the waterways adjacent to the Barker Slough Pumping Plant, however several years of monitoring have failed to consistently capture any salmonids during the winter Delta Smelt surveys (1996 to 2004) in Lindsey Slough or Barker Slough. Captures of Chinook Salmon have usually occurred in the months of February and March and typically are only a single fish per net haul (<http://www.delta.dfg.ca.gov/data/nba>). Most Chinook Salmon captured have come from Miner Slough, which is a direct tributary from the Sacramento River via Steamboat and Sutter Sloughs. Few if any San Joaquin River-origin Fall-run Chinook Salmon are expected to be exposed to the North Bay aqueduct under the proposed action because it is not on the migration route of this species.

5.14.5.3.15 Water Transfers

As discussed in the Spring-run Chinook Salmon section, Reclamation's proposed action includes expanding the water transfer window to July to November. This could result in approximately 50 TAF of additional pumping in most water year types (Figure 5.8-47). This additional pumping could increase entrainment, routing, or through-Delta mortality for Fall-run Chinook Salmon.

5.14.5.3.15.1 Rearing to Outmigrating Juvenile

Rearing to outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to increased pumping due to the water transfer window expansion in the fall associated with the proposed action, although this is not at the peak of the juvenile outmigration window. Effects are the same as those discussed under OMR management and include entrainment and predation.

5.14.5.3.15.2 Migrating Adults

Adult Fall-run Chinook Salmon would be exposed to increased pumping due to the water transfer window expansion in the fall associated with the proposed action. Effects are the same as those discussed under OMR management.

5.14.5.3.16 Clifton Court Forebay Aquatic Weed Program

Few if any juvenile Fall-run Chinook Salmon would be expected to be exposed to the Clifton Court Forebay Aquatic Weed Control Program under the Proposed Action. Juvenile Fall-run and Late Fall-run Chinook Salmon are present in the Delta between mid-November and early June with a peak in April (Table 5.6-1). The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. Thus, the probability of exposing Fall-run Chinook Salmon to the herbicide is very low. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the water temperatures would be incompatible with salmonid life history preferences, generally exceeding 70°F by mid-June. Mechanical harvesting would occur on an as-needed basis and therefore Fall-run Chinook Salmon could be exposed to this action, if entrained into the Forebay.

5.14.5.3.17 Suisun Marsh

5.14.5.3.17.1 Salinity Control Gates

Operation of the SMSCG from October through May coincides with downstream migration of juvenile Fall-run Chinook Salmon (Table 5.14-1). NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.3.17.2 Roaring River Distribution System

The RRDS' water intake (eight 60-inch-diameter culverts) under the proposed action is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s (for Delta Smelt protection), so that juvenile Fall-run Chinook Salmon would be excluded from entrainment.

5.14.5.3.17.3 Morrow Island Distribution System

Although Fall-run Chinook Salmon have been entrained at this facility that is part of the proposed action, only a small proportion of total migrants are likely to encounter it.

5.14.5.3.17.4 Goodyear Slough Outfall

NMFS (2009: 438) concluded that it would be unlikely that Chinook Salmon would encounter or be negatively affected by the Goodyear Slough outfall given its location and design, which is intended to improve water circulation in Suisun Marsh and therefore was felt by NMFS (2009: 438) to likely be of benefit to juvenile salmonids by improving water quality and increasing foraging opportunities.

5.14.5.4 Effects of Maintenance

Under WOA, no maintenance would occur as the CVP and SWP are not operating. Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real-Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Green Sturgeon adults from maintenance activities.

5.14.5.4.1 Operation of a Shasta Dam Raise

Under the proposed action, Reclamation would operate a raised Shasta Dam consistent with scenario CP4A in the 2015 Shasta Lake Water Resources Investigation Feasibility Report. Shasta Dam raise is anticipated to increase the cold water pool in Shasta Reservoir, to the benefit of salmonids holding or spawning downstream in the summer and fall. As shown in the Winter-run Chinook salmon section, the operation of the Shasta Dam raise would result in similar flow releases to the proposed action without the Shasta Dam raise. The operation of a Shasta Dam raise would be anticipated to increase flows in September and November and decrease flows in December to May, as compared to the proposed action without Shasta Dam raise.

The effect of a raised Shasta Dam operating for CVP only on the proposed action may be uncertain, however all scenarios provide the same or greater flows compared to the WOA between June-November (Figure CP4A_Avg in the 2015 Shasta Lake Water Resources Investigation Feasibility Report), an important period for Fall-run Chinook salmon adult holding, as well as spawning. Flows under the proposed action would decrease in spring as compared to WOA, but the operation of a Shasta Dam raise would not modify the proposed action without Shasta Dam raise flows significantly. Flows are increased from October to November and therefore do not present a risk of redd de-watering or reductions compared to the proposed action without a raised Shasta Dam.

5.14.5.5 Effects of Conservation Measures

Conservation measures would not occur under WOA.

5.14.5.5.1 Lower Intakes Near Wilkins Slough

5.14.5.5.1.1 Eggs to Fry Emergence

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run and Late Fall-run Chinook salmon egg and fry. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages. Specifically, operation of diversions with fish screens near Wilkins Slough would:

- Improve water temperatures and increase DO.
- Increase habitat complexity.
- Increase side-channel rearing habitat.
- Increase floodplain habitat and increase connectivity of floodplains with the river mainstem.
- Increase refuge habitat.
- Increase availability and quality of prey organisms.
- Reduce crowding and competition.
- Decrease predation risk.
- Decrease entrainment risk.
- Decrease potential for pathogens and diseases.
- Lower concentrations of toxic contaminants.
- Increase emigration cues.

The egg and fry life stage of Fall-run and Late Fall-run Chinook salmon, as well as the population, would benefit from this action. The survival of this life stage would directly benefit the Southern Resident Killer Whale, by increasing its available prey.

Egg and fry of Fall-run/Late Fall-run Chinook salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough. Peak spawning time for Fall-run and Late Fall-run Chinook Salmon is typically in October-November, but can continue through December and into January (CDFG date unknown - <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=104280>). Juveniles typically emerge from the gravel in December through March. Construction would occur during an inwater work window between June 1 and October 1; therefore, egg and fry would not be affected.

5.14.5.5.1.2 Rearing to Outmigrating Juveniles

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run and Late Fall-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Rearing and outmigrating Fall-run and Late Fall-run Chinook Salmon would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Fall-run/Late Fall-run Chinook Salmon rearing between one to seven months after emerging between December through March (CDFW website). Juveniles typically move downstream quickly into large rivers within a few weeks. Salmon smolts initiate migration during storm events and flow is positively correlated with migration rate (McCormick et al. 1998, Michel et al. 2013 *as cited in* CDFG website).

If rearing salmon are present in Wilkins Slough during the June 1 through October 1 in-water work window, individuals may be exposed to temporary disturbances associated with the construction of a cofferdam. Water quality may be temporarily disturbed, in addition the noise associated with construction of the cofferdam may temporarily affect juvenile Fall-run Chinook Salmon. Additionally, fish rescue operations may need to be conducted during the period when water within the coffered area needs to be pumped. However, implementation of AMM's identified in Appendix E, *Avoidance and Minimization Measures* would further minimize any effects to the salmon.

Outmigrating juvenile Fall-run/Late Fall-run Chinook Salmon in the Upper Sacramento River would not be affected by the construction of a new diversion and fish screens near Wilkins Slough associated with the proposed action, based on juveniles emigrating quickly downstream. Construction of diversions and fish screens near Wilkins Slough would occur during an in-water work window (June 1 and October 1), avoiding the emigration period; therefore effects of construction on emigrating Fall-run and Late Fall-run are not expected.

5.14.5.5.1.3 Rearing to Outmigrating Juveniles in the Bay Delta

The installation of fish screens near Wilkins Slough would be beneficial to Fall-run/Late Fall-run Chinook. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Rearing and outmigrating Fall-run and Late Fall-run Chinook Salmon in the Bay-Delta would not be affected by the construction of a new diversion and screens near Wilkins Slough, based on Fall-run and Late Fall-run Chinook Salmon being located far downstream of construction activities. Wilkins Slough is located outside of the legal Bay-Delta – no tidal influence.

5.14.5.5.1.4 Adult Migration

The installation of fish screens near Wilkins Slough under the Proposed Action would be beneficial to Fall-run/Late Fall-run Chinook Salmon. The fish screens would prevent fish entrainment at diversions, thus increasing the survival of emigrating juveniles and immigrating adults, and in turn potentially increasing successful spawning. Additionally, the installation of new diversions and screens that would operate at lower flows, would directly benefit fish of all life stages.

Yoshiyama *et al.* (1998) identifies the migration period for Fall-run Chinook Salmon as June through December, with a peak period of September through October. The migration period for Late Fall-run Chinook Salmon is October through April, with a peak in December (Yoshiyama *et al.* 1998). Construction activities would occur during an in-water work window from June 1 through October 1. Although migrating salmon may be present during the latter portion of the window, the migrating fish would not be affected by construction windows, as the construction activities would occur in an already dewatered area. Flow would not be impeded; therefore, migration of salmon to upstream spawning

habitats would not be prevented. The implementation of the in-water work wind-down and other AMM's identified in Appendix E, *Avoidance and Minimization Measures* would reduce the effects of construction activities on migrating salmon.

5.14.5.5.1.5 Adult Holding

Holding Fall-run/Late Fall-run Chinook Salmon, as well as the population, would benefit from the installation of fish screens near Wilkins Slough under the proposed action.

The construction activities associated with the diversions and associated fish screens under the proposed action are not expected to affect adults holding Fall-run/Late Fall-run Chinook Salmon, due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, *Avoidance and Minimization Measures*, Reclamation will implement an in-water work window of June 1 through October 11 to reduce further effects to holding individuals. Additionally, Fall-run and Late Fall-run Chinook Salmon typically need cold water temperatures for holding; however, Wilkins Slough does not have suitable holding habitat; therefore, would not be affected by the onset of construction activities within the in-water work window.

5.14.5.5.2 Shasta Dam TCD Improvements

5.14.5.5.2.1 Eggs to Fry Emergence

Improvements to the Shasta Dam TCD would accommodate relatively small raises to Shasta Dam and reduce leakage of warm water into the structure that increases of the water temperature of the cold water that is released to maintain suitable temperatures for Fall-run/Late Fall-run Chinook Salmon that spawn in the upper Sacramento River (from Keswick Dam to the Red Bluff Diversion Dam). Because there is some overlap between winter-run and Fall-run/Late Fall-run spawning and egg/alevin incubation periods, Fall-run/Late Fall-run eggs and alevins would be somewhat similarly affected by the upper Sacramento River water temperatures, and as described previously, the proposed action would in fact be more protective of Fall-/Late Fall-run Chinook Salmon than COS and WOA. The improved flow and water temperature management associated with the Shasta Dam TCD improvements under the proposed action would be expected to provide a moderate benefit to Fall-run/Late Fall-run Chinook Salmon eggs and alevin relative to the WOA.

5.14.5.5.2.2 Rearing to Outmigrating Juveniles

All water temperatures under COS and proposed action scenarios during the Fall-run/Late Fall-run juvenile rearing period are consistently below the 61 degrees Fahrenheit threshold, except for June through September. However, during June through September, water temperatures under the WOA would be substantially higher (~10 to 20 degrees Fahrenheit) than those under the proposed action and COS. Therefore, in general, water temperature conditions under COS and the proposed action would provide high benefits relative to the WOA conditions to juvenile Fall-run/Late Fall-run rearing in the upper Sacramento River. The ability to better manage the cold water pool and cold water releases through the Shasta TCD improvements would result in increased probability and likelihood of maintaining suitable rearing temperatures within the middle reaches of the Sacramento River. Therefore, this action would have high-level population benefits on this life stage.

5.14.5.5.2.3 Adult Migration

Under the proposed action and COS, the monthly mean water temperatures in the middle Sacramento River below the Colusa Basin Drain would be below the 68 degrees Fahrenheit threshold for immigrating Fall-run/Late Fall-run Chinook Salmon (Figures 14-9, 14-10, 14-12, 14-13 in the HEC 5Q Temperatures section in Appendix D). The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable migrating water temperatures within the Sacramento River.

5.14.5.5.2.4 Adult Holding

Under the COS and proposed action scenarios, the monthly mean water temperatures in the upper Sacramento River at Keswick, under the COS and proposed action scenarios, the average water temperatures would be well below the 61 degrees Fahrenheit threshold for holding adults from December through May (Figures 5-9, 5-12, 5-15 in the HEC-5Q Temperatures section of Appendix D). The ability to better manage the cold water pool and cold water releases would result in increased probability and likelihood of maintaining suitable migrating ad holding temperatures within the Sacramento River.

5.14.5.5.3 Sacramento River Spawning and Rearing Habitat

5.14.5.5.3.1 Egg to Fry Emergence

Habitat restoration activities under the proposed action would benefit Fall-run Chinook Salmon by increasing available spawning habitat (by placement of additional spawning gravel). The plot below shows the available spawning habitat in the Sacramento River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon on the Sacramento River.

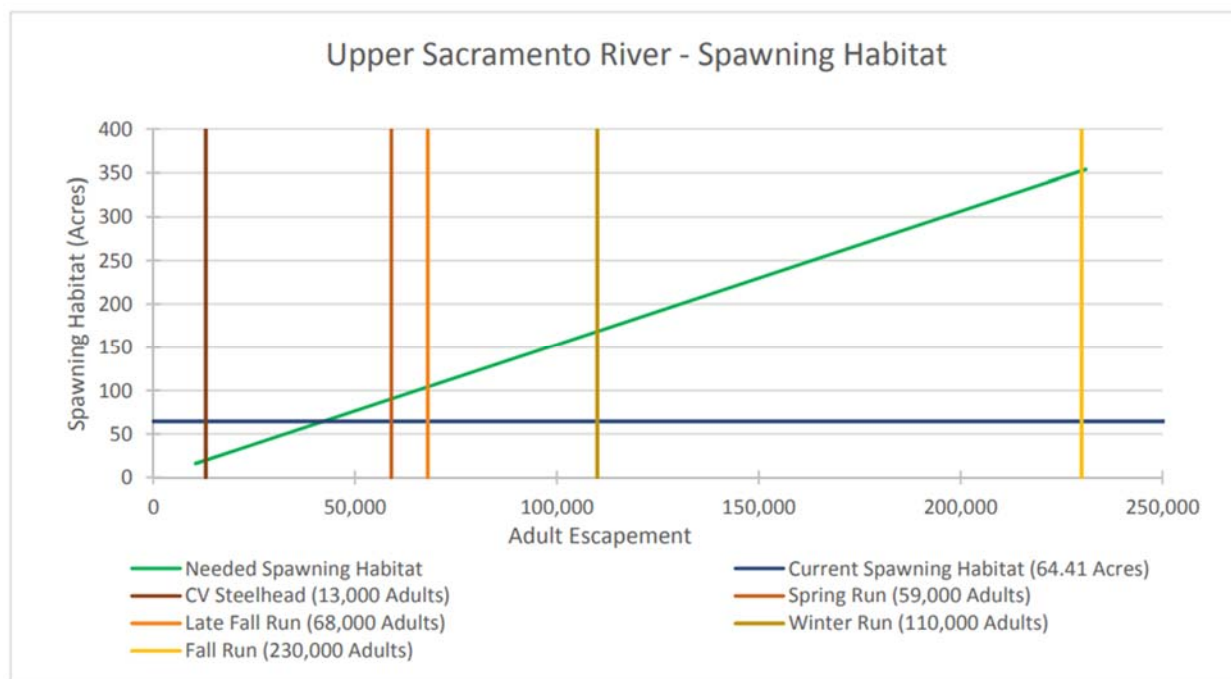


Figure 5.14-19. Estimated Salmonid habitat needed in the Sacramento River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning habitat restoration under the proposed action are not expected to affect eggs and emerging fry due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15). The in-water work window will completely avoid the eggs and emerging fry life stage, as Fall-run/Late Fall-run Chinook Salmon typically spawn between October through November, and fry emerge between December and March (Table 5.14-2).

5.14.5.5.3.2 Rearing to Outmigrating Juveniles in the Rivers

Habitat improvement projects in the Sacramento River under the proposed action focus on increasing productivity of Fall-run Chinook Salmon and Steelhead. The in-river work occurs during low flows (less than about 5,000 cfs) in the July to October timeframe to avoid the most sensitive young juvenile and egg life stages of Steelhead and Chinook Salmon. Projects focus on rearing habitat and strive to provide spawning habitat close to the rearing habitat in the upper half of the river. Lower river projects (below River Bend) focus solely on rearing habitats and include side channel and floodplain types of habitat. Woody material is incorporated in all projects wherever possible.

Rearing and outmigrating individuals would benefit from increased side channel habitat, floodplain, gravel, and large wood resulting from habitat restoration in the Sacramento River. Effects would include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality. Figure 5.14-20 shows the amount of rearing habitat needed to support the range of Chinook Salmon escapement sizes in the Sacramento River along with the estimated amount of rearing habitat currently available. Rearing habitat appears particularly limited with habitat currently available to support the production of less than 500 Chinook Salmon. Rearing habitat improvements are particularly beneficial.

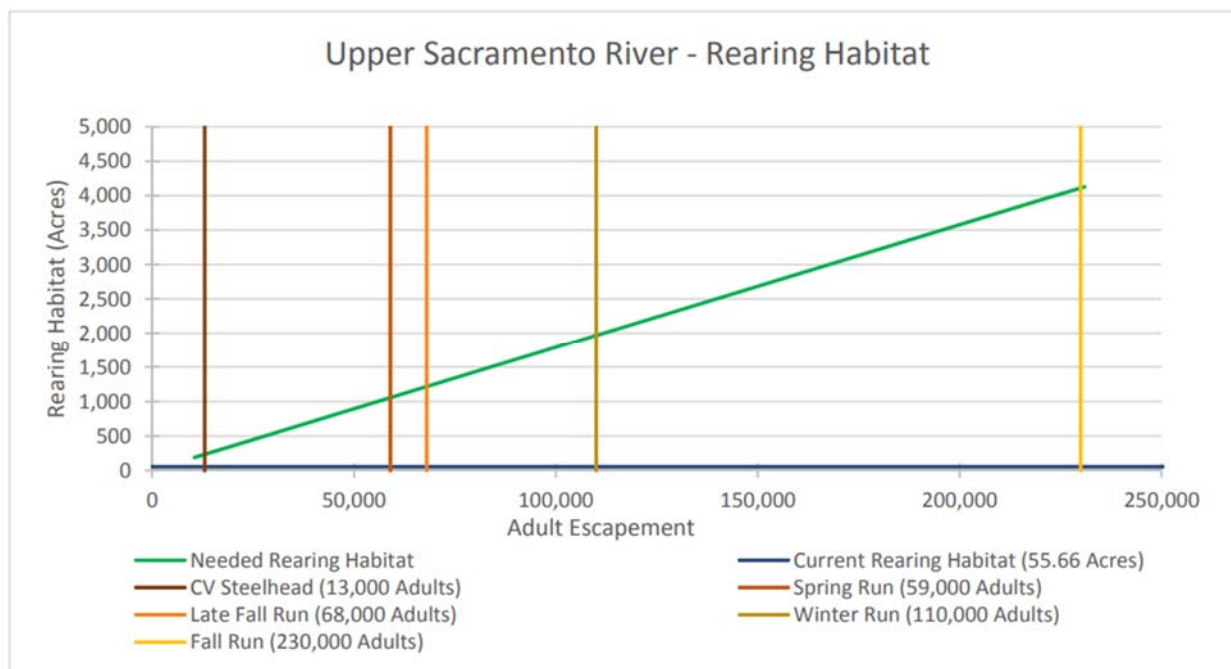


Figure 5.14-20. Estimated Salmonid rearing habitat needed in the Sacramento River to support the range of escapement sizes (CVPIA 2018).

Few rearing and outmigrating Fall-run/Late Fall-run Chinook salmon juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation under the proposed action, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the Sacramento River (year-round; Table 5.14-1). Most juveniles leave the river before July. Years when juvenile Chinook are present into July are wet years with high flows prohibiting in-river habitat improvement work from occurring. Construction activities in the Sacramento River could result in mortality of this life stage by crushing from heavy equipment in the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery. Due to the juvenile life stage timing rarely overlapping with habitat work any effects would be minimal.

Any exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities under the proposed action would be minimized and affect a low number of individuals.

5.14.5.5.3.3 Adult Migration

Habitat restoration activities would benefit Fall-run/Late-Fall run Chinook Salmon by increasing available spawning habitat.

The construction activities under the proposed action associated with spawning habitat restoration are not expected to affect immigrating Fall-run/Late Fall-run Chinook Salmon because of the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to avoid effects to immigrating Fall-run/Late Fall-run Chinook Salmon.

5.14.5.5.3.4 Adult Holding

Habitat restoration activities under the proposed action would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration under the proposed action are not expected to impact adults Fall-run/Late Fall-run Chinook Salmon holding in the Sacramento River due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to reduce further effects to holding individuals.

5.14.5.5.4 Small Screen Program

5.14.5.5.4.1 Egg to Fry Emergence

No egg-to-emergence Fall-run/Late Fall-run Chinook Salmon in the Sacramento River would be exposed to fish screens since they remain in the gravel. Therefore, there would be no effects from fish screen operation for this life stage.

Few if any Sacramento River Fall-run/Late Fall-run Chinook Salmon in the egg-to-emergence life stage would be expected to be exposed to the effects of construction of screens on water diversion intakes under the proposed action based on the seasonal occurrence of this life stage in the Sacramento River. The egg to fry emergence stage follows the fall and winter spawning period (Table 5.14-1 and 5.14-2), which is outside of the timing of in-water construction (July 15 – October 15). Since spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water velocities (Fisher 1994), there is the potential for redds to occur in the work areas or in the direct vicinity of the construction sites. However, these work areas are localized and the number of redds in these areas is expected to be low. Potential short-term adverse impacts may include temporary, localized fine sediment disturbance and deposition in spawning and embryo incubation areas directly adjacent construction sites. There could be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*.

5.14.5.5.4.2 Rearing to Outmigrating Juveniles in Rivers

The operation of fish screens on water diversions under the proposed action would beneficially affect juvenile Fall-run/Late Fall-run Chinook Salmon rearing and migrating in the Sacramento River by reducing the entrainment of rearing and migrating fish into unscreened or poorly screened diversions. There is the potential for adverse effects to this life stage, including injury or mortality from exposure to screens that are not functioning properly due to lack of maintenance, occlusion, debris accumulation or other factors. However, the risk of this exposure will be minimized since the screens would be designed to meet NMFS and CDFW fish screen criteria and protect this life stage. Therefore, it is concluded that the operation of fish screens under the proposed action would result in beneficial effects for this life stage, due to the reduced risk of entrainment and injury.

Juvenile Fall-run/Late Fall-run Chinook Salmon rearing and migrating in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes due to their occurrence during the in-water construction season (July 15 – October 15) (Tables 5.14-1 and 5.14-21). However, the localized work area of these projects limits the potential for exposure to these projects. Potential short-term adverse effects may include temporary effects to water quality as result from in-water work, resulting in increased turbidity and suspended sediments and sediment deposition in the direct vicinity of the work area, and the temporary displacement of individual fish in the work area. If fish are present in the work area, flowing water will be isolated and fish captured and relocated to an appropriate location in an effort to minimize possible mortality. Juveniles would likely experience increased levels of stress and injury during handling, which could be exacerbated by poor water quality (increased temperatures, low dissolved oxygen saturation), and prolonged periods of holding between capture and release. There may be a minor effect to a small number of individuals, although the risk from these potential effects would be minimized through the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. In addition, the appropriate conservation measures and handling techniques will be employed to ensure that the stress resulting from handling and transport is short-lived and minor.

5.14.5.5.4.3 Rearing to Outmigrating Juveniles in the Bay-Delta

There may be moderate overlap Fall-run/Late Fall-run Chinook Salmon with the main late spring-fall irrigation period for small diversions, and small diversion screening under the proposed action could reduce entrainment of late migrating individuals.

Few if any juvenile Fall-run/Late Fall-run Chinook Salmon rearing and outmigrating in the Bay-Delta are expected to be exposed to the effects of construction of screens on water diversion intakes under the proposed action. Juvenile Sacramento River Fall-run/Late Fall-run Chinook Salmon primarily migrate from November through early May (NMFS 2014), largely outside of the timing of in-water construction (July 15 – October 15). In addition, the work area for these projects is small, limiting exposure to construction.

5.14.5.5.4.4 Adult Migration

Operational effects for adults are the same as those described above for juveniles. Adult Sacramento River Fall-run/Late Fall-run Chinook Salmon may be exposed to the effects of construction of screens on water diversion intakes based on the timing of in-water construction (August–October), the late-summer to early Fall seasonal occurrence of this life stage in the Sacramento River (Tables 5.14-1 and 5.14-2). AMMs would minimize risks.

5.14.5.5.4.5 Adult Holding

Operational effects for adults are the same as those described above for juveniles. Adult Fall-run/Late Fall-run Chinook Salmon in the holding in the Sacramento River may be exposed to the effects of construction of screens on water diversion intakes due the overlap of the timing of in-water construction (July 15 – October 15), and the July through April occurrence of this life stage (Tables 5.14-1 and 5.14-2). AMMs would minimize risks.

5.14.5.5.4.5.1 Adult Rescue

The operation of adult rescue is targeted towards adult salmonids and sturgeon, including adult Fall-run/Late Fall-run Chinook Salmon, that become trapped in the Yolo and Sutter bypasses, with the goal of increasing the number of adults returning to spawning areas; therefore, this effort could increase the number of Fall-run/Late Fall-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries, and the ocean.

Exposure of this life stage to adult rescue effects would be restricted only to those adult Fall-run/Late Fall-run Chinook Salmon that become stranded in the Yolo and Sutter Bypasses and subsequently rescued and released to the Sacramento River. Adults that migrate in-river or that do not become stranded in the Yolo and Sutter bypasses would be unaffected by adult rescue activities. The number of adult Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the abundance of adults that stray into the bypasses and the timing and frequency of stranding events in the bypasses. Individual adult Fall-run/Late Fall-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality, which could vary in intensity depending on the techniques used to capture individuals. Injury and increased stress associated with capture, handling and transport may affect survival of individuals after release. The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*). As such, it is concluded that the overall population-level negative effects on this life stage of Fall-run/Late Fall-run Chinook Salmon from

adult rescue activities would be low relative to the without action (no rescue of stranded adult Fall-run/Late Fall-run Chinook Salmon in Yolo and Sutter bypasses).

Given that eggs are in gravel substrates and adult rescue activities would occur downstream of Fall-run/Late Fall-run Chinook Salmon spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing adult rescue activities.

As discussed for Winter-run and Spring-run Chinook Salmon, juvenile Fall-run/Late Fall-run Chinook Salmon occur in the Yolo and Sutter Bypasses when Sacramento River flows overtop the Fremont and/or Tisdale Weirs. Although they are unlikely to occur in the bypasses during periods when flow does not overtop the weirs, proposed modifications to the Fremont Weir to increase inundation of the Yolo bypass for floodplain rearing would provide juveniles with more consistent access to the Yolo bypass. Therefore, these juveniles could be exposed to the effects of adult rescue activities if they become stranded with adults that are targeted by adult rescue activities. The number of juvenile Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of adult rescue activities would be based on the timing of proposed adult rescue activities, gear type used to rescue adults, and the typical seasonal occurrence of this life stage in the Yolo and Sutter bypasses. Individual juvenile Fall-run/Late Fall-run Chinook Salmon exposed to adult rescue activities would be at risk of increased stress, injury, and/or mortality during efforts to capture stranded adults, handling, and transport. Injury and increased stress associated with capture, handling, and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Fall-run/Late Fall-run Chinook Salmon would be expected to be offset by benefits associated with increased numbers of adult Fall-run/Late Fall-run Chinook Salmon returning to spawning grounds. As such, it is concluded that the overall population-level negative effects on this life stage of Fall-run/Late Fall-run Chinook Salmon from adult rescue activities would be low relative to the without action (no rescue of adult Fall-run/Late Fall-run Chinook Salmon in Yolo and Sutter bypasses).

5.14.5.5 Juvenile Trap and Haul

The operation of the juvenile trap and haul is targeted towards juvenile Fall-run/Late Fall-run Chinook Salmon, with the goal of increasing the survival of juveniles and, ultimately, returning adults; therefore, this effort could increase the number of Fall-run/Late Fall-run Chinook Salmon of all lifestages in the Sacramento River and its tributaries.

The number of juvenile Fall-run/Late Fall-run Chinook Salmon that would be expected to be exposed to the effects of juvenile trap and haul activities under the proposed action would be based on the timing of proposed juvenile trap and haul activities (December 1 to May 31), trapping location and efficiency, and the typical seasonal occurrence of this life stage in the Sacramento River (Tables 5.14-1 and 5.14-2). Individual juvenile Fall-run/Late Fall-run Chinook Salmon exposed to juvenile trap and haul activities would be at risk of increased stress, injury, and/or mortality. Injury and increased stress associated with handling and transport may reduce disease resistance, swimming ability, and osmoregulatory ability in juveniles, thereby adversely affecting survival of affected individuals after release. Furthermore, the risk of these effects to this life stage may be dependent on fish size (fish collected at a smaller [younger] size may be more susceptible to injury and stress) and timing of collection (fish collected later in the season

when water quality conditions [e.g., water temperature] generally are more stressful for fish may make fish more susceptible to injury and stress-related effects). The risk from these potential effects would be minimized through application of AMM8 *Fish Rescue and Salvage Plan* (Appendix E, *Avoidance and Minimization Measures*), and any potential adverse effects on individual juvenile Fall-run/Late Fall-run Chinook Salmon would be expected to be offset by benefits associated with expected increased survival of the overall brood-year of Fall-run/Late Fall-run Chinook Salmon. As such, it is concluded that the overall population-level negative effects on this life stage of juvenile Fall-run/Late Fall-run Chinook Salmon from juvenile trap and haul activities would be low relative to the without action (no trapping and hauling of juvenile Fall-run/Late Fall-run Chinook Salmon during drought years) and would be potentially offset by benefits (increased juvenile survival and ultimately increased adult escapement) associated with the juvenile trap and haul program.

Given that eggs are in gravel substrates and temporary juvenile collection weirs would be placed downstream of Fall-run/Late Fall-run Chinook Salmon spawning areas in the Sacramento River and its tributaries, there would be no direct effects on this life stage from implementing juvenile trap and haul activities.

Transport may also result in earlier ocean arrival and reduced growth rates in juveniles, leading to increased mortality from predation.

Exposure of adults to trap and haul effects would be restricted only to those adult Fall-run/Late Fall-run Chinook Salmon that were trapped in the Sacramento River as juveniles and subsequently released to the lower Sacramento River and/or Bay-Delta as part of the juvenile trap and haul program. Ocean adults that had out-migrated in-river as juveniles would not be affected by juvenile trap and haul activities. Because transported juveniles are more likely to have impaired homing behavior as adults, juvenile trap and haul activities may increase the rate of straying by returning adults. Adults that stray into tributaries with unsuitable habitat may not survive or spawn successfully if habitat conditions are suitable. Adults that stray into tributaries with suitable habitat may compete with native-run adults for spawning space, excavate or superimpose their redds on the redds or native-run fish, or spawn with native-run fish, thereby introducing genes from neighboring populations that have strayed into the river.

5.14.5.5.6 Clear Creek Restoration Program

5.14.5.5.6.1 Eggs to Fry Emergence

Eggs and emerging fry of Fall-run/Late Fall-run Chinook Salmon would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek if geomorphic flows did not achieve sufficient gravel mobilization. Exposure to the effects of gravel mobilization would be beneficial, and include an increase in total incubation habitat area and reduced likelihood of redd superimposition.

A low number of eggs and emerging fry would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (December-April; Table 5.14-1). Mechanical gravel mobilization in Clear Creek could result in mortality of eggs and emerging fry by crushing if heavy equipment entered the stream channel or otherwise disturbed redds during manipulation of gravel. Individuals exposed to this activity could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. Eggs and emerging fry could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended

solids and turbidity, leading to direct physiological effects on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), and loss of aquatic vegetation providing physical shelter.

The likelihood and magnitude of these effects and the risk of exposure by eggs and fry would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. Including the precautions described in AMM 1–5, the temporary, adverse impacts that may result from the construction activities under the proposed action would be minimized and few individuals would be affected.

5.14.5.5.6.2 Rearing to Outmigrating Juveniles

Rearing Fall-run/Late Fall-run Chinook Salmon juveniles could be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek if mechanical gravel mobilization affected existing gravels in suitable rearing habitat, including channel margins, side channels, or other shallow, slow-moving habitat with adequate cover. Assuming mechanical gravel mobilization is undertaken in areas of the channel more likely to be used for spawning nearer the mid-channel this action will have no effect on existing suitable juvenile rearing habitat.

Rearing and outmigrating juveniles would be exposed to mechanical gravel mobilization, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and peak seasonal occurrence of this life stage in Clear Creek (year-round; Table 5.14-1). Construction activities in Clear Creek could result in mortality of this life stage by crushing if heavy equipment entered the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery.

Exposure to these effects under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse impacts that may result from the proposed construction activities would be minimized and affect a low number of individuals.

5.14.5.5.6.3 Adult Migration from Ocean to Rivers

Few, if any, migrating adults would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek. Adult migration habitat is typically situated in deeper water near mid-channel and away from shallower riffles, and pool tails where most mechanical gravel mobilization would occur.

A low number of migrating adults would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (October-December; Table 5.14-1). Construction activities in Clear Creek could result in mortality of migrating adults by crushing if heavy equipment entered the stream channel or otherwise disturbed suitable habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, including loss or degradation of habitat used for resting or sheltering from predators. Migrating adults could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), loss of aquatic vegetation providing physical shelter, and impediments and delay in migration caused by elevated noise levels from machinery.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed construction activities would affect few if any individuals of this life stage.

5.14.5.5.6.4 Adult Holding in Rivers

Few, if any, holding adults would be exposed to the effects of increased gravel resulting from mechanical gravel mobilization under the proposed action in Clear Creek. Holding habitat is typically situated in deep water near mid-channel and away from shallower riffles, and pool tails where most mechanical gravel mobilization would occur. Therefore, an increase in gravel would have no effect on this life stage of Fall-run/Late Fall-run Chinook Salmon.

A low number of Fall-run/Late Fall-run Chinook Salmon holding adults would be expected to be exposed to mechanical gravel mobilization under the proposed action, based on the timing of the in-water work window (to be determined in coordination with NMFS, USFWS, and DFW) and seasonal occurrence of this life stage in Clear Creek (July-December; Table 5.14-1). Construction activities in Clear Creek could result in mortality of holding adults by crushing if heavy equipment entered the stream channel or otherwise disturbed suitable habitat during manipulation of gravel. Individuals exposed to construction could also experience loss of aquatic habitat, including loss or degradation of holding pools required as hiding cover and resting areas by adult Fall-run/Late Fall-run Chinook Salmon during the gamete maturation period prior to spawning. Holding adults could also be negatively affected by 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 (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), 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.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment, as well as AMM1 and AMM2. Including the precautions described in AMM 1-5, the

temporary, adverse effects that may result from the proposed construction activities would affect a low number, if any, individuals of this life stage.

5.14.5.5.7 American River Spawning and Rearing Habitat

5.14.5.5.7.1 Eggs to Fry Emergence

Eggs and emerging fry would be exposed to the effects of increased side channel habitat, gravel, and large wood resulting from habitat restoration under the proposed action in the American River. Effects of this exposure would be beneficial and include an increase in total spawning habitat area and reduced likelihood of redd superimposition. Figure 5.14-21 shows the amount of spawning habitat needed to support the range of Chinook escapement sizes in the lower American River along with the estimated amount of spawning habitat currently available. Projects in the upper half of the lower American River under the proposed action strive to provide rearing habitat and spawning habitat adjacent to each other so that when fry emerge from the gravel they are able to move quickly into suitable habitats. Despite the plentiful spawning habitat in the upper 18 miles of the lower American River, the fish congregate in the upper three miles of the river resulting in high levels of superimposition on the riffles at Nimbus Basin, Sailor Bar, and around Sunrise Avenue. Habitat improvements in these areas under the proposed action help to distribute fish among available habitat and increase survival by reducing superimposition and providing nearby rearing habitat. These projects should be a net benefit to productivity of Fall-run/Late Fall-run Chinook Salmon and Steelhead that spawn and rear in the lower American River.

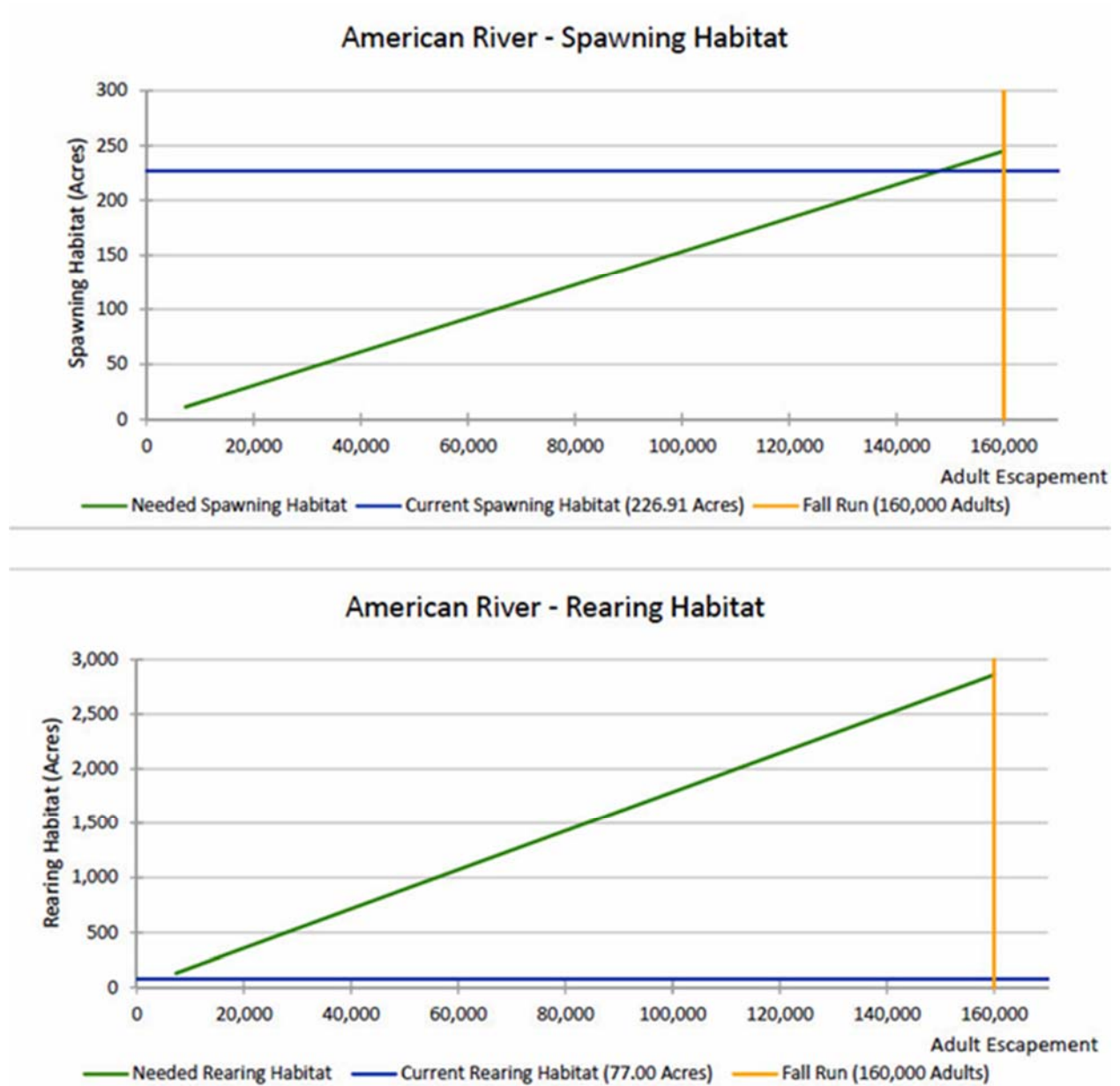


Figure 5.14-21. Estimated Chinook spawning and rearing habitat needed in the lower American River to support the range of escapement sizes (CVPIA 2018).

Construction activity occurs between July and October when no Fall-run or Late Fall-run Chinook Salmon eggs or fry are present.

5.14.5.5.7.2 Rearing to Outmigrating Juveniles

Habitat improvement projects in the lower American River under the proposed action focus on increasing productivity of Fall-run Chinook Salmon and Steelhead. The in-river work occurs during low flows (less

than about 5,000 cfs) in the July to October timeframe to avoid the most sensitive young juvenile and egg life stages of Steelhead and Fall-run Chinook Salmon. Projects focus on rearing habitat and strive to provide spawning habitat close to the rearing habitat in the upper half of the lower American River. Projects on the lower part of the lower American River (below River Bend) focus solely on rearing habitats and include side channel and floodplain types of habitat. Woody material is incorporated in all projects wherever possible.

Rearing and outmigrating individuals would benefit from increased side channel habitat, floodplain, gravel, and addition of large woody material resulting from habitat restoration in the lower American River under the proposed action. Effects would include an improved likelihood of rearing success due to an increase in total rearing habitat area, and rearing habitat quality. Figure 5.14-22 shows the amount of rearing habitat needed to support the range of Chinook escapement sizes in the lower American River along with the estimated amount of rearing habitat currently available. Rearing habitat appears particularly limited with habitat currently available to support the production of less than 10,000 Chinook Salmon. Hence, rearing habitat improvements under the proposed action are particularly beneficial.

Few rearing and outmigrating Fall-run/Late Fall-run Chinook Salmon juveniles would be exposed to construction of side channel habitat, gravel augmentation, and large wood installation, based on the timing of the in-water work window (July 1-September 30) and seasonal occurrence of this life stage in the lower American River (year-round; Table 5.14-1). Most juvenile Fall-run Chinook Salmon leave the river before July. Years when juvenile Fall-run/Late Fall-run Chinook Salmon are present into July are wet years with high flows prohibiting in-river habitat improvement work from occurring. Construction activities under the proposed action in the lower American River could result in mortality of this life stage by crushing from heavy equipment in the stream channel, if individuals were stranded or isolated during dewatering, or if construction otherwise disturbed rearing juvenile habitat during manipulation of gravel, installation of large wood or creation of side channels. Individuals exposed to construction could also experience loss of aquatic habitat, leading to increased predation, increased water temperature, and reduced food availability. This life stage could also be negatively affected by degraded water quality from contaminant discharge by heavy equipment and soils and increased discharges of suspended solids and turbidity, leading to direct physiological impacts on fish health/performance (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), loss of aquatic vegetation providing physical shelter, reduced foraging ability caused by decreased visibility, and impeded or delayed migration caused by elevated noise levels from machinery. Due to the juvenile life stage timing rarely overlapping with habitat work, effects would be minimal.

Exposure to these effects would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention, and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed action construction activities would be minimized and affect a low number of individuals.

5.14.5.5.7.3 Adult Migration from Ocean to Rivers

Early migrating adult Fall-run Chinook Salmon would be exposed to construction of side channel and floodplain habitat, gravel augmentation, and large wood installation under the proposed action. Low numbers of Fall-run Chinook Salmon enter the lower American River through the summer with the peak immigration in October. The behavior of these fish depends on conditions in the river. During higher flow years with cooler than average water temperatures, the fish hold throughout the lower American River but

wet years with high flows prohibit in-river habitat improvement work from occurring. Even if construction occurred during high flow years, during these years, fish are generally in healthy conditions and readily able to avoid in-water activities and temporary turbidity increases. During dryer years, water temperatures are warmer and flows are typically lower. These conditions are more stressful for the fish and they migrate quickly to the upstream most accessible area, either in Nimbus Basin or below the hatchery weir. The only project site that would affect these fish would be the work in Nimbus Basin.

Exposure to effects of activities under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5, the temporary, adverse effects that may result from the proposed action construction activities would affect few if any individuals to Fall-run/Late Fall-run Chinook Salmon immigrating into the lower American River.

5.14.5.5.7.4 Adult Holding in Rivers

Early arriving adult Fall-run Chinook Salmon would be exposed to construction of side channel and floodplain habitat, gravel augmentation, and large wood installation under the proposed action. Low numbers of Fall-run Chinook Salmon enter the lower American River through the summer with the peak immigration in October. The behavior of these fish depends on conditions in the river. During higher flow years with cooler than average water temperatures, the fish hold throughout the lower American River and are more likely to be holding close to activities, although construction actions are less likely to occur. During these years, Fall-run Chinook Salmon are in healthy conditions and readily able to avoid in-water activities and temporary turbidity increases. During dryer years, water temperatures are warmer and flows are typically lower. These conditions are more stressful for the fish and they migrate quickly to the upstream most accessible area, either in Nimbus Basin or below the hatchery weir. The only project site that would affect these fish would be the work in Nimbus Basin.

Exposure to effects of habitat construction under the proposed action would be minimized with incorporation of AMM1, which requires construction personnel education, and AMM2, which specifies an in-water work window and oversight by a qualified biologist. Exposure would be further minimized by implementing AMM3, 4, and 5, which stipulate best practices for stormwater pollution prevention, erosion and sediment control, and spill prevention and containment. With application of AMM 1–5 the temporary, adverse effects that may result from construction of side channel habitat, gravel augmentation, and large wood installation would affect few if any holding Fall-run Chinook Salmon adults.

5.14.5.5.8 Drought Temperature Facility Improvements (American River)

5.14.5.5.8.1 Eggs to Fry Emergence

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam under the proposed action to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. Excessively high water temperatures has been identified as one the factors threatening Fall-run/Late Fall-run Chinook Salmon in the Central Valley (NMFS 2014). Cool water temperatures are important for embryo survival; water temperatures reportedly must be between 41°F and 55.4°F maximum survival (Moyle 2002). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for Fall-run Chinook Salmon during drought conditions and improve conditions for this life stage. Therefore,

it is concluded that this proposed action would likely beneficially affect the egg-to-emergence life stage of Fall-run Chinook Salmon in the lower American River by reducing the effects of drought conditions on water temperatures.

5.14.5.5.8.2 Rearing to Outmigrating Juveniles

Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam under the proposed action to allow temperature flexibility in severe droughts, thereby reducing water temperatures in the lower American River. A few Juvenile Fall-run/Late Fall-run Chinook Salmon may be present in the American River year-round since they may reside in freshwater for 12 to 16 months (Tables 5.14-1 and 5.14-2), however, some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage water temperatures in the lower American River and meet water temperature requirements for rearing Fall-run/Late Fall-run Chinook Salmon during drought conditions and improve conditions for this life stage.

5.14.5.5.8.3 Adult Migration from Ocean to Rivers

Adult Central Valley Fall-run/Late Fall-run Chinook Salmon are present in summer through winter and in relatively high abundance primarily in October through March, spawning soon after entering their natal streams (Tables 5.14-1 and 5.14-2) (Moyle 2002; Yoshiyama et al. 1998). Central Valley Fall-run/Late Fall-run Chinook Salmon require cool freshwater. In the Central Valley, fall water temperatures are reportedly suitable for Chinook Salmon only above 150 to 500-m elevations, and most of that high elevation habitat is now upstream of impassable dams (Schick et al. 2005). The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage temperatures in the lower American River and meet water temperature requirements for Chinook Salmon during drought conditions and improve conditions for this life stage. Therefore, it is concluded that this proposed action would likely beneficially affect this life stage of Fall-run/Late Fall-run Chinook Salmon in the lower American River by reducing the effects of drought conditions on water temperatures.

5.14.5.5.8.4 Adult Holding in Rivers

The implementation of the proposed drought temperature management measures under the proposed action would improve Reclamation's ability to manage temperatures in the lower American River and meet water temperature requirements for Fall-run/Late Fall-run Chinook Salmon holding in the lower American River during drought conditions and improve conditions for this life stage.

5.14.5.5.9 Stanislaus River Spawning and Rearing Habitat

5.14.5.5.9.1 Eggs to Fry Emergence

Habitat restoration activities under the proposed action would benefit Fall-run Chinook Salmon by increasing available spawning habitat (by placement of additional spawning gravel). The plot below shows the available spawning habitat in the Stanislaus River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon the Stanislaus River.

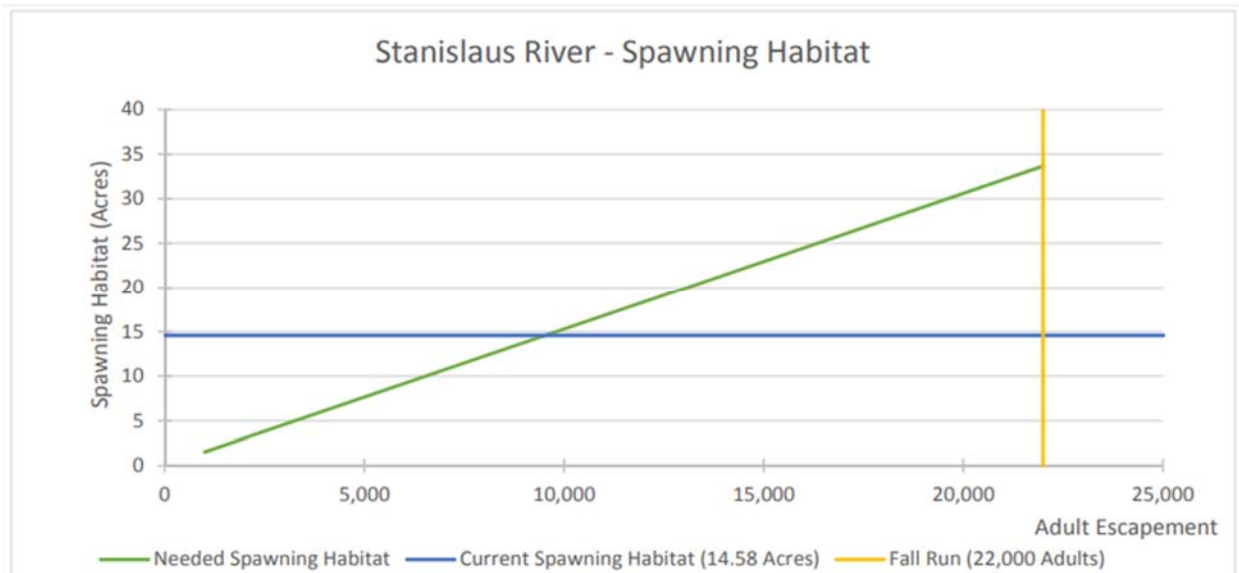


Figure 5.14-22. Estimated Chinook spawning habitat needed in the Stanislaus River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning habitat restoration are not expected to affect eggs and emerging fry due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15th). The in-water work window will completely avoid the eggs and emerging fry life stage, as Fall-run/Late Fall-run Chinook Salmon typically spawn between October through November, and fry emerge between December and March (Table 5.14-2).

5.14.5.5.9.2 Rearing to Outmigrating Juveniles

Habitat restoration activities would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available rearing habitat. Reclamation expects that the additional rearing habitat would support the progeny of an additional 2,800 adult salmon. The plot below shows the available rearing habitat in the Stanislaus River, along with the needed habitat to support various population sizes. Also shown is the CVPIA doubling goal for Fall-run Chinook Salmon in the Stanislaus River. The creation of side channel and rearing habitat would increase the quality and quantity of off channel rearing (and spawning areas). The habitat restoration activities would improve the riparian habitat available for, Fall-run Chinook Salmon rearing. The benefit of the habitat restoration activities within the Stanislaus River would yield increasing riparian vegetation, which provides:

- instream object and overhanging object cover;
- new shaded riverine habitat; and
- additional area for food source.

The creation of side-channel and floodplain rearing habitat would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover.

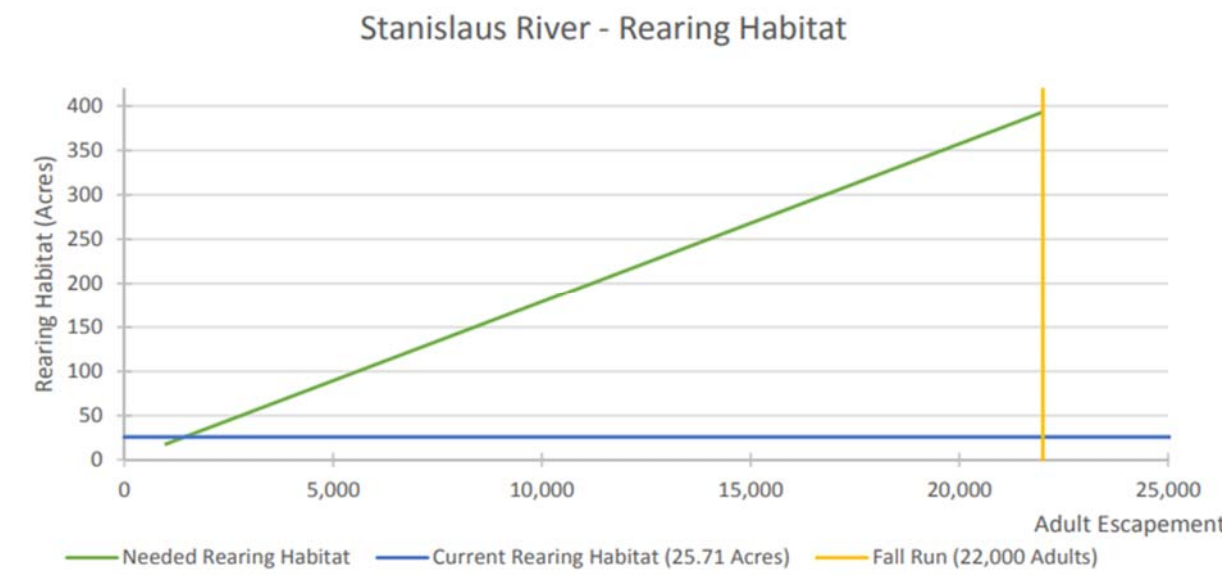


Figure 5.14-23. Estimated Chinook rearing habitat needed in the Stanislaus River to support the range of escapement sizes (CVPIA 2018).

The construction activities associated with spawning and rearing habitat restoration under the proposed action are not expected to affect rearing and outmigrating Fall-run Chinook Salmon due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures* and implementation of an in-water work window (July 15 through October 15th).

5.14.5.5.9.3 Adult Migration from Ocean to Rivers

Habitat restoration activities under the proposed action would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration are not expected to affect immigrating Fall-run/Late Fall-run Chinook Salmon to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to avoid effects to immigrating individuals.

5.14.5.5.9.4 Adult Holding in Rivers

Habitat restoration activities would benefit Fall-run/Late Fall-run Chinook Salmon by increasing available spawning habitat.

The construction activities associated with spawning habitat restoration are not expected to affect adults holding Fall-run/Late Fall-run Chinook Salmon in the Stanislaus River due to the implementation of general avoidance and minimization measures identified in Appendix E, *Avoidance and Minimization Measures*. Additionally, per Appendix E, Reclamation will implement an in-water work window of July 15 through October 15 to reduce further effects to holding individuals.

5.14.5.5.10 Lower SJR Habitat

Under the proposed action, restoration of lower San Joaquin River spawning and rearing habitat for salmonids, including a large extent of floodplain habitat, would have the potential to increase rearing habitat for Fall-run Chinook Salmon on the San Joaquin River. Increased rearing habitat provides cover from predators and habitat complexity as well as food. Construction impacts to Fall-run Chinook salmon due to potential outmigrating juveniles would be minimized with AMMs.

5.14.5.5.11 Tracy Fish Facility Improvements

5.14.5.5.11.1 Rearing to Outmigrating Juveniles in the Bay-Delta

A small proportion of juvenile Fall-run Chinook Salmon are expected to be exposed to the Tracy Fish Facility improvements (Zeug and Cavallo 2014). However, for fish that arrive at the facility, the proposed improvements are likely to increase survival through the facility.

Few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to construction of the CO₂ injection device proposed for the Tracy Fish Facility Improvements, based on lack of observed salvage during the August–October in-water work window (Figures WR_salvage_unclipped_date, WR_salvage_clipped_date, and WR_salvage_clipped_CWT_race in Appendix F, *Juvenile Salmonid Monitoring, Sampling, and Salvage Summary from SacPAS*). To the extent that the construction affects the ability of juvenile Fall-run, and Late-Fall run Chinook Salmon to be efficiently salvaged (as part of the entrainment risk habitat attribute in the SAIL conceptual model; Figure WR_CM4), there could be a minor effect to a small number of individuals, although risk would be minimized through appropriate AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.14.5.5.12 Suisun Marsh Salinity Control Gates Operation

5.14.5.5.12.1 Rearing to Outmigrating Juveniles in the Delta

Under the proposed action, Reclamation would operate the SMSCG to provide food for Delta Smelt in Suisun Marsh. Operation of the SMSCG from June through September under the proposed action coincides with a portion of the downstream migration of Fall-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. However NMFS (2009) determined that operation of the SWSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.5.12.2 Adult Migration from Ocean to Rivers

Operation of the SMSCG from June through September under the proposed action coincides with a portion of the upstream migration of Fall-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. Due to their strong swimming ability and migratory route, the operation of the Suisun Marsh Salinity Control Gate is unlikely to impede the migration of adult salmonids or produce conditions that support unusually high numbers of predators.

5.14.5.5.13 Fall Delta Smelt Habitat

Some juvenile Fall-run Chinook Salmon are anticipated in the Delta in the summer and fall, during the time period that Reclamation would be operating for Fall Delta Smelt habitat. However, actions Reclamation would take under this are unlikely to affect Fall-run Chinook Salmon.

5.14.5.5.14 Clifton Court Predator Management

Predator control efforts in Clifton Court Forebay under the proposed action could reduce pre-screen loss of juvenile Fall-run Chinook Salmon entrained into Clifton Court Forebay. Larger proportions of Late Fall-run Chinook Salmon are lost at the facilities and this action would have a larger beneficial effect for this run.

5.14.5.5.15 Sacramento Deepwater Ship Channel

Moderate to high proportions of juvenile Fall-run Chinook Salmon are expected to be exposed to the Sacramento Deepwater Ship Channel (SDWSC) conservation measure under the proposed action. This conservation measure would hydrologically connect the Sacramento River with the SDWSC via the Stone Lock facility from mid-spring to late fall (Wood Rodgers 2018), allowing food to enter the Delta and an alternate migration pathway. Juvenile Fall-run Chinook Salmon abundance in the Delta is moderate in peaks in April and May (Table 5.14-1). Juvenile Fall-run Chinook Salmon passing the Stone Lock facility when there is a hydrologic connection between the waterways could potentially be entrained into the SDWSC. Estimates of salmonid survival in the SDWSC are not available to compare with rates in the Sacramento River route. However, fish entering the SDWSC would not be exposed to entrainment into the interior Delta through the DCC or Georgiana Slough which would provide a benefit if survival rates are similar.

No San Joaquin River-origin Fall-run are expected to be exposed to the Sacramento Deepwater Ship Channel.

5.14.5.5.16 North Delta Food Subsidies / Colusa Basin Drain

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall, and possibly could contribute food to increase food web productivity during Fall-run Chinook Salmon juvenile outmigration.

5.14.5.5.17 Suisun Marsh Roaring River Distribution System Food Subsidies Study

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG would occur in summer/fall and therefore would have limited effects on Spring-run Chinook Salmon, who are in the Delta between January – February for adults, and November through June for juveniles, with a peak of juvenile migration from March to April.

5.14.5.5.18 Tidal and Channel Margin Restoration

A large proportion of juvenile Fall-run and Late-Fall run Chinook Salmon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. Tidal habitat restoration is expected to benefit juvenile Fall-run/Late Fall-run Chinook Salmon in several aspects represented by the Winter-run conceptual model (5.6-4) including, increased food availability and quality and refuge habitat from predators. These benefits can manifest in higher growth rates and increased survival through the Delta. Migration through the Delta represents a short period in the migration of juvenile and Late Fall-run Chinook Salmon.

Few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to the effects of construction of 8,000 acres of tidal habitat restoration, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Tables 5.14-1 and 5.14-2). Individuals being exposed to construction could experience risk of potential effects similar to those suggested in recent restoration projects such as the Lower Yolo Restoration Project (NMFS 2014). This includes 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 (e.g., gill damage and reduced ability to take in oxygen, increasing metabolic cost), indirect impairment of aquatic ecosystem productivity (e.g., reduction in benthic macroinvertebrate production and availability), 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. Many of these are elements highlighted in the SAIL conceptual model (Figure 5.6-4). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*).

5.14.5.5.19 Predator Hot Spot Removal

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids including Fall-run and Late-Fall run Chinook Salmon. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated are in the primary migratory routes of juvenile Fall-run Chinook. All 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. 2017, Sabal et al. 2017).

5.14.5.5.20 Delta Cross Channel Gate Improvements

Few Fall-run and Late-Fall run Chinook Salmon are expected to be exposed to improvements to the Delta Cross Channel. Seasonal closure periods would still be in place to protect migrating salmonids. Potential diurnal operation during closure periods could increase exposure of Fall-run and Late-Fall run juvenile to entrainment into the interior Delta. However, improved biological and physical monitoring associated with improvements would likely minimize potentially increased entrainment. Greater operational flexibility and increased gate reliability resulting from improvements would reduce the risk of gate failure that could result in higher rates of entrainment.

5.14.5.5.21 Tracy Fish Facility Improvements

Although these actions could positively affect juvenile Fall-run Chinook Salmon through greater salvage efficiency, only small proportions of Fall-run Chinook Salmon are lost at the CVP (Zeug and Cavallo 2014).

5.14.5.5.22 Skinner Fish Facility Improvements

Skinner fish facility improvements from predator control efforts to reduce predation following entrainment into Clifton Court Forebay could reduce pre-screen loss of Fall-run/Late Fall-run juvenile Chinook Salmon entrained into Clifton Court Forebay. However, only small proportions of Fall-run Chinook Salmon are lost at the SWP (Zeug and Cavallo 2014). Larger proportions of Late Fall-run Chinook Salmon are lost at the facilities and this action would have a larger effect for this run.

5.14.5.5.23 Delta Fishes Conservation Hatchery

Potential effects of the Delta Fishes Conservation Hatchery include inadvertent propagation and release of nuisance species and reduced water quality resulting from hatchery discharge. Mitigation and minimization measures are detailed in the EIR/EIS for the facility (Horizon Water and Environment

2017) Potential exposure of juvenile Fall-run Chinook Salmon would be restricted to a small spatial area within the primary migration route.

As with the other proposed construction activities under the proposed action in the Bay-Delta, few juvenile Fall-run or Late-Fall run Chinook Salmon would be expected to be exposed to the effects of construction of the Delta Fishes Conservation Hatchery based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (Tables 5.14-1 and 5.14-2). The relatively few 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 AMMs (Appendix E, *Avoidance and Minimization Measures*). The application of AMMs will reduce effects, and the in-water construction is of a small scale.

5.14.5.6 Monitoring

Effects to Fall-run Chinook Salmon from monitoring would be similar to those discussed for Winter-run and Spring-run Chinook Salmon, as discussed in those sections.

5.15 Effects on Southern Resident Killer Critical Habitat

Critical habitat for the Southern Resident Killer Whale was designated in November 2006 (71CFR 229). Three specific areas are designated, (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, which comprise approximately 2,560 square miles (6,630 sq km) of marine habitat. The designation includes the following PBFs essential for conservation of the Southern Resident Killer Whale:

1. Water quality to support growth and development; and
2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
3. Passage conditions to allow for migration, resting, and foraging.

Southern Resident Killer Whales rely on 23 different species as prey, with salmon being the preferred prey (71 CFR 229). Given that critical habitat occurs within Puget Sound and the Strait of Juan de Fuca, the majority of prey consumed within critical habitat consists of populations native to rivers tributary to that habitat. The precise proportion of Central Valley-origin Chinook salmon consumed in the Southern Resident Killer Whale diet when they are feeding within critical habitat has not been determined, but fewer than 10% of Central Valley-origin Chinook salmon are collected from as far north as Tillamook Head on the northern Oregon coast (Satterthwaite et al. 2013). Southern Resident Killer Whale critical habitat is several hundred kilometers north of that area. The principal source of prey for Southern Resident Killer Whale within critical habitat is Fraser River-origin Chinook salmon, with chum salmon also important for fall foraging in Puget Sound (National Marine Fisheries Service 2014b).

In summary, the proposed action has no potential to affect water quality within Southern Resident Killer Whale critical habitat. The proposed action is unlikely to affect the production of Central Valley–origin Chinook salmon; and the proportion of Central Valley-origin Chinook salmon occurring within designated critical habitat is very low and thus has negligible potential to affect the Southern Resident Killer Whale prey base within critical habitat.

5.16 Delta Smelt

The effects of seasonal operations in the proposed action, as compared to without action, include entrainment into the central and south Delta, salvage loss in the export facilities, lower Delta outflow during the spring, and higher Delta outflow in the summer and fall. The effects of lower flows reduce food production and transport. OMR management as part of the proposed action Core Water Operation seeks to minimize and/or avoid entrainment risk and salvage loss. The proposed action includes the Fall Delta Smelt Habitat action, Suisun Marsh Salinity Control Gate Operation, and restoration of tidal marsh habitat. These conservation measures seek to provide a low salinity zone within productive Delta Smelt habitat. Conservation measures under the proposed action also include food subsidy studies aiming to meet the needs of Delta Smelt for food production and retention that would otherwise occur in lost habitat.

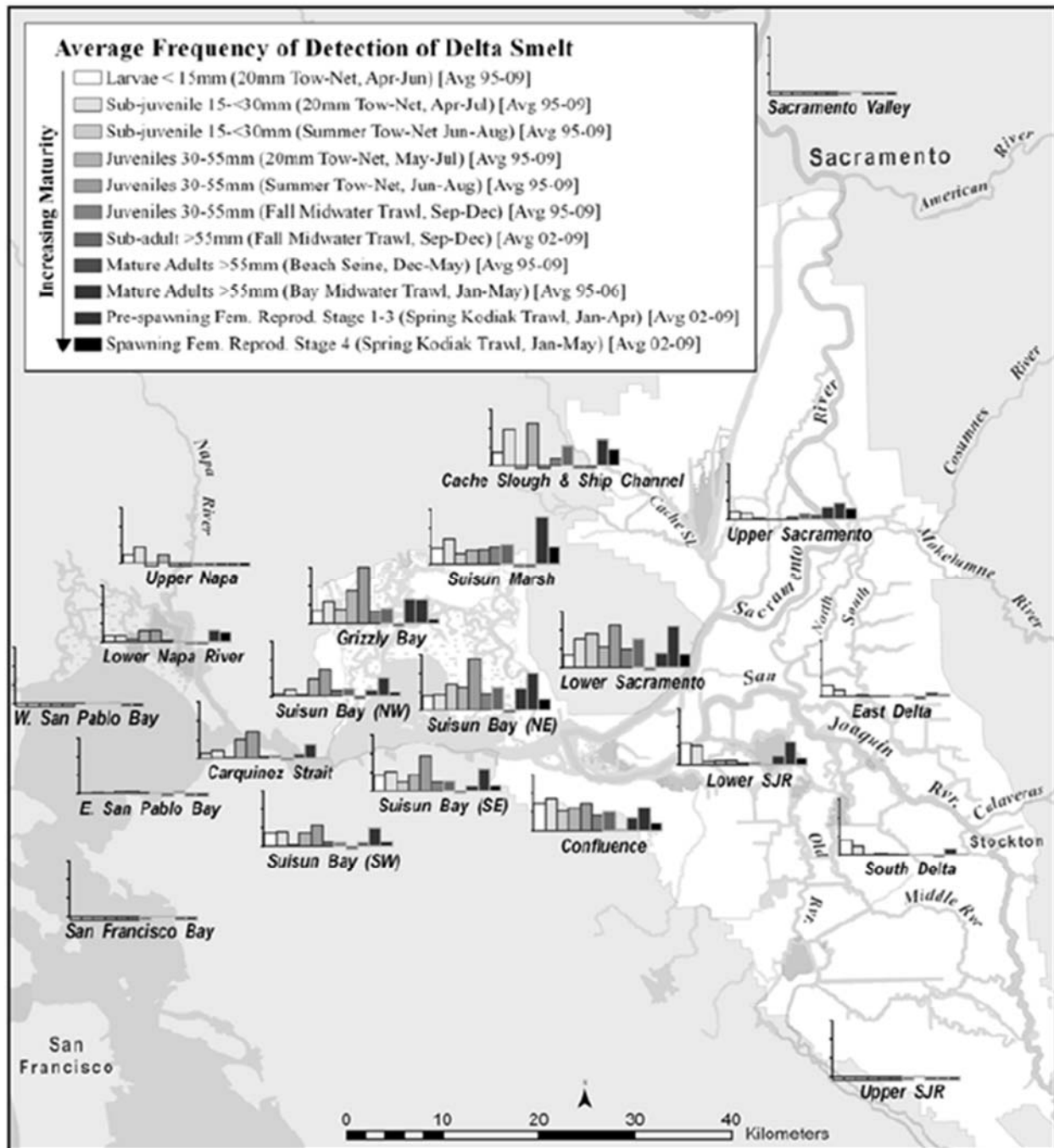
OMR management for Delta Smelt under the proposed action establishes protective criteria to avoid entrainment based on work from the Delta Smelt Scoping Team under the Collaborative Science and Adaptive Management Team. Additional protective measures occur when environmental criteria indicate that entrainment is more likely. Enhanced monitoring in real-time and predictive tools provide additional information that allows for more flexible water operations.

The legacy of levees and dredging of channels reduced the availability of high quality habitat to areas within a “north Delta arc” (habitats within the north portion of the Delta along the Sacramento River) and downstream of the confluence of the Sacramento and San Joaquin Rivers into Suisun Marsh and Suisun Bay. The absence of habitat throughout the Delta requires higher Delta outflow to maintain suitable water quality in the remaining areas that Delta Smelt can rear. The proposed action is structured to respond to this degraded environmental baseline. Management of the low salinity zone into the confluence provides low salinity water quality and food export into the remaining areas of high productivity. Operation of the Suisun Marsh Salinity Control Gate provides low salinity habitat at a lower water cost. Tidal habitat restoration increases the areas of high quality habitat. Food subsidy projects address stresses on populations due to food limited conditions in the absence of productive habitat.

Other stressors continue to impact Delta Smelt including contaminants, invasive species and warm water temperatures. These factors will continue to reduce the ability of Delta Smelt to reproduce and rebuild populations. Reintroduction from the U.C. Davis Fish Conservation and Culture Laboratory jump starts rebuilding the population to buffer against external factors. In the long-term, the Delta Fish Species Conservation Hatchery under the proposed action can support the population.

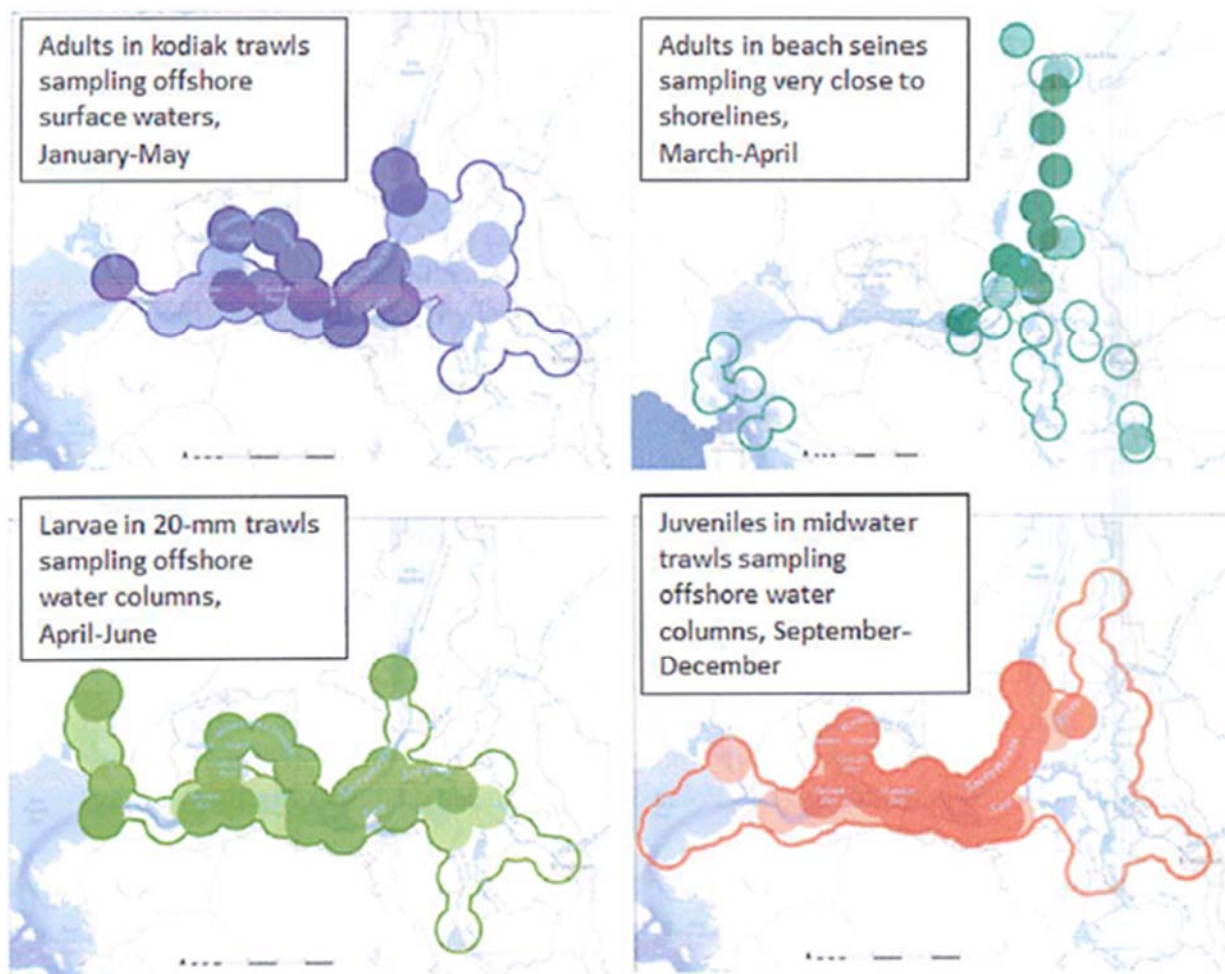
5.16.1 Lifestage Timing and Distribution

The effect analysis considers where the proposed action overlaps with the life stage timing and distribution of Delta Smelt in the action area, as illustrated in Figures 5.16-1 and 5.16-2.



Source: Merz et al. (2011, p.178). Note: Regions where the average frequency of detection for a given life stage was zero are indicated by no data column being present. Regions that were not sampled for a given life stage are indicated by a data column suspended slightly below the x-axis. Y-axis ticks indicate frequencies of 0, 25, 50, 75, 100 percent.

Figure 5.16-1. Average Annual Percentage of Sampling Events Where Delta Smelt Were Observed by Life Stage and Region for Interagency Ecological Program Surveys.



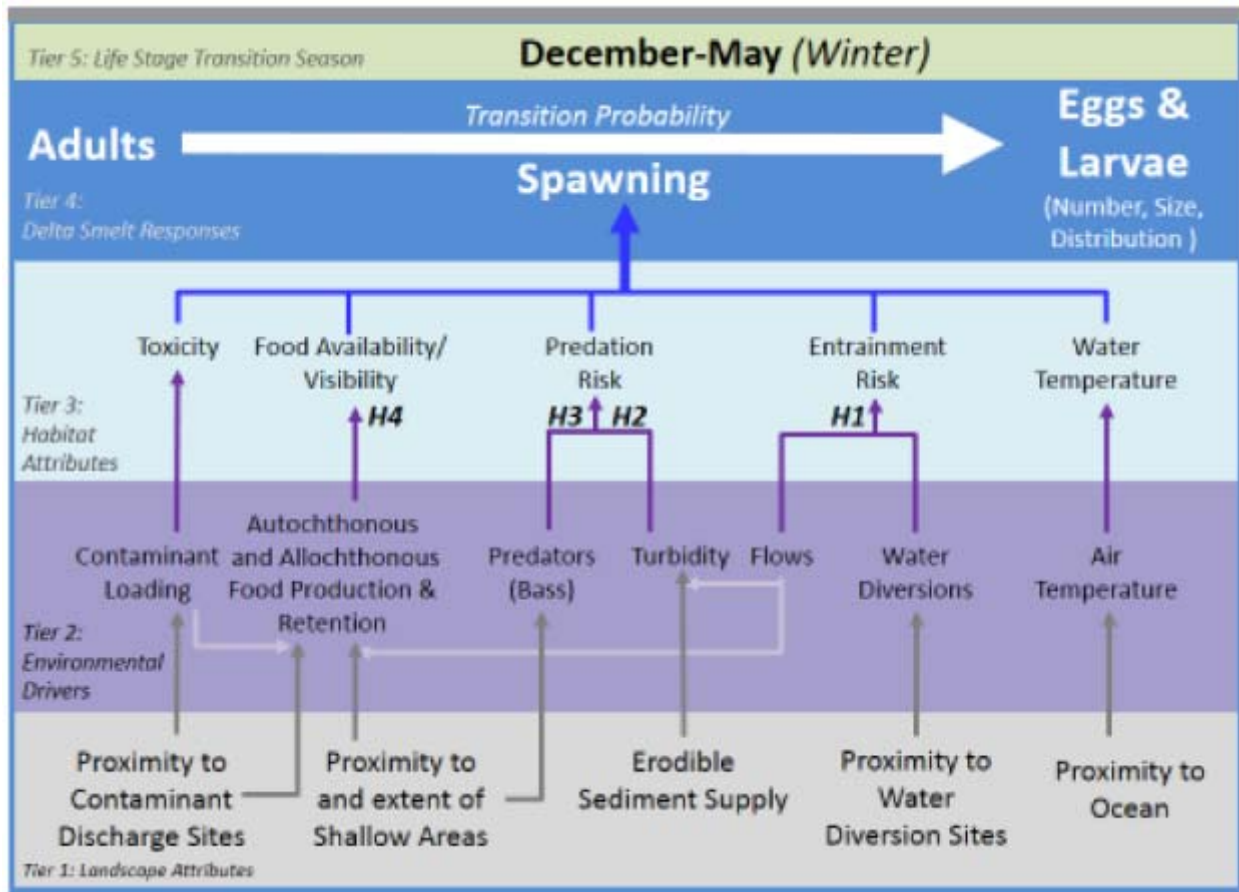
Source: USFWS (2017a, p.141). Note: The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the Delta Smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of delta smelt collections occurred.

Figure 5.16-2. Maps of Multi-Year Average Distributions of Delta Smelt Collected In Four Monitoring Programs

5.16.2 Conceptual Models

The IEP MAST (2015) developed “a general life cycle conceptual model for the four Delta Smelt life stages (adults, eggs and larvae, juveniles, and subadults) that includes stationary landscape attributes and dynamic environmental drivers, habitat attributes, and Delta Smelt responses”.

A life stage transition in the December–May period addresses adults transitioning to eggs and larvae. Adults seldom if ever fully mature in December, but begin dispersing at that time. Additionally, there is limited impact to eggs/larvae until February. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-3.

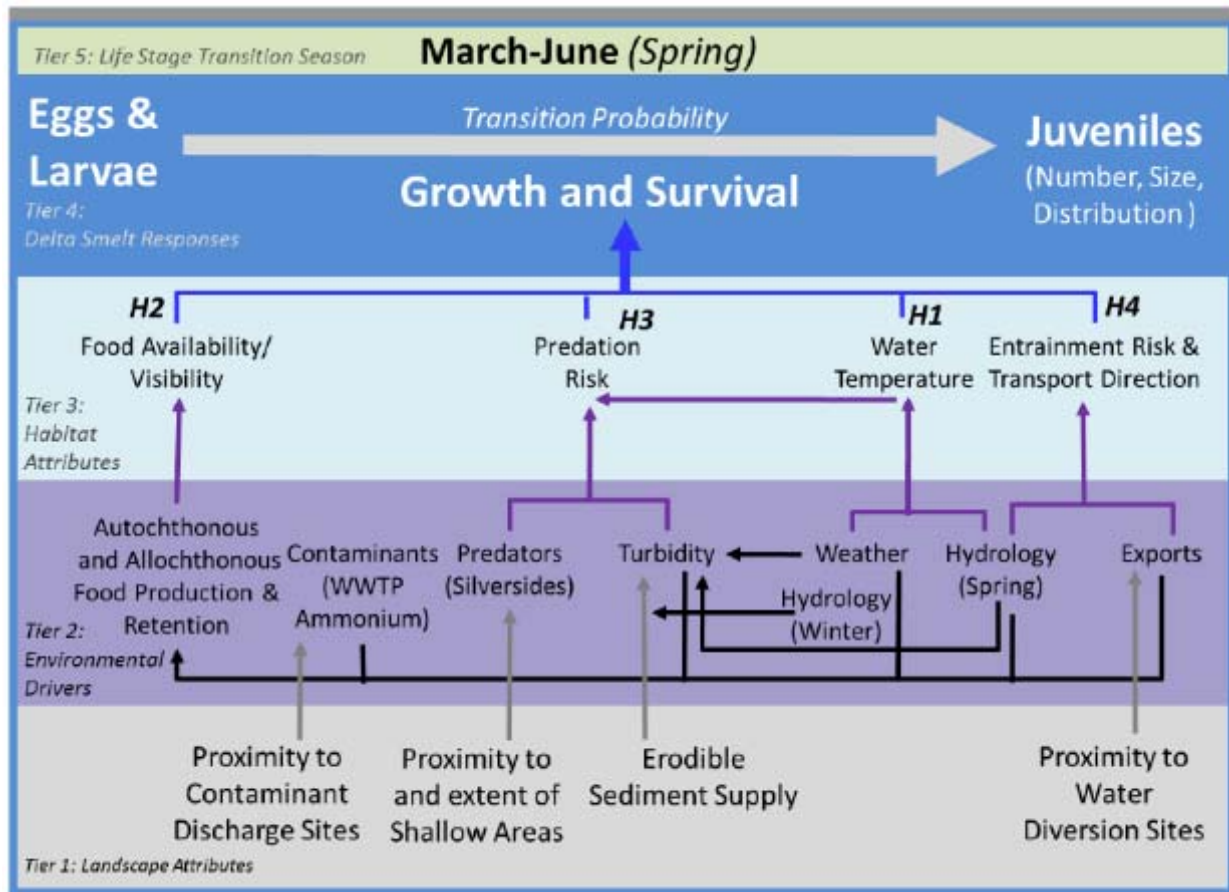


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-3. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Adults to Eggs/Larvae.

Adult habitat attributes and environmental drivers related to the proposed action are primarily entrainment risk due to exports and food availability.

A life stage transition in the March–June period address eggs/larvae transitioning to juveniles. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-4.

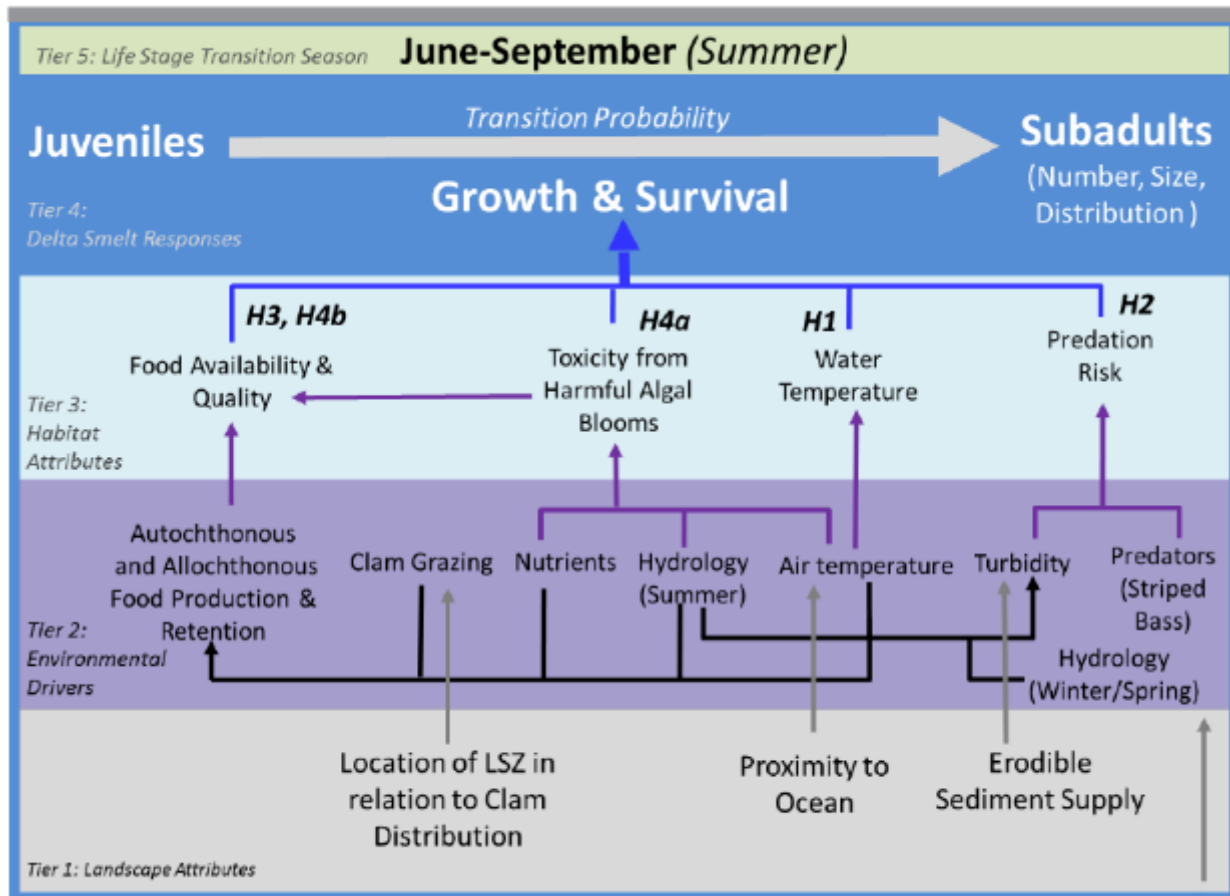


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-4. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Eggs/Larvae to Juveniles.

Larvae habitat attributes and environmental drivers related to the proposed action are primarily food availability from food production and retention and entrainment risk due to exports.

A life stage transition in the June–September period addresses juveniles transitioning to subadults. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-5.

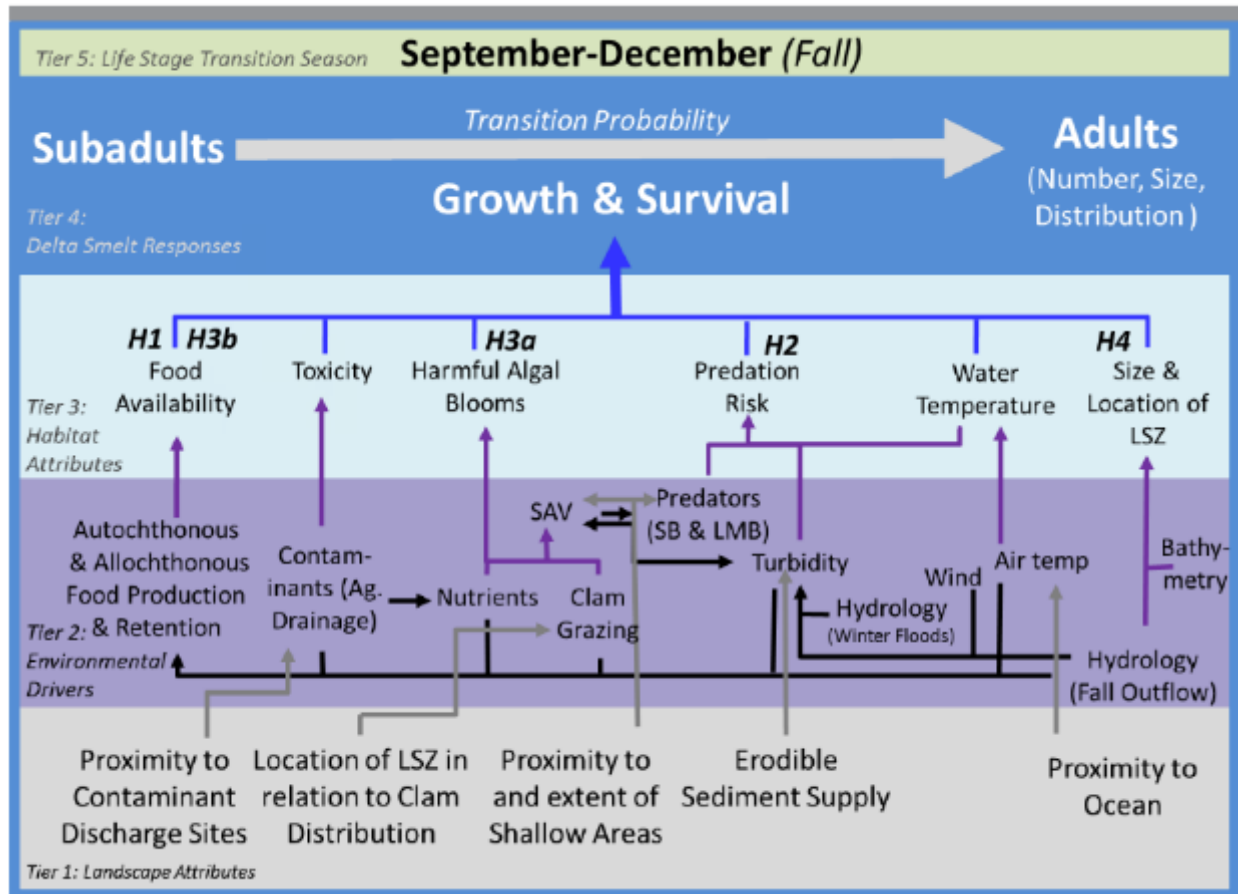


Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-5. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Juveniles to Subadults.

Juvenile habitat attributes and environmental drivers related to the proposed action are primarily food availability from food production and retention, as well as sediment changes relating to predation, and algal blooms.

A life stage transition in the September–December period addresses subadults transitioning to adults. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are illustrated in Figure 5.16-6.



Source: IEP MAST (2015). Note: Hypotheses are referenced by the H-number for habitat attributes.

Figure 5.16-6. Conceptual Model of Drivers Affecting the Transition of Delta Smelt Subadults to Adults.

Subadult habitat attributes and environmental drivers relates to the proposed action are primarily food availability from food production and retention.

5.16.3 Effects of Operations and Maintenance

5.16.3.1 Seasonal Operations

The storage and diversion of water under the proposed action results in changes to the low salinity zone as represented in the position of X2. The position of X2 for the proposed action is further upstream than without action on average (Figure 5.16-7).

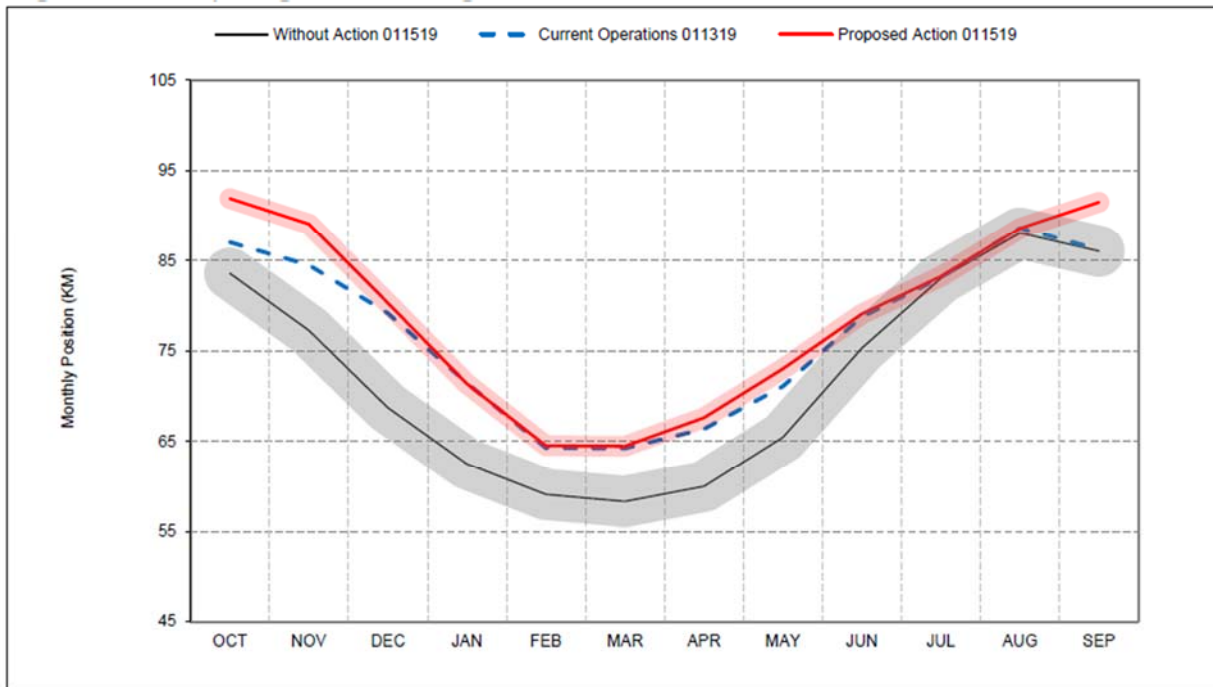


Figure 5.16-7. X2 Long-term Average Position by Month

The differences between the proposed action and without action depend upon the water year type and season (Figure 5.16-8 and 5.16-9).

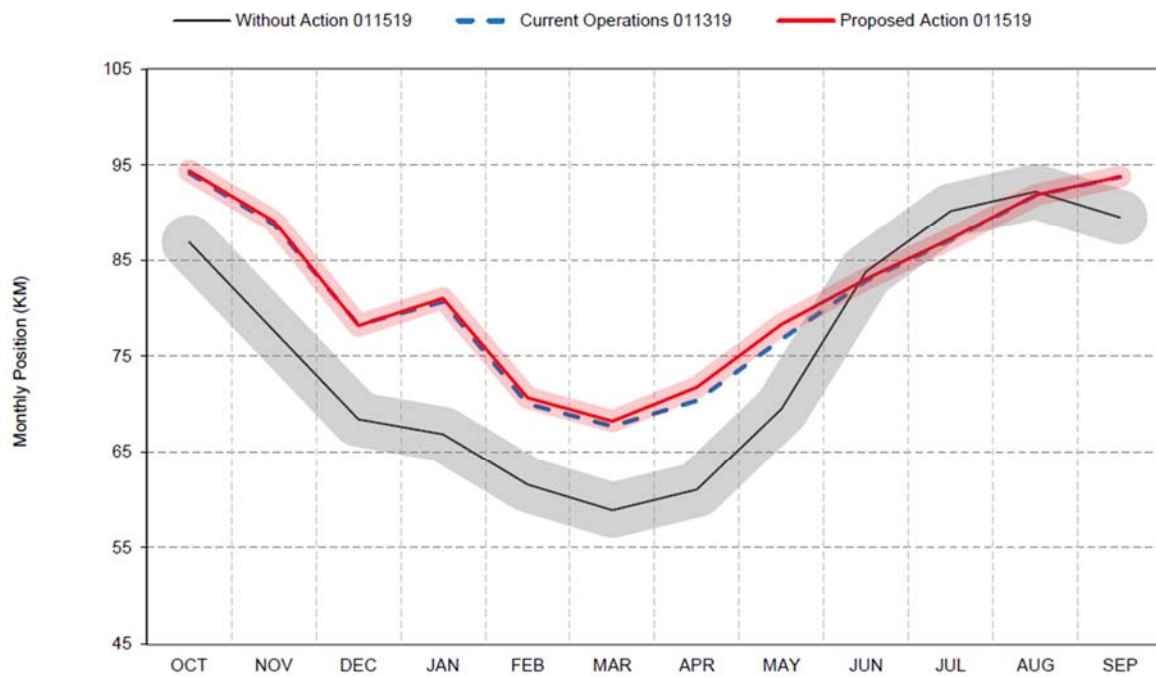


Figure 5.16-8. X2 Dry Year Position by Month

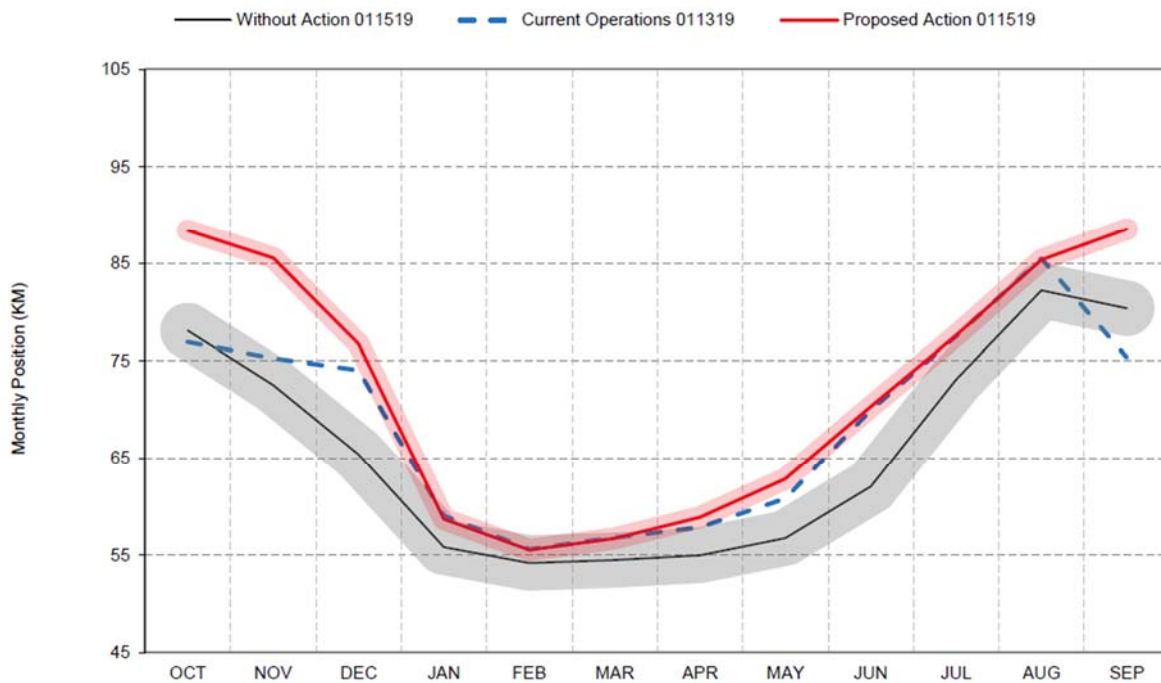


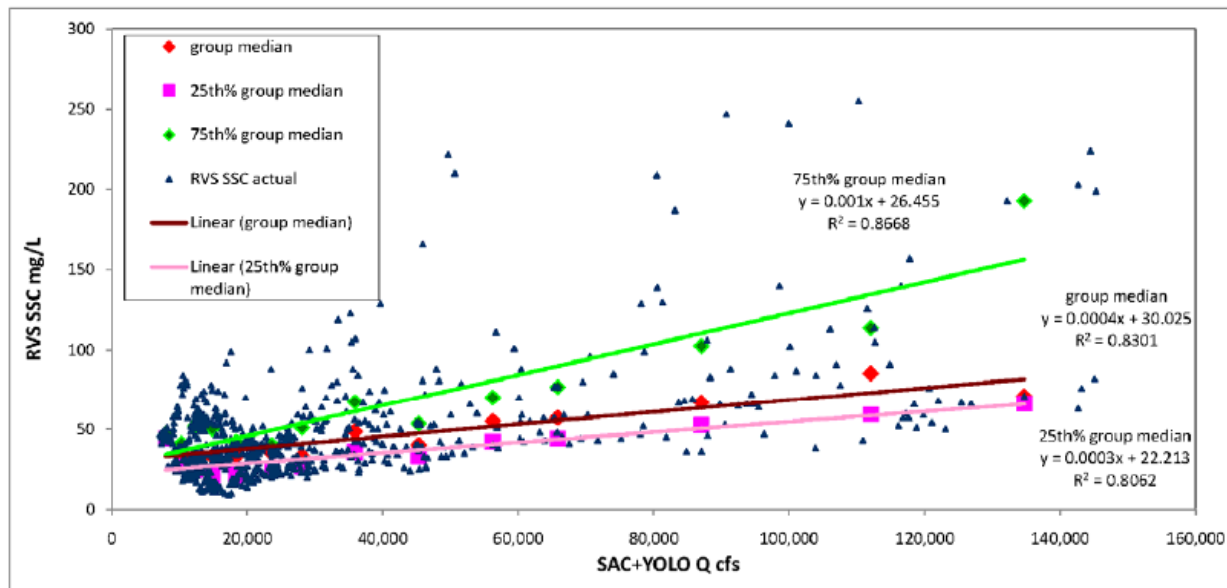
Figure 5.16-9. X2 Wet Year Position by Month

The effect of seasonal operations in the proposed action as compared to without action is to reduce the frequency of the low salinity zone being located within the productive habitat of Suisun Marsh and bay during some seasons and hydrologic year types, and increase the frequency in others.

5.16.3.1.1 Adults to Eggs and Larvae

5.16.3.1.1.1 Predation Risk

The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting Delta Smelt egg survival (Figure 5.16-3). Flows interact with erodible sediment supply to affect turbidity. In general, greater turbidity is thought to lower the risk of predation on delta smelt. Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action. A conceptual model of sedimentation in the Delta includes a submodel for river supply, which notes that dams and reservoirs have contributed to decreased sediment supply to the Delta (Schoellhamer et al. 2012, their Figure 4). Under the without action scenario, the dams and reservoirs continue to block sediment supply. Greater flow passing through reservoirs may pass greater amounts of sediment supply than under current operations and the proposed action. Cloern et al. (2011, their Figure S1) developed a rating curve of Sacramento River at Rio Vista suspended sediment concentration as a function of Sacramento River at Freeport + Yolo Bypass flows to the Delta (reproduced as Figure 5.16-10, below). Based on this curve, differences between the proposed action and without action scenarios in suspended sediment concentration as a function of mean winter-spring Rio Vista flows (Figures 32-9, 32-10, 32-11, 32-12, 32-13, and 32-14 in Appendix D, *Modeling*) are suggested to potentially be low during the high flow winter months (December–February), whereas differences in spring (April–May) could be greater.



Source: Cloern et al. (2011, their Figure S1).

Figure 5.16-10. Sediment Rating Curve for the Sacramento River at Rio Vista, 1998-2002

Below is a figure showing daily observed turbidity at the False River Near Oakley (FAL) gaging station versus Delta outflow, raw data from 2007-2018 (Figure 5.16-11).

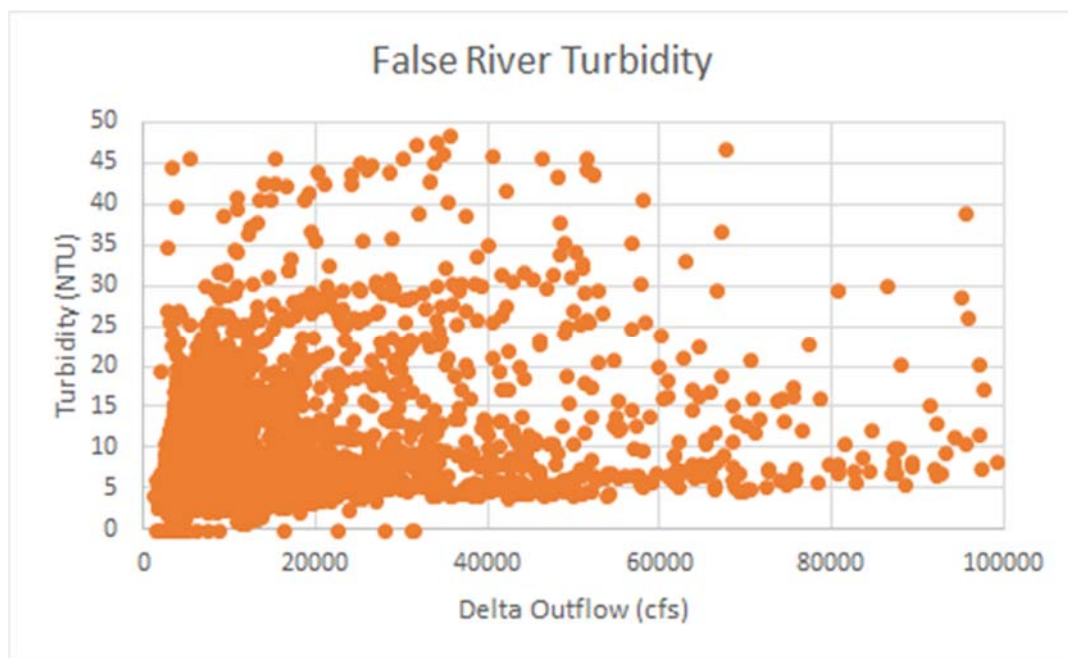


Figure 5.16-11. Turbidity versus flow at False River (FAL) from 2007-2018

Available estimates of sediment removal by the south Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in 1999–2002 (Wright and Schoellhamer 2005). These estimates were made at similar ratios of south Delta exports to Sacramento River + Yolo Bypass inflow as were modeled for the proposed action scenario suggesting that south Delta exports under the proposed action would remove only a small percentage of sediment entering the Delta. Given the limited expected difference in suspended sediment entering the Delta under the proposed action relative to without action, as well as the small percentage of sediment that would be expected to be removed by the south Delta export facilities, the potential negative effect of the proposed action on turbidity generally would be expected to be low. Per the MAST conceptual model, high turbidity relates to low predation risk for Delta Smelt. There is uncertainty in this conclusion given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012, their Figure 7), and the fact that quantitative analyses of the effects of exports on predation risk and turbidity have not been conducted (IEP MAST 2015, p.52).

5.16.3.1.1.2 Food Availability

Although food availability during other life stages has been suggested to be important from various statistical and modeling analyses (e.g., Miller et al. 2012; Kimmerer and Rose 2018), food availability is also posited by the IEP MAST (2015) conceptual model to affect the probability of adults spawning and transitioning to egg/larval production (Figure 5.16-3). The draft Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR suggests that implementation of the Fremont Weir notch could increase food web productivity and therefore benefit growth and survival of Delta Smelt adults occurring downstream of the Yolo Bypass during the winter (DWR and Reclamation 2017, p.8-111 to p.8-112). This potential positive effect could improve the likelihood of adult Delta Smelt successfully spawning, per the mechanism described by the IEP MAST (2015) conceptual model (Figure 5.16-3). Flow is needed in the Yolo Bypass to create this food effect. The Yolo Bypass was assumed to be operational in this biological assessment, therefore all modeling scenarios show flow through Yolo Bypass, providing for this potential positive effect on Delta Smelt spawning (see Appendix D, *Modeling* for the mean modeled flow through Yolo Bypass in various months).

5.16.3.1.2 Eggs and Larvae to Juveniles (March - June)

5.16.3.1.2.1 Food Availability

The IEP MAST (2015) conceptual model suggests that south Delta exports could affect food availability for larval Delta Smelt (Figure 5.16-4), due to entrainment of food (Jassby and Cloern 2000; Kimmerer and Rose (2018 Trans Am Fish Soc)). There is a positive correlation between the density of the important Delta Smelt larval/juvenile zooplankton prey *Eurytemora affinis* in the low salinity zone and Delta outflow (as indexed by X2) during the spring (March–May; Kimmerer 2002, Greenwood 2018). Also, outflow is required to continuously flush *P. forbesi*, a relatively recent important Delta Smelt food source, from freshwater areas where it grows (Kimmerer et al. 2018 SFEWS) into Delta Smelt habitat, where it is eaten by larval Delta Smelt once it is abundant in May–June (Nobriga 2002; Slater and Baxter 2014). Therefore, the mechanism suggested by the conceptual model for the effects of south Delta exports on food availability could be related to hydrodynamic effects of Delta outflow. As shown in Figure X2_marmay, Delta outflow would be lower under the PA than the WOA scenario, and therefore X2 would be greater (i.e., further upstream). Based on the negative relationship between *Eurytemora affinis* density and X2, the modeling results suggest that food density for *Eurytemora affinis* under the proposed action could be negatively affected, which could potentially affect individual Delta Smelt growth and survival per the MAST conceptual model assuming other interactions in the relationship are fixed. As noted by Greenwood (2018, p.4-5), there is appreciable uncertainty in the predictions of *Eurytemora affinis* density as a function of X2, with 95% prediction intervals typically spanning several orders of

magnitude. This correlation may be reflecting a water temperature influence of high flow conditions and the loss of mysids which were a historical predator whose abundance was high when flow was high.

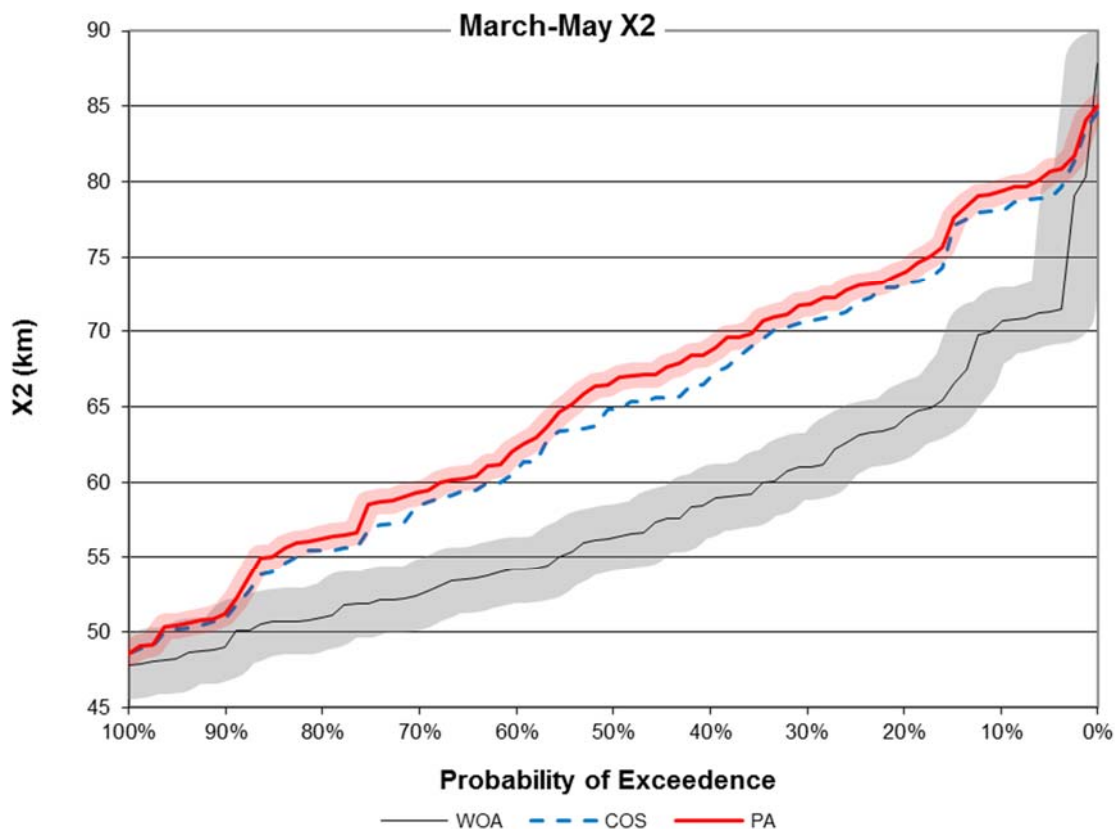


Figure 5.16-12. Mean Modeled X2 from CalSim, March–May

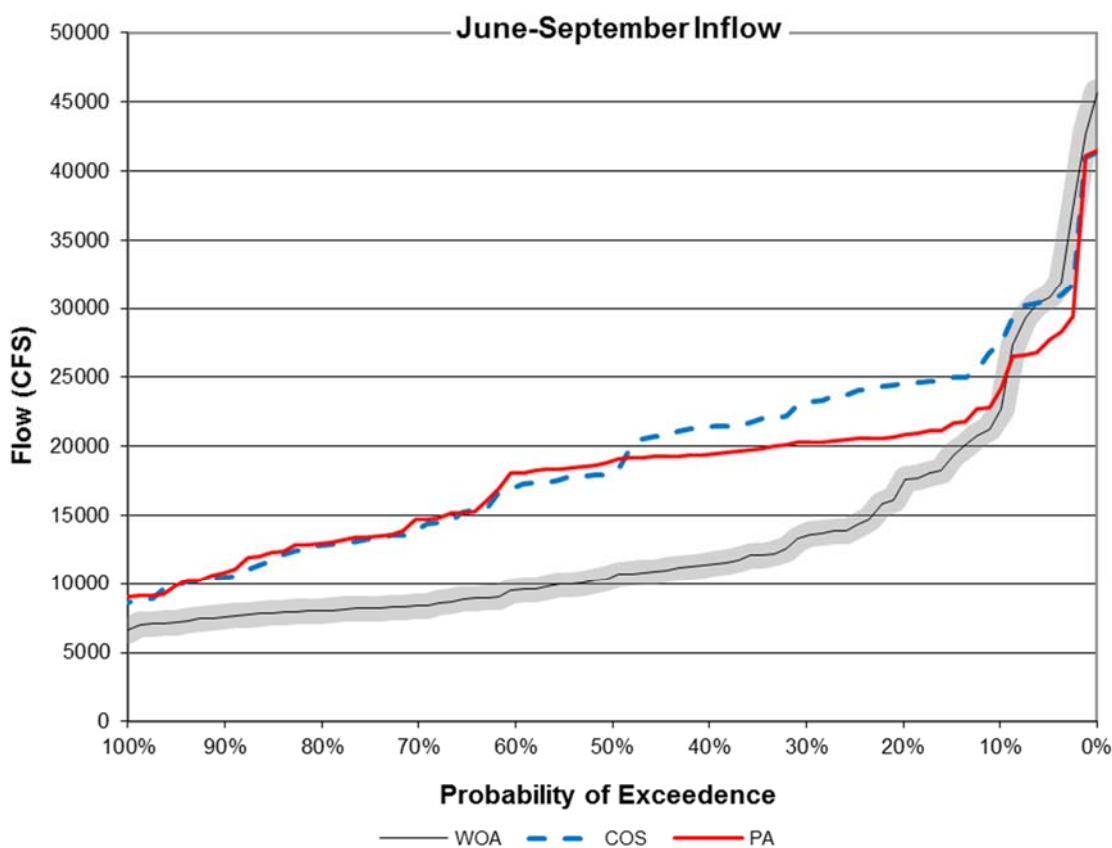
The proposed action includes construction of the rest of the 8,000 acres of tidal habitat restoration to offset potential negative effects on food availability based on the hydrodynamic influence of the south Delta export facilities during the spring larval and early juvenile Delta Smelt period (Kratville 2010); these factors could reduce the potential negative effects from the proposed action on larval/early juvenile Delta Smelt food availability. Under WOA, habitat restoration would not occur.

5.16.3.1.2.2 Predation Risk

The IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides) (Figure 5.16-4). As previously described for adult Delta Smelt, potential effects of the proposed action on turbidity as a result of reduced upstream supply and removal by south Delta exports are concluded to be low, although this is uncertain. Wild detection of embryos and larvae are sparse, which reduces the certainty of any conclusions, although silversides have been found with Delta Smelt in their guts during the larval period (Schreier et al. 2016). As discussed by USFWS (2017a, p.274), water temperature in the San Francisco Estuary is driven mainly by air temperature and

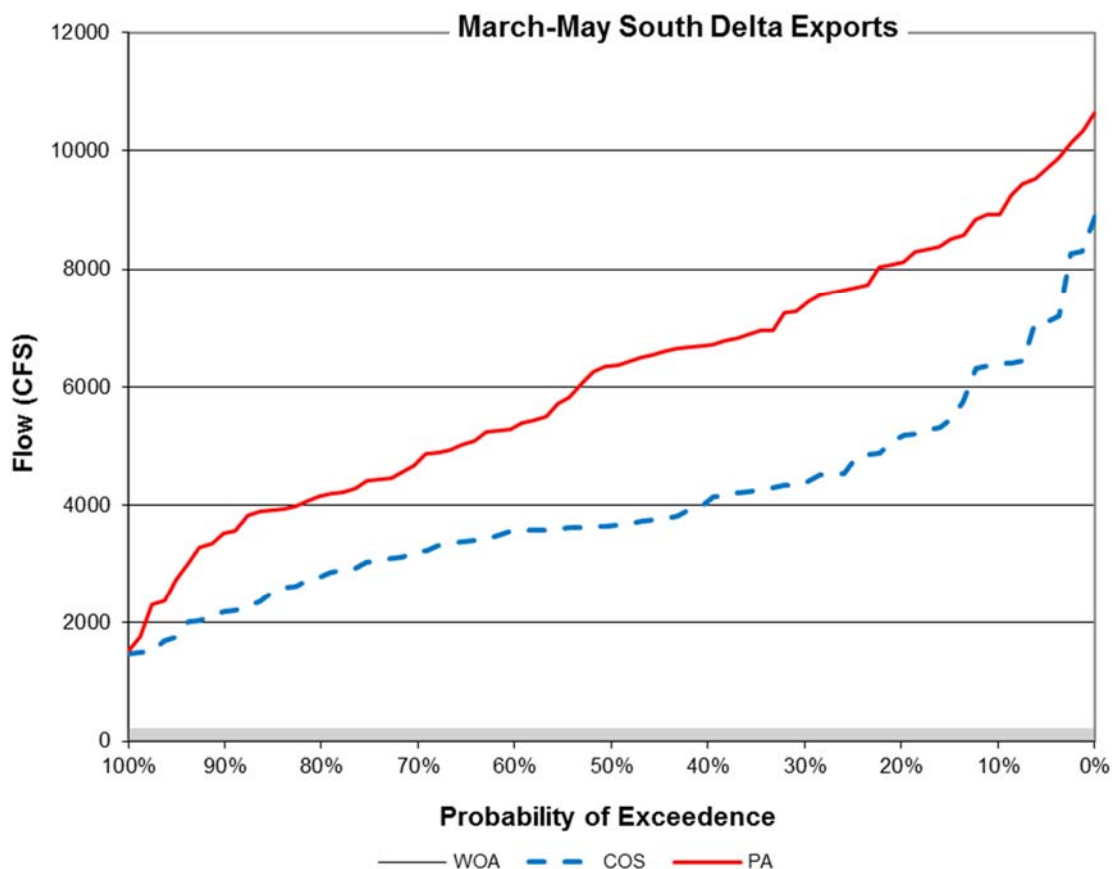
even in the Delta the water temperature is only slightly affected by freshwater inflow; flow-related effects on Delta water temperature are expected to be minor (Wagner et al. 2011).

With respect to silversides, Mahardja et al. (2016) found in a multivariate model that summer (June–September) Delta inflow and spring (March–May) south Delta exports had the strongest correlations with cohort strength; both relationships were negative. Mahardja et al. (2016, p.12) cautioned that the relationships are not meant to imply causality, given that the mechanisms could not be identified, and that further investigation is merited. In addition, beach seines (used in the study) only sample upstream of the confluence, so if high flow moves silversides downstream, then the inverse correlation of flow and abundance is misleading. Recognizing this uncertainty, the proposed action would not be expected to result in greater silverside cohort strength than without action, given that both spring south Delta exports and summer inflow to the Delta generally are greater under the PA compared to WOA, as shown in Figure 5.16-13 and Figure 5.16-14. A similar situation exists for the comparison of COS to the WOA.



Note: Delta inflow is represented by Freeport + Yolo + Mokelumne + Vernalis flow.

Figure 5.16-13. Mean Modeled Delta Inflow, June–September



Note: South Delta exports under the WOA scenario are zero.

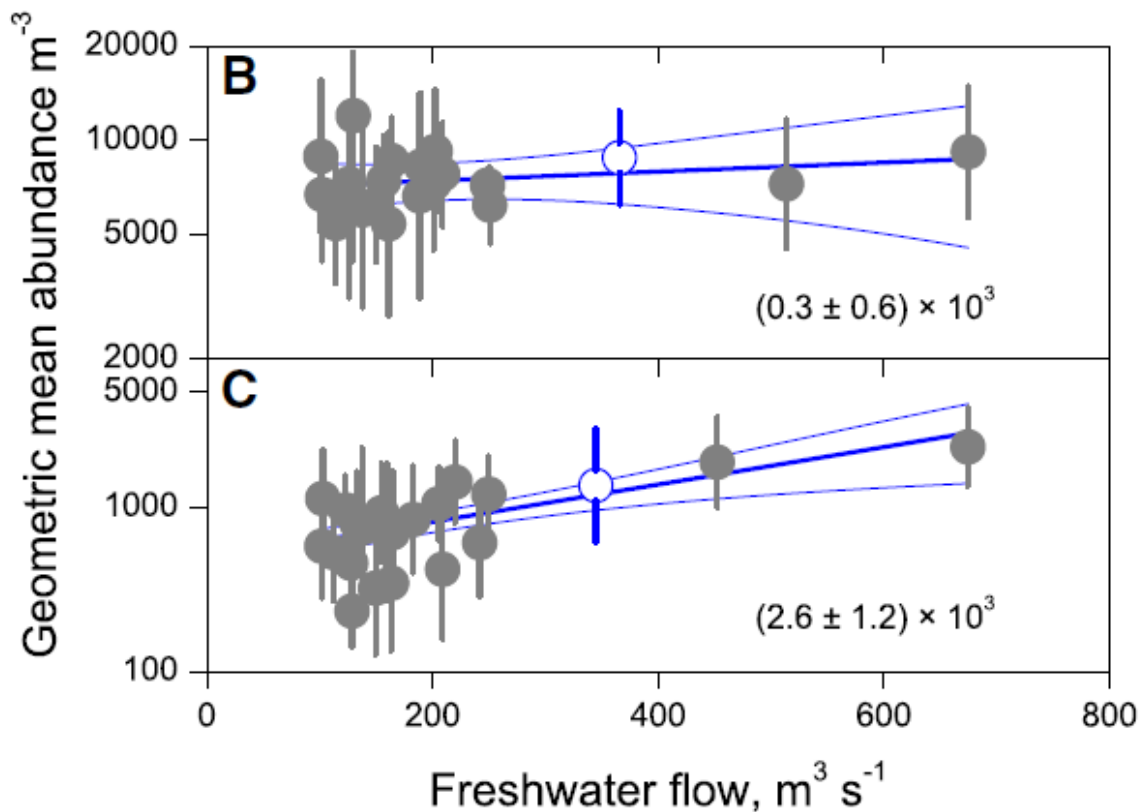
Figure 5.16-14. Mean Modeled South Delta Exports, March–May

5.16.3.1.3 Juveniles to Subadults (June-September)

5.16.3.1.3.1 Food Availability

As described in the IEP MAST (2015) conceptual model, food availability and quality is a key component of the June–September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals (Figure 5.16-5). The south Delta exports influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018a), with these potential negative effects probably being of particular importance on the San Joaquin River side of the Delta given the high density of *P. forbesi* there (Kimmerer et al. 2018b). South Delta exports may entrain *P. forbesi* (USFWS 2008, p.228; Kimmerer et al. 2018b), resulting in a positive correlation between July–September Delta outflow and *P. forbesi* density in the low salinity zone (Kimmerer et al. 2018a; Figure pforbes1). Given the suggested importance of the San Joaquin River side of the Delta for spatial subsidy of *P. forbesi* to the low salinity zone and modeled losses of *P. forbesi* to entrainment by the south Delta export facilities (Kimmerer et al. 2018b), modeled flows in the lower San Joaquin River (DSM2 outputs RSAN018 + SLTRM004 + SLDUT007, which is a representation of QWEST) may offer some perspective on relative differences in this potential negative effect between

operational scenarios. QWEST is defined as the average daily flow traveling past Jersey Point. As shown in the figures below (Figures 5.16-16 to 5.16-18), July–September QWEST flows generally would be positive under WOA, whereas the PA would have positive QWEST flows in a small percentage of years (similar to COS), possibly indicating a lower potential for spatial subsidy of *P. forbesi* to the low salinity zone under the proposed action relative to without action.



Source: Kimmerer et al. (2018b). Note: Error bars are 95% confidence limits based on all samples from the selected stations, and points for 2011 are shown as open circles. Lines with error bounds are from least-squares models of log of abundance versus flow, weighted by the inverse of variance. Values are slopes with 95% confidence intervals; only the slope for the low salinity zone stations was statistically significant.

Figure 5.16-15. July–September Geometric Mean Abundance of *Pseudodiaptomus forbesi* Copepodites and Adults for 1994–2016 in (B) Freshwater Stations (Salinity < 0.5) and (C) Low Salinity Zone Stations (Salinity 0.5–5), Excluding Suisun Marsh and the Central to Eastern Delta.

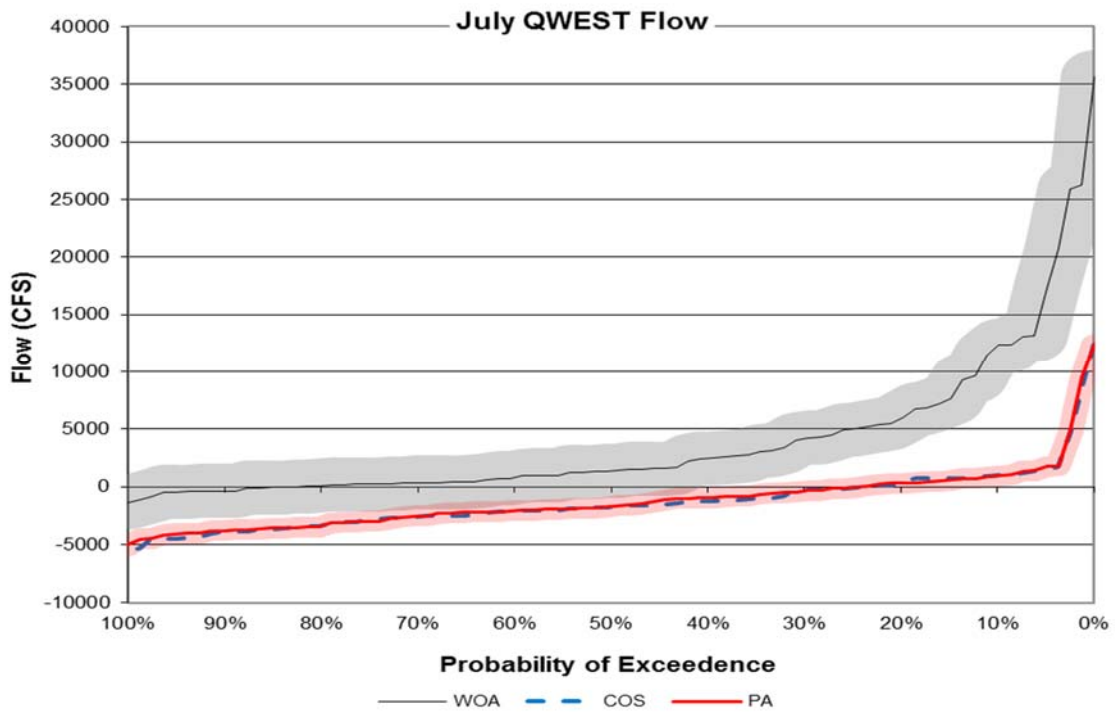


Figure 5.16-16. Mean Modeled QWEST Flow, July

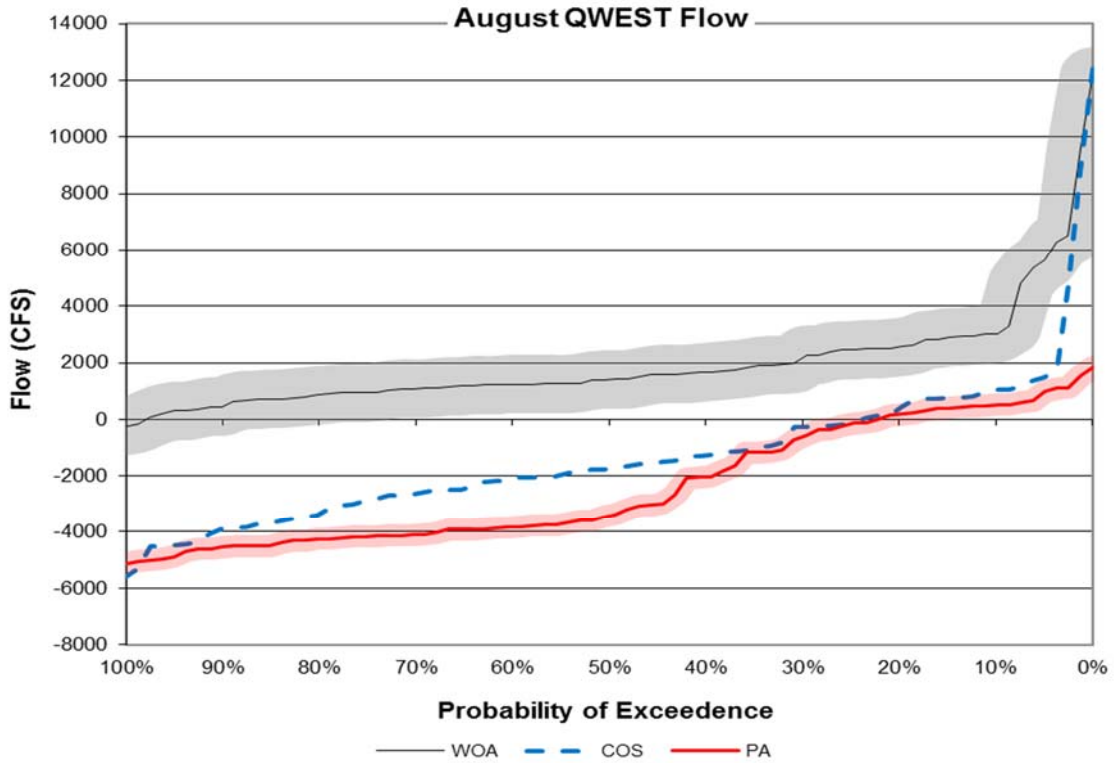


Figure 5.16-17. Mean Modeled QWEST Flow, August

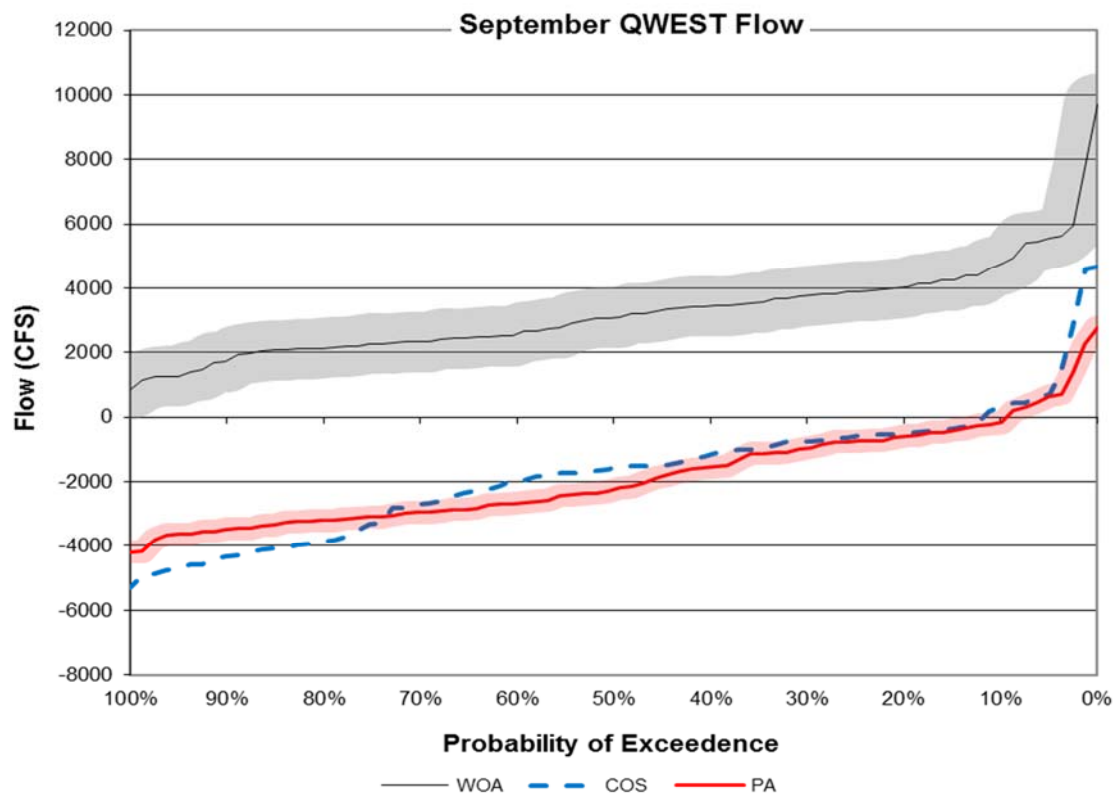


Figure 5.16-18. Mean Modeled QWEST Flow, September

P. forbesi suffers from high mortality rates on its nauplii (larvae) when it resides in the low salinity zone. This mortality is not caused by salinity, but by predation on the nauplii (larvae) (Kayfetz et al. 2017). This means that *P. forbesi* abundance in the low-salinity zone would crash similarly to *E. affinis* if it were not for an upstream subsidy from the Delta where *P. forbesi* densities are higher (Kimmerer et al. 2018; E&C). Delta outflow appears to provide this subsidy by facilitating the transport of *P. forbesi* from the Delta into Suisun Bay; Kimmerer et al. (2018; Hydrobiologia) demonstrated that although system-wide, *P. forbesi* density does not correlate with Delta outflow, its density in the low-salinity zone does. Therefore, there is some evidence for potential OMR management effects on *P. forbesi* transport to the low salinity zone, but not for overall calanoid copepod density in the low salinity zone.

Potential effects from the proposed action related to both the SMSCG action (beneficial effects, discussed below) and the south Delta export facilities on food availability would be expected to have the potential to affect a sizable portion of the Delta Smelt population. Bush (2017) demonstrated that on average 77 percent of adult Delta Smelt either migrate to the low salinity zone as early juveniles or are resident in the low salinity zone throughout their lives. In contrast, an average of 23 percent of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives. Those Delta Smelt resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region would not be expected to be affected by seasonal flows of the proposed action in terms of SMSCG operations and the south Delta export facilities. During and just after the August 2018 pilot implementation of the SMSCG action, EDSDM data from surveys between August 6 and September 7 suggest an average of 20 percent (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although

there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM). The IEP MAST (2015) conceptual model posited link between summer hydrology and clam grazing (Figure 5.16-5) was not supported by an examination of *P. amurensis* biomass and grazing rate during the fall (Brown et al. 2014, p.50-56), so it is unclear what effect differences in hydrology might have on clam grazing.

Overall, it is concluded with some uncertainty that OMR management under the proposed action would have negative effects on transport of *P. forbesi* to the low salinity zone relative to without action. However, operations of the SMSCG under the proposed action would provide greater access to the relatively food-rich Suisun Marsh habitat in above normal and below normal water years (further discussed below). Moreover, tidal habitat restoration (an additional approximately 6,000 acres) would be undertaken as part of the proposed action, and has the potential to reduce some of the negative effects from OMR management on food availability.

5.16.3.1.3.2 Harmful Algal Blooms

The IEP MAST (2015) conceptual model posits a linkage between various factors (nutrients, summer hydrology, and air temperature) and toxicity from harmful algal blooms to Delta Smelt and their prey (Figure 5.16-5). Based on this conceptual model (see also additional discussion in IEP MAST 2015, p.85-86), differences in flows could influence harmful algal blooms. Lehman et al. (2013) reported on *Microcystis* blooms observed from 2004-2008. During these years, median QWEST flows differed by only 6 m³/s between the two wetter years and the two drier years and *Microcystis* density showed no response to this flow variable. Lehman et al. (2013) described the range of QWEST flow at which *Microcystis* occurred in their study (-8,500 to 1,800 cfs). It is uncertain if QWEST greater than this range would result in lower likelihood of *Microcystis* blooms, but if so, there may be greater potential for blooms under the PA than WOA given that flows above the range noted by Lehman et al. (2013) occur less frequently under the PA during the main *Microcystis* summer/early fall months (Figures 5.16-16 to 5.16-18). The pattern is essentially the same for the COS compared to WOA. However, consideration only of flow does not account for other factors that could be affected by water operations that may be important in affecting *Microcystis*, such as channel velocity (RBI 2017). Note also that this analysis does not account for other factors shown to correlate with occurrence of *Microcystis* blooms that are not greatly affected by water operations such as water temperature and nutrients (RBI 2017).

A previous analysis by RBI (2017) examined DSM2-HYDRO-modeled maximum daily absolute velocity during June–November at various locations in the south Delta which are susceptible to *Microcystis* blooms, in relation to a critical velocity of threshold of 1 ft/s, above which turbulent mixing may disrupt *Microcystis* blooms. Note that there is uncertainty in this threshold given that it was developed for a different system and velocity below this threshold has been shown to disrupt blooms in other systems (RBI 2017). Applying a similar analysis for the present effects analysis suggested that along the mainstem San Joaquin River from Antioch to Brandt Bridge, current operations and the proposed action would differ little from without action in terms of having channel velocity that potentially could disrupt *Microcystis* blooms (Figure 5.16-19, Figure 5.16-20, Figure 5.16-21). In Old River at Tracy Road and Middle River at Bacon Island, maximum velocity under the PA and COS would be lower than WOA, although all scenarios generally would have maximum velocity below 1 ft/s and, therefore, may not differ in terms of potentially providing conditions unlikely to disrupt *Microcystis* blooms (Figure 5.16-22 and Figure 5.16-23). In contrast, maximum velocity at Grant Line Canal downstream of the temporary barrier, Old River at Bacon Island, and Old River at Highway 4 generally was below 1 ft/s under PA and COS, but close to or above 1 ft/s under WOA (Figure 5.16-24, Figure 5.16-25, Figure 5.16-26). Greater maximum velocity under WOA reflects the absence of agricultural barriers, which reduce tidal flows under current operations and the proposed action. A greater frequency of maximum velocity below 1 ft/s

may indicate greater potential for *Microcystis* blooms not to be disrupted in Old River and Grant Line Canal close to the agricultural barriers under the proposed action compared to without action. However, even if *Microcystis* blooms were disrupted less under the proposed action, these blooms would not necessarily directly or indirectly (through effects on prey) affect juvenile Delta Smelt in the low salinity zone given that the prevailing direction of movement would be upstream because of south Delta export pumping (e.g., Figures 5.16-16 through 5.16-18). The IEP MAST conceptual model also notes that relatively clear water is a factor thought to cause more intensive *Microcystis* blooms (IEP MAST 2015, p.85). The proposed action has less sediment supply and, therefore, potentially less sediment for resuspension in the Bay-Delta during the summer/fall period when *Microcystis* blooms occur.

There is a difference in flows between the proposed action and without action scenarios, as well as possibly greater potential for lower velocity to limit *Microcystis* bloom disruption, and the potential for higher water clarity as a result of reduced sediment supply.

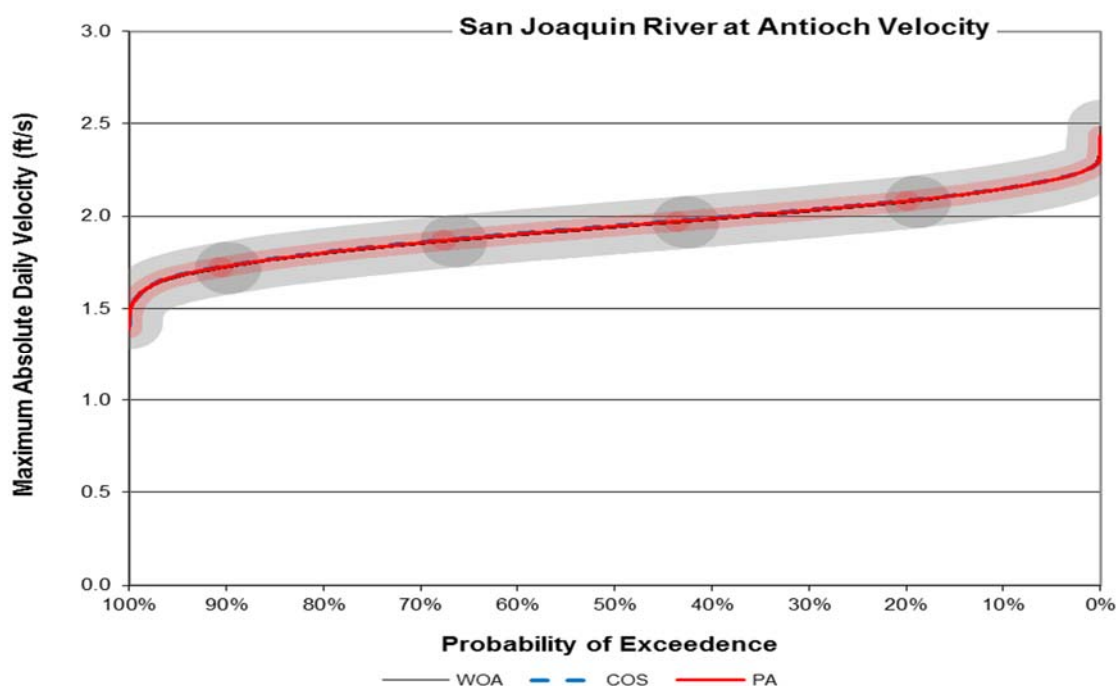


Figure 5.16-19. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Antioch, June–November

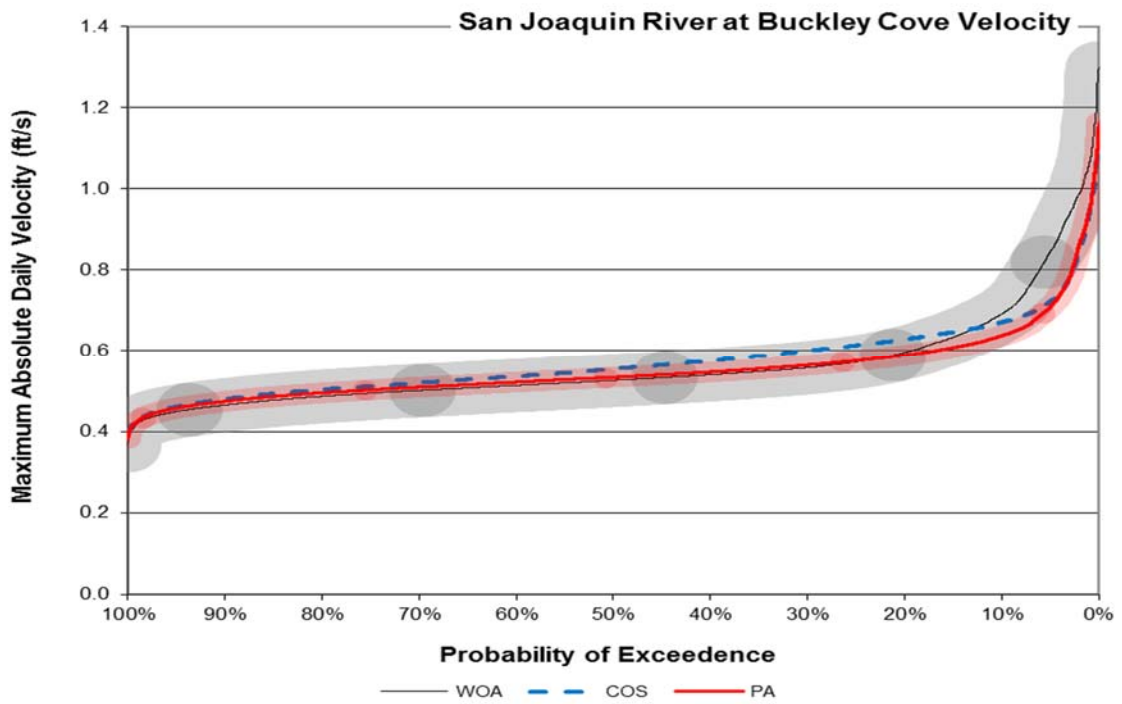


Figure 5.16-20. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Buckley Cove, June–November

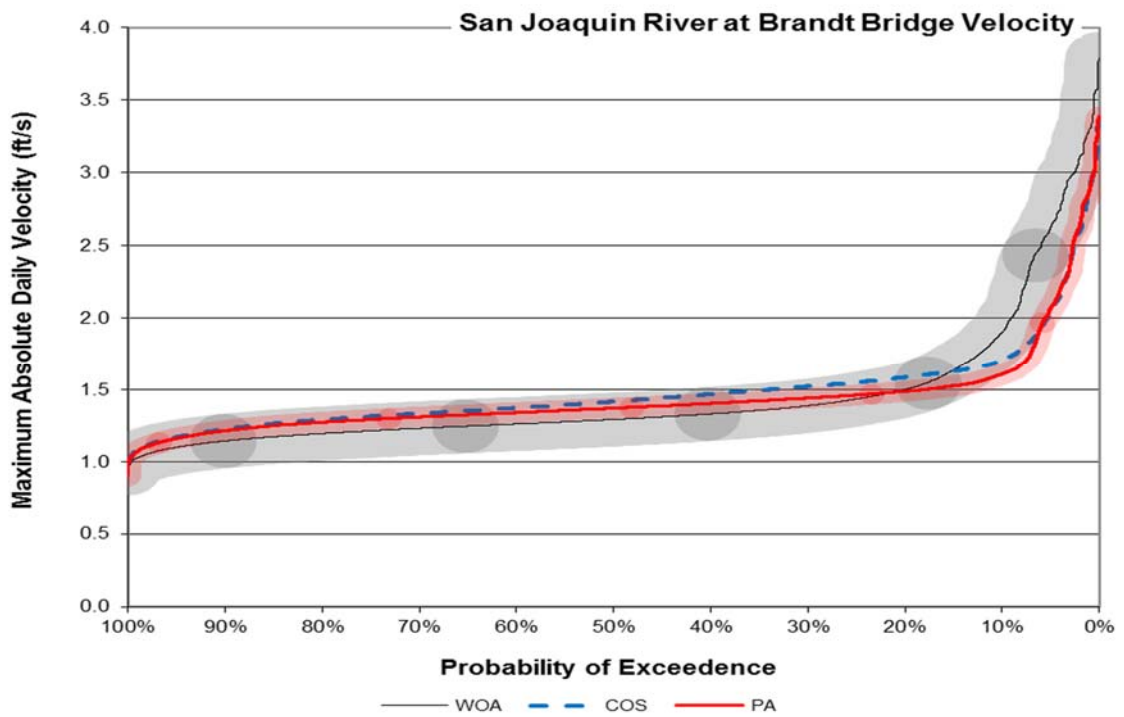


Figure 5.16-21. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Brandt Bridge, June–November

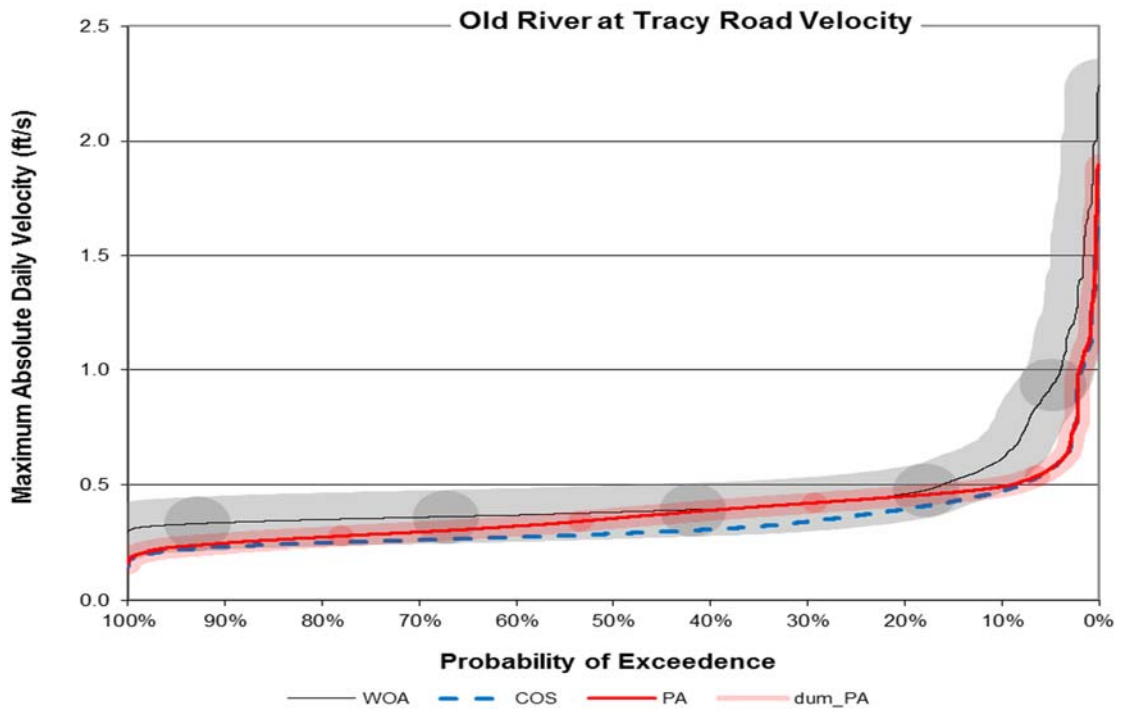


Figure 5.16-22. Modeled Maximum Absolute Daily Velocity in Old River at Tracy Road, June–November

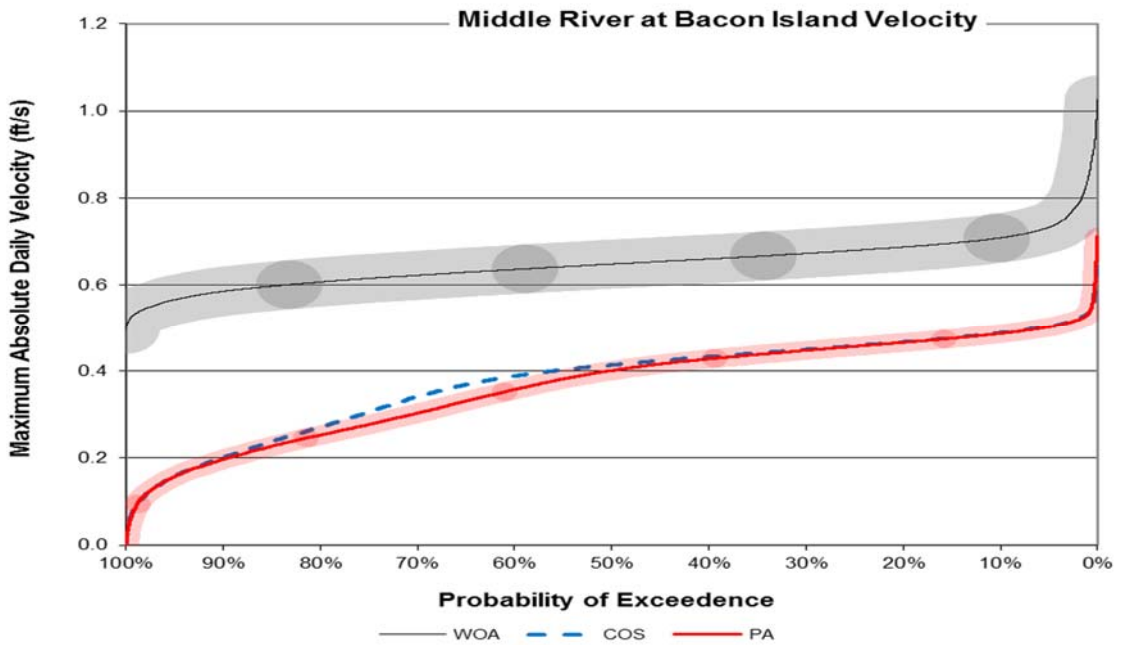


Figure 5.16-23. Modeled Maximum Absolute Daily Velocity in Middle River at Bacon Island, June–November

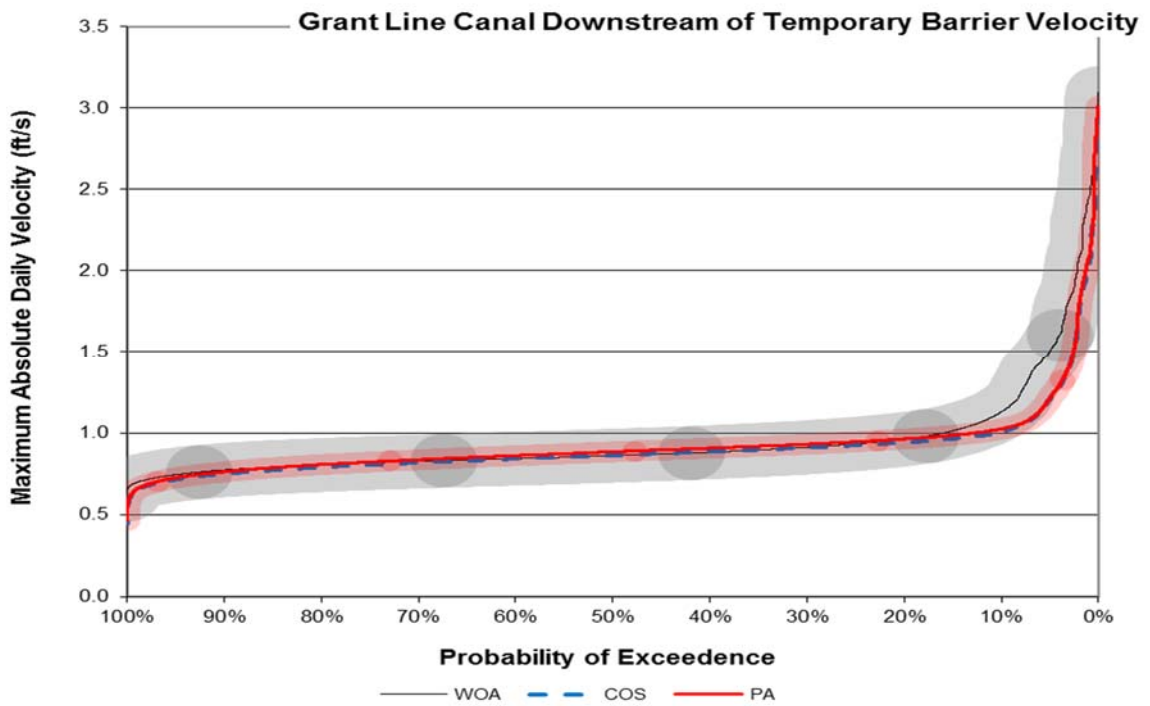


Figure 5.16-24. Modeled Maximum Absolute Daily Velocity in Grant Line Canal Downstream of the Temporary Barrier, June–November

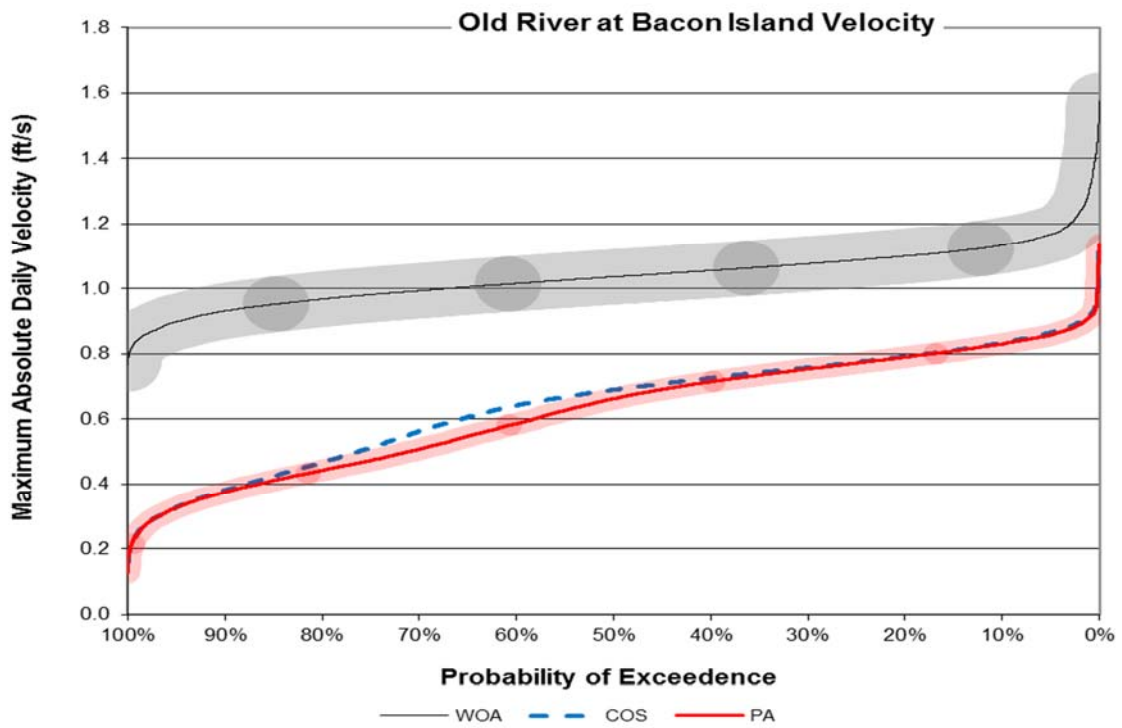


Figure 5.16-25. Modeled Maximum Absolute Daily Velocity in Old River at Bacon Island, June–November

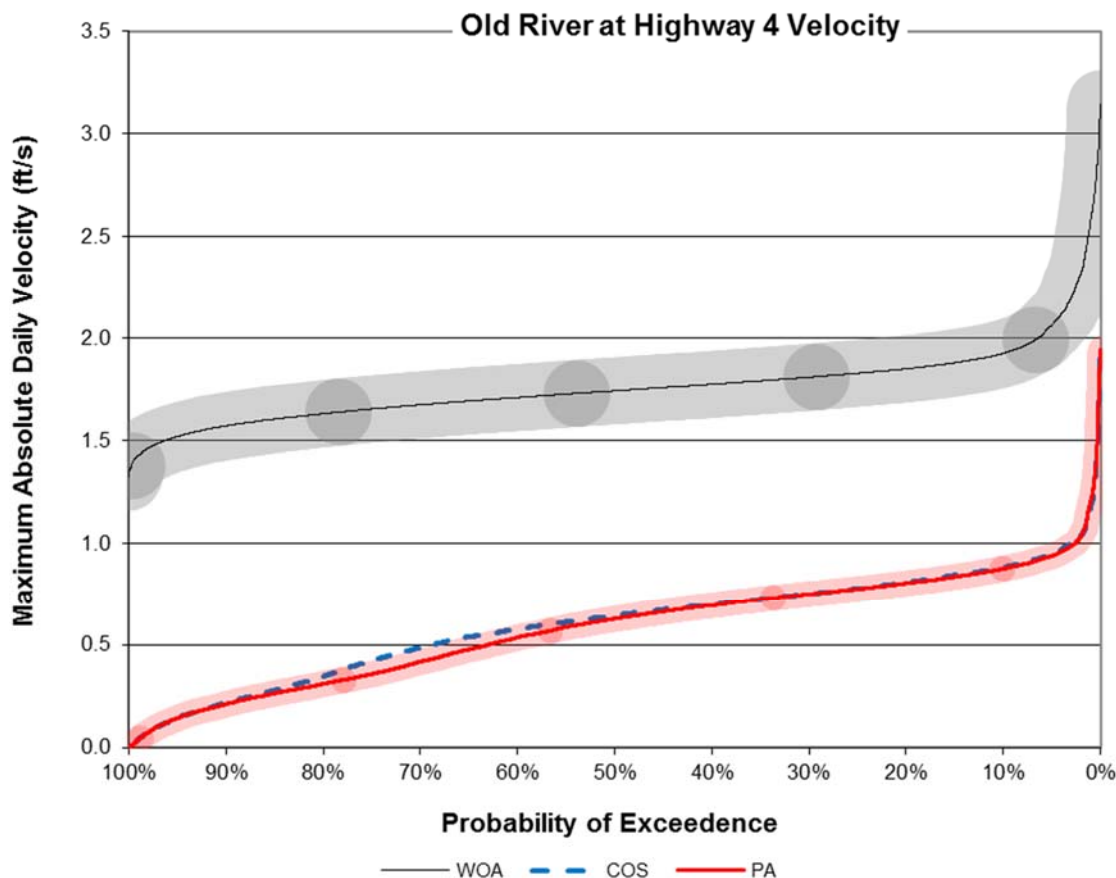


Figure 5.16-26. Modeled Maximum Absolute Daily Velocity in Old River at Highway 4, June–November

5.16.3.1.3.3 Predation Risk

The IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators (in particular Striped Bass), turbidity, and water temperature (Figure 5.16-5). As previously discussed for larval Delta Smelt, effects on water temperature from the proposed action relative to without action would be negligible. Turbidity during the low-flow summer and fall periods is partly a function of sediment delivery during the high-flow winter/spring periods, for it influences the amount of sediment for available (see summary by IEP MAST 2015, p.50). As discussed previously for adult Delta Smelt, differences in winter/spring flows and sediment delivery may result in a negative effect as a result of the proposed action potentially providing less sediment for resuspension in the summer/fall compared to without action. The IEP MAST (2015) conceptual model does not include factors affecting the abundance of predators (Striped Bass). Recent studies suggest that greater fall Delta outflow (represented by X2) and lower water clarity are positively linked to age-0 abundance (Mac Nally et al. 2010; Thomson et al. 2010), although there is uncertainty in the extent to which such effects would translate to changes in abundance of Striped Bass ages 1 to 3 (i.e., the subadults suggested to prey on Delta Smelt by IEP MAST

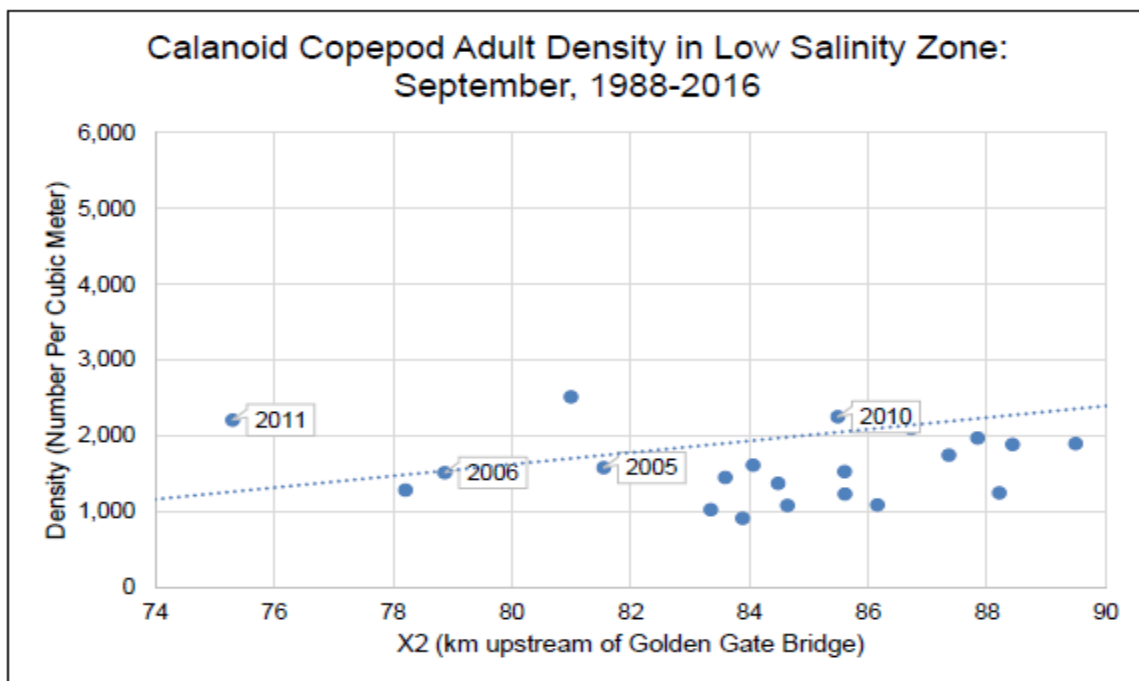
2015, p.132) given relatively low correspondence in abundance trends for age 0 and age 1 (Sommer et al. 2011) and apparent density dependence between ages 1 and 2 (Kimmerer et al. 2000).

5.16.3.1.4 Subadults to Adults (September - December)

The proposed action's OMR management during the Delta Smelt subadult to adult transition period (September–December) has the potential to influence several habitat attributes posited to be affected by Delta outflow in the IEP MAST (2015) conceptual model. These include food availability, size and location of the low salinity zone, and turbidity affecting predation risk (Figure 5.16-6).

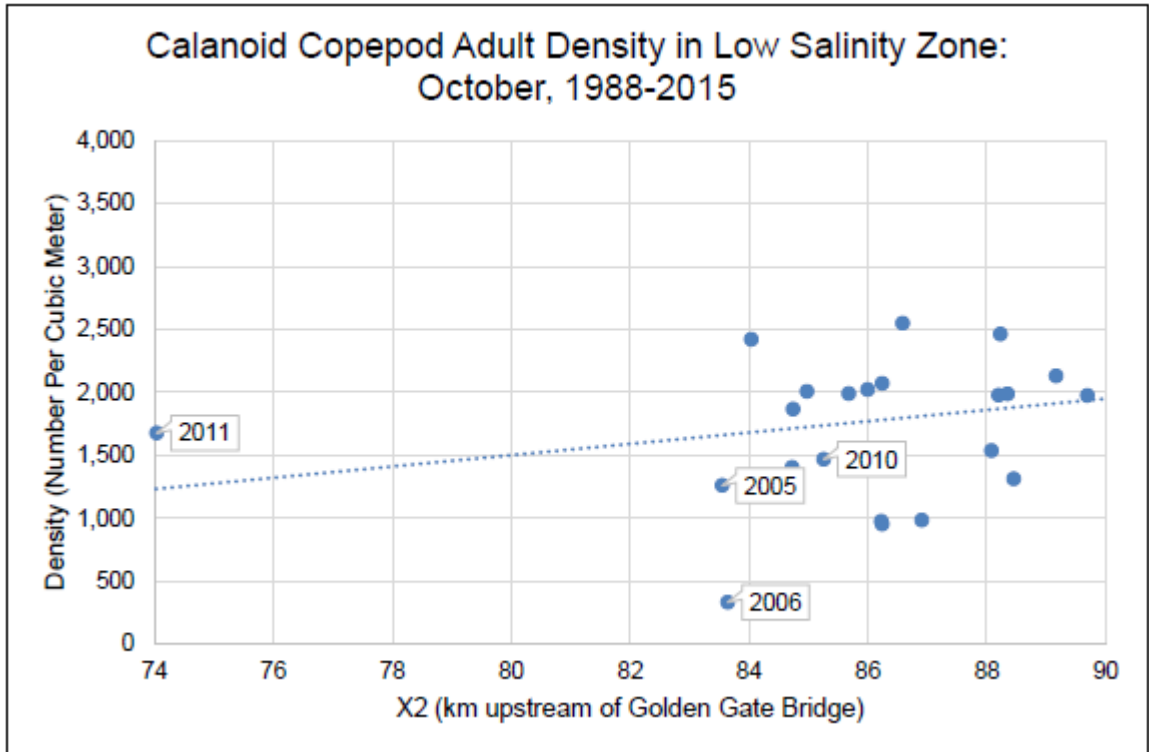
5.16.3.1.4.1 Food Availability

As also discussed for juvenile Delta Smelt, seasonal south Delta export operations have the potential to negatively affect Delta Smelt food availability through reduced *P. forbesi* subsidy to the low salinity zone rearing habitat occupied by most Delta Smelt reaching adulthood. Although the FLASH investigations predicted that Delta Smelt food availability (as represented by calanoid copepods) in the fall low salinity zone would be greater with lower X2 (i.e., higher outflow) (Brown et al. 2014, p.25), this was not found to be the case either for the post--*Potamocorbula amurensis* invasion period (1988–2015/2016; Figure 5.16-27; Figure 5.16-28; Figure 5.16-29; Figure 5.16-30; Figure 5.16-31; Figure 5.16-32) or for the period following onset of the Pelagic Organism Decline (2003–2015/2016; ICF 2017, p.78–82). Therefore, as noted for juvenile Delta Smelt, there is some evidence for potential negative OMR management-related effects on *P. forbesi* transport to the low salinity zone, but not for overall calanoid copepod density in the low salinity zone.



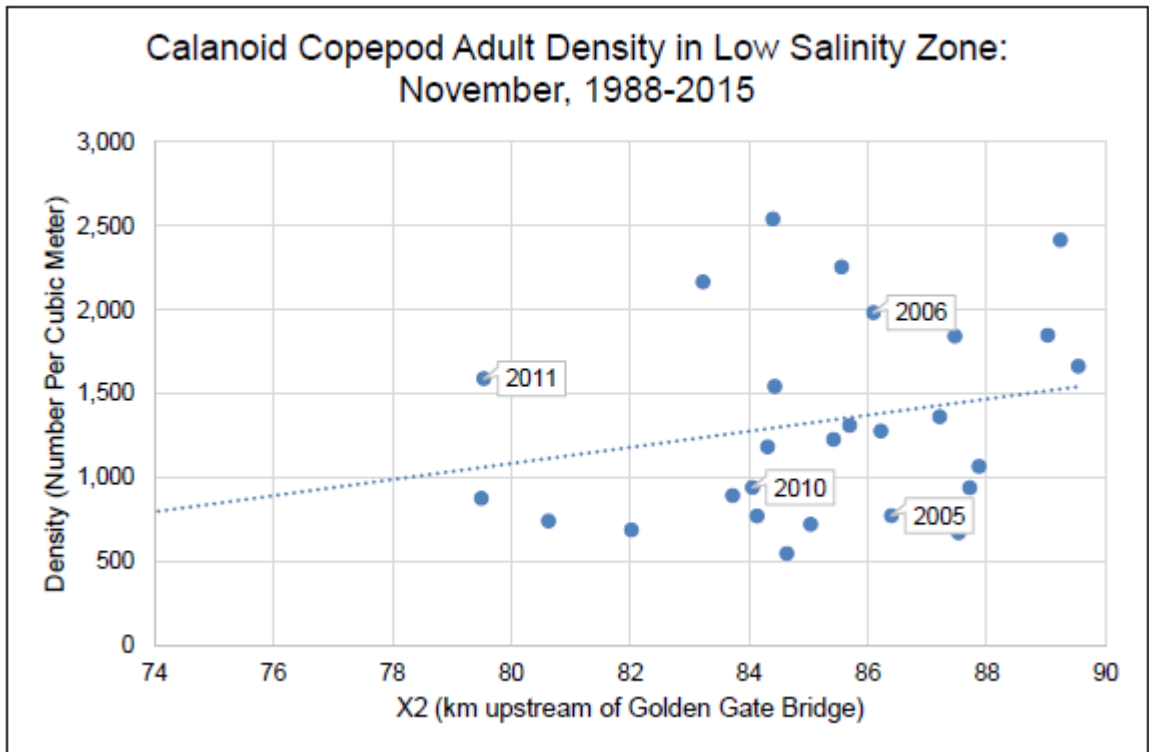
Source: ICF (2017, p.74). Note: Trend line shows non-significant linear regression.

Figure 5.16-27. Mean September Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



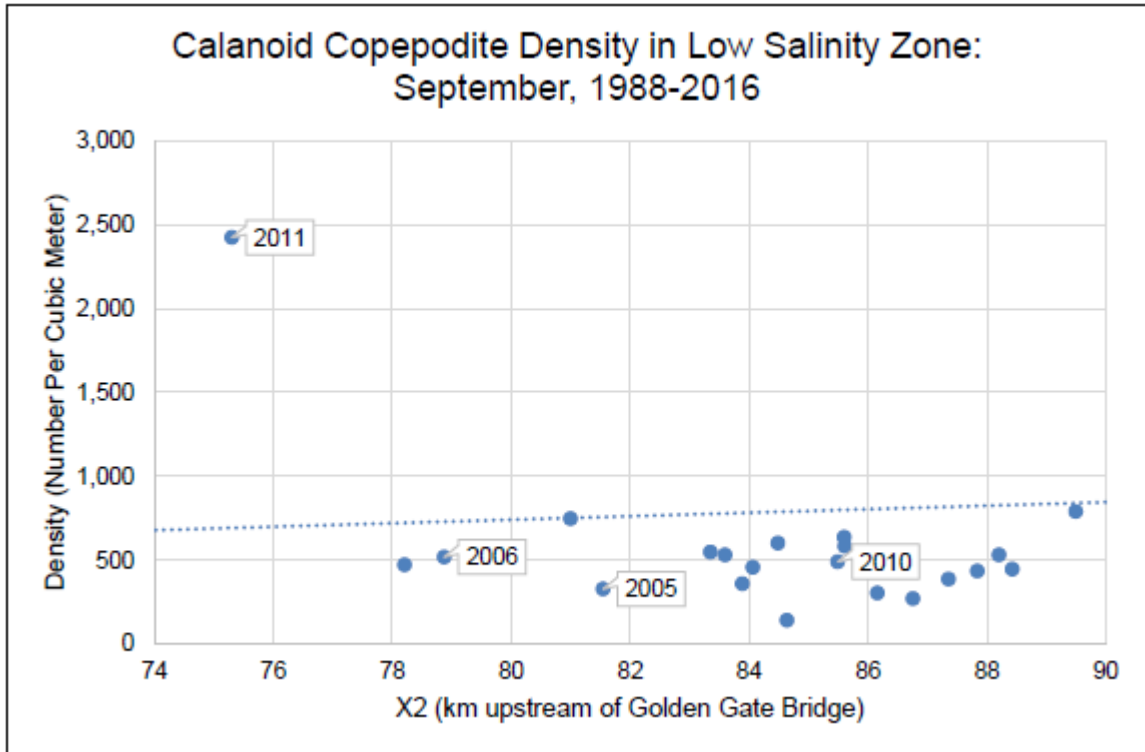
Source: ICF (2017, p.74). Note: Trend line shows non-significant linear regression.

Figure 5.16-28. Mean October Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



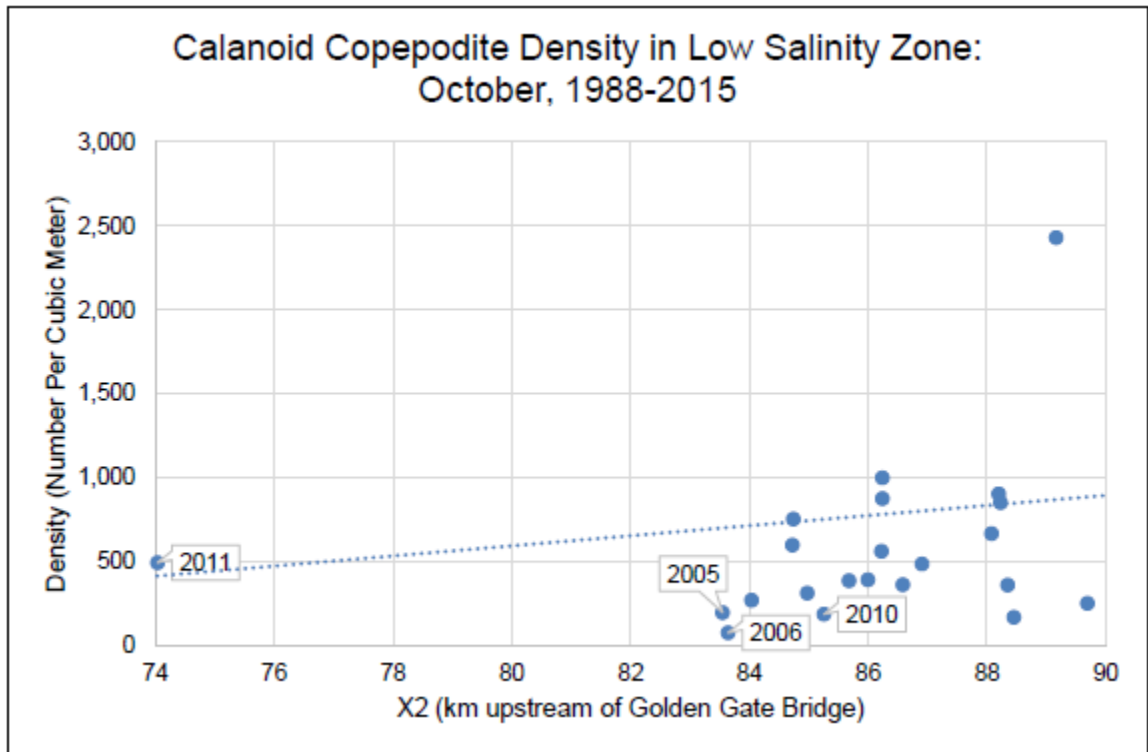
Source: ICF (2017, p.75). Note: Trend line shows non-significant linear regression.

Figure 5.16-29. Mean November Calanoid Copepod Adult Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



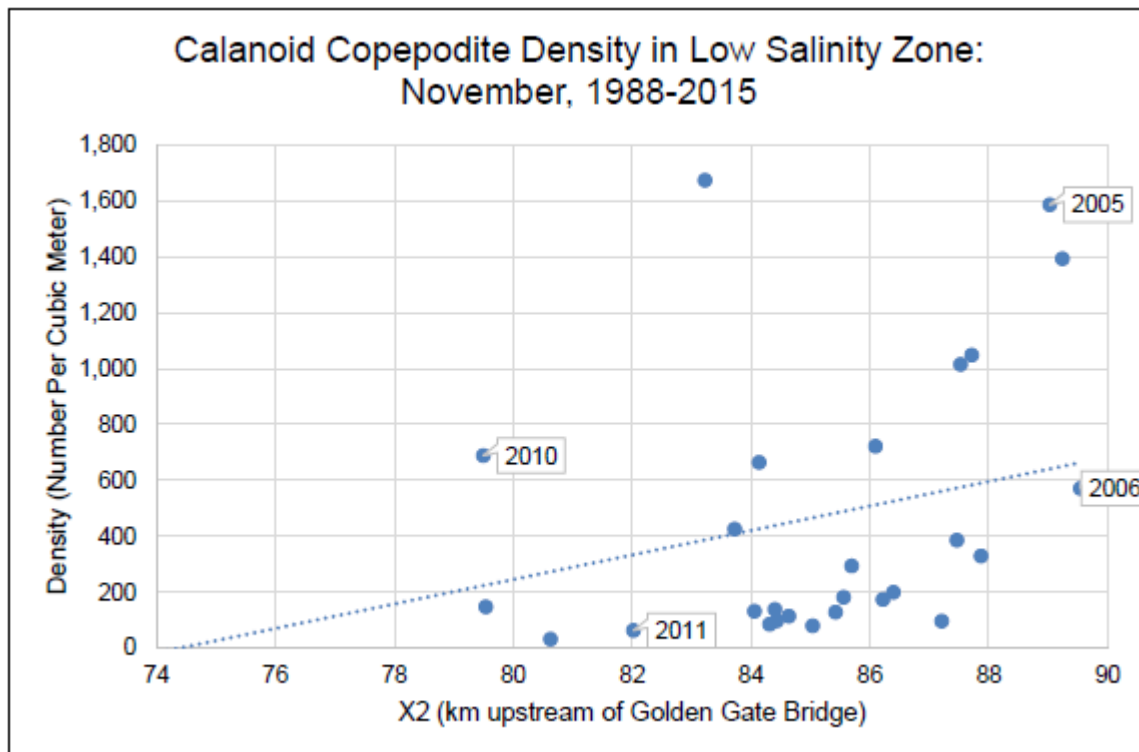
Source: ICF (2017, p.75). Note: Trend line shows non-significant linear regression.

Figure 5.16-30. Mean September Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



Source: ICF (2017, p.76). Note: Trend line shows non-significant linear regression.

Figure 5.16-31. Mean October Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.



Source: ICF (2017, p.76). Note: Trend line shows non-significant linear regression.

Figure 5.16-32. Mean November Calanoid Copepod Copepodite Density in the Low Salinity Zone (Salinity = 1 to 6) from Environmental Monitoring Program Zooplankton Survey Data (Clarke-Bumpus Net) versus Mean X2 from 1988-2016.

5.16.3.1.4.2 Size and Location of the Low Salinity Zone

Pertaining to the indication that subadult Delta Smelt abundance, survival and growth are affected by the size and position of the low salinity during fall, as posited by the IEP MAST conceptual model, IEP MAST (2015, p.142) concluded: “The limited amount of available data provides some evidence in support of this hypothesis, but additional years of data and investigations are needed.” Others have found that low salinity zone habitat may not be a predictor of Delta Smelt survival (Reclamation, 2017).

The proposed action does not include the fall X2 action from the 2008 biological opinion, which results in X2 under the PA being essentially the same as COS in drier years, but greater (more upstream) than WOA and COS in wet and above normal years. Given these caveats, the model shows September X2 would tend to be ≥ 85 km in around 95% or more of years, which would give a predicted low salinity zone area of around 11,000 acres (4,480 hectares; Figure 5.16-36, as developed from the X2-low salinity zone area look-up table from Brown et al. 2014, p.79) or less. X2 greater than or equal to 85 km results in the low salinity zone generally not occurring in the broader, shallower habitat in Suisun Bay (specifically Honker Bay) that provides an increase in the area of the lower salinity zone (DMA 2014, p.38). By way of comparison, September X2 under WOA would be around 75–83 km at 50–95% exceedance, giving a predicted low salinity zone area of 12,500–20,800 acres (5,100–8,400 hectares; Figure 5.16-36), and the low salinity zone occurring in Suisun Bay in around two thirds of years (Figure 5.16-33). Similar patterns

(i.e., appreciably lower predicted low salinity zone area in wetter years under the PA relative to WOA) would also generally be evident in October (Figure 5.16-37), whereas larger differences between the PA and WOA would tend to occur in 60% of years in November (Figure 5.36-38). Operation of the SMSCG and additional Delta outflow to ensure no net upstream movement of X2 during proposed SMSCG operation in June–September of above normal and below normal years was not modeled in CalSim; it is not expected that these factors would have a large influence on X2 relative to the modeling results from CalSim.

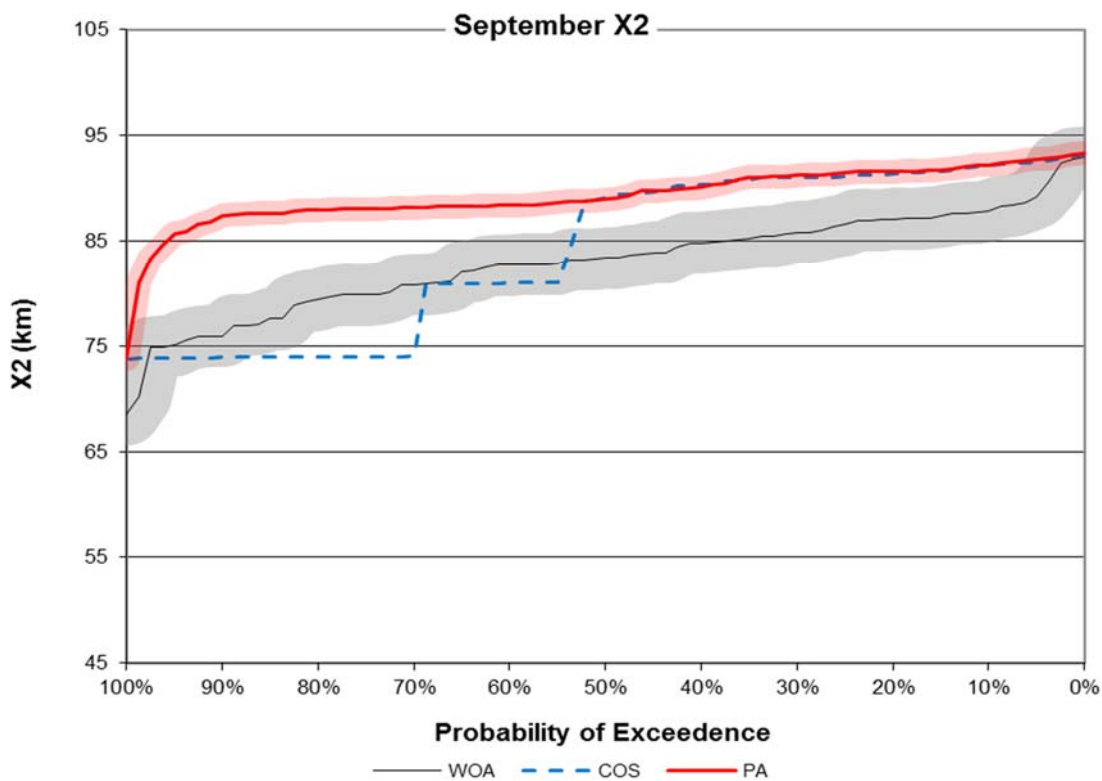


Figure 5.16-33. Mean Modeled X2 from CalSim, September.

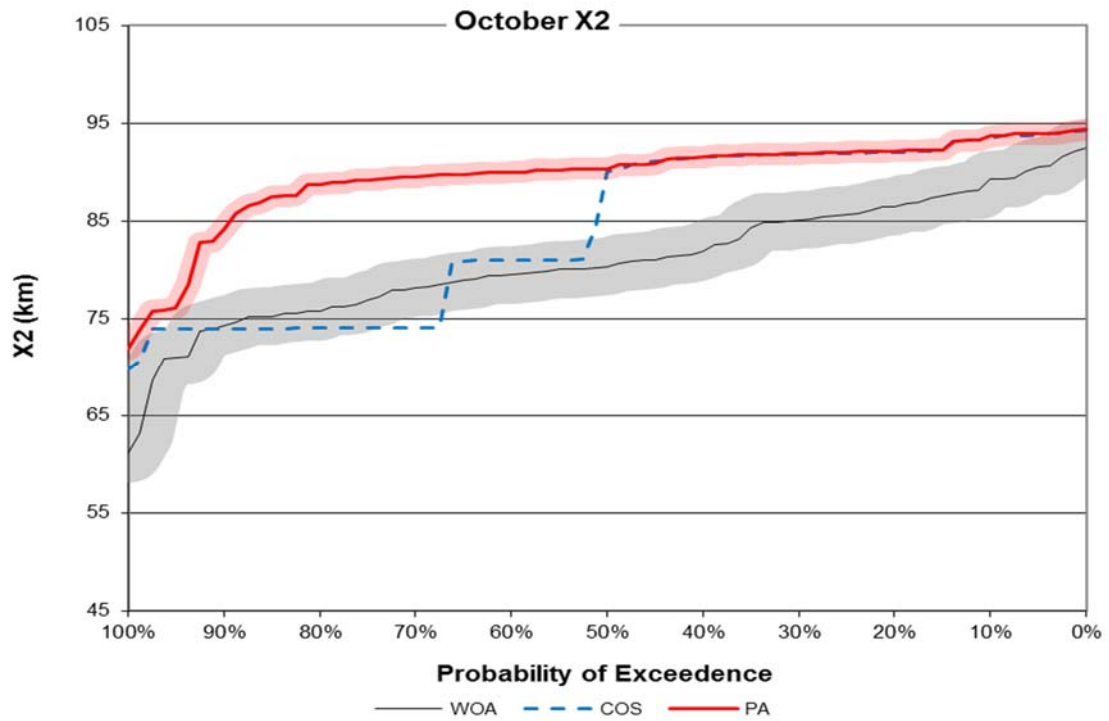


Figure 5.16-34. Mean Modeled X2 from CalSim, October.

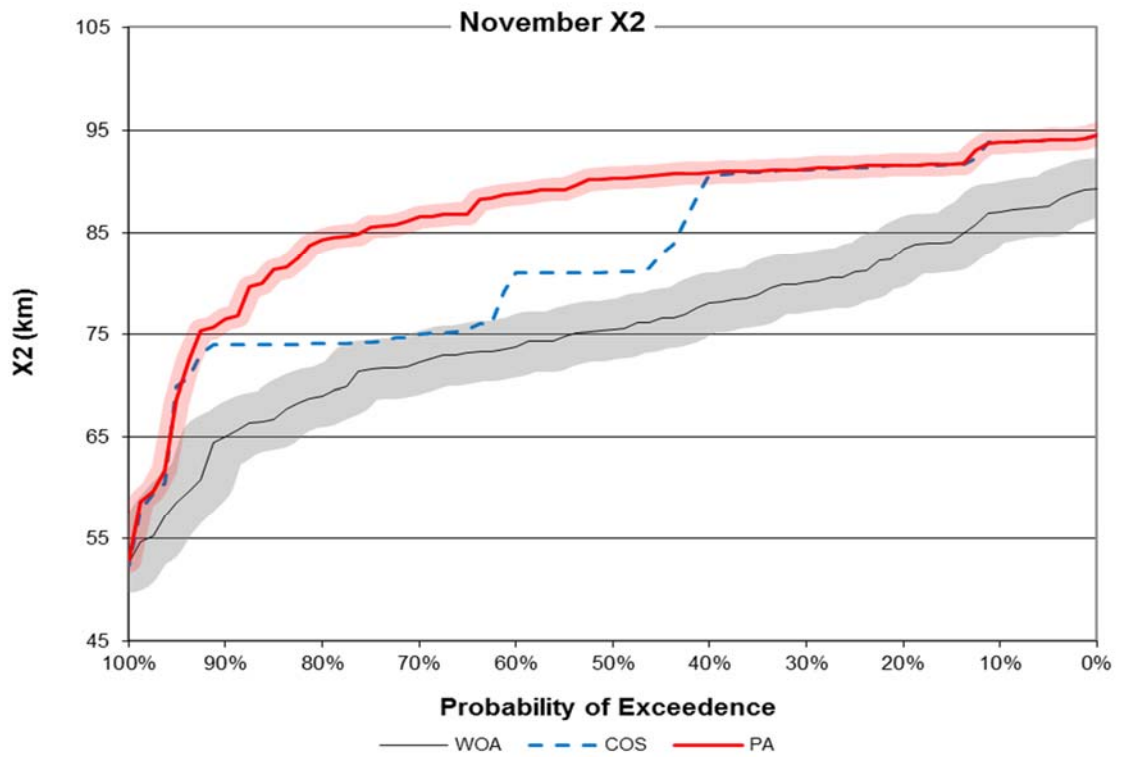


Figure 5.16-35. Mean Modeled X2 from CalSim, November.

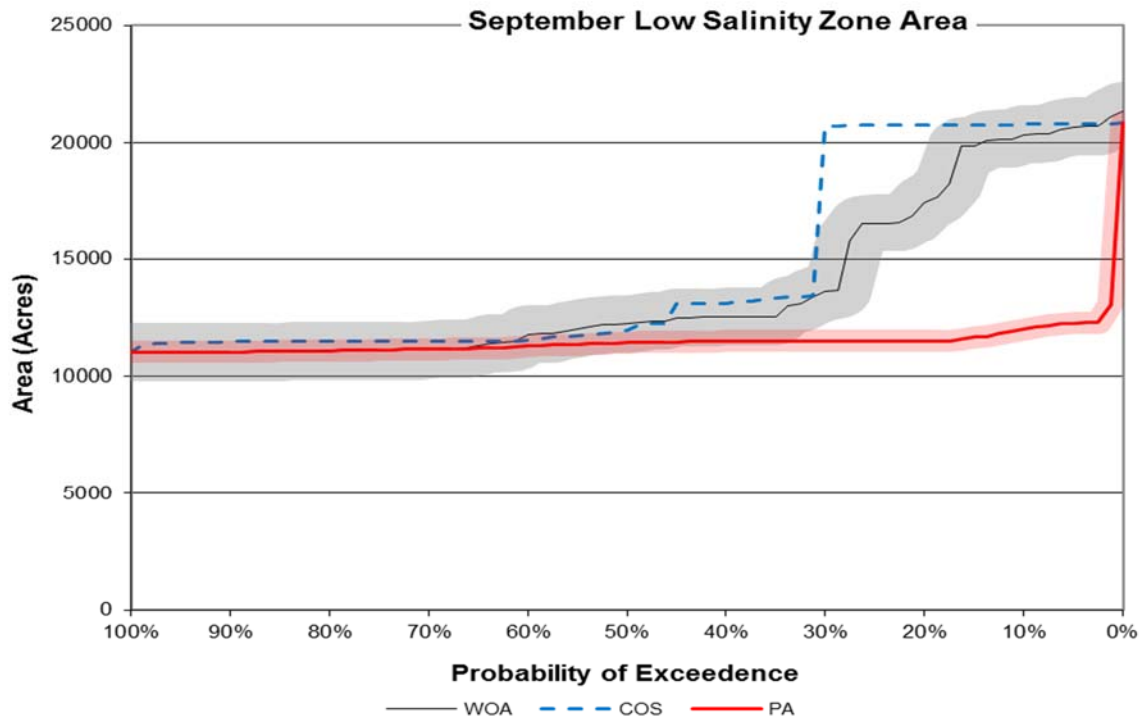


Figure 5.16-36. Mean Modeled Low Salinity Zone Area, September.

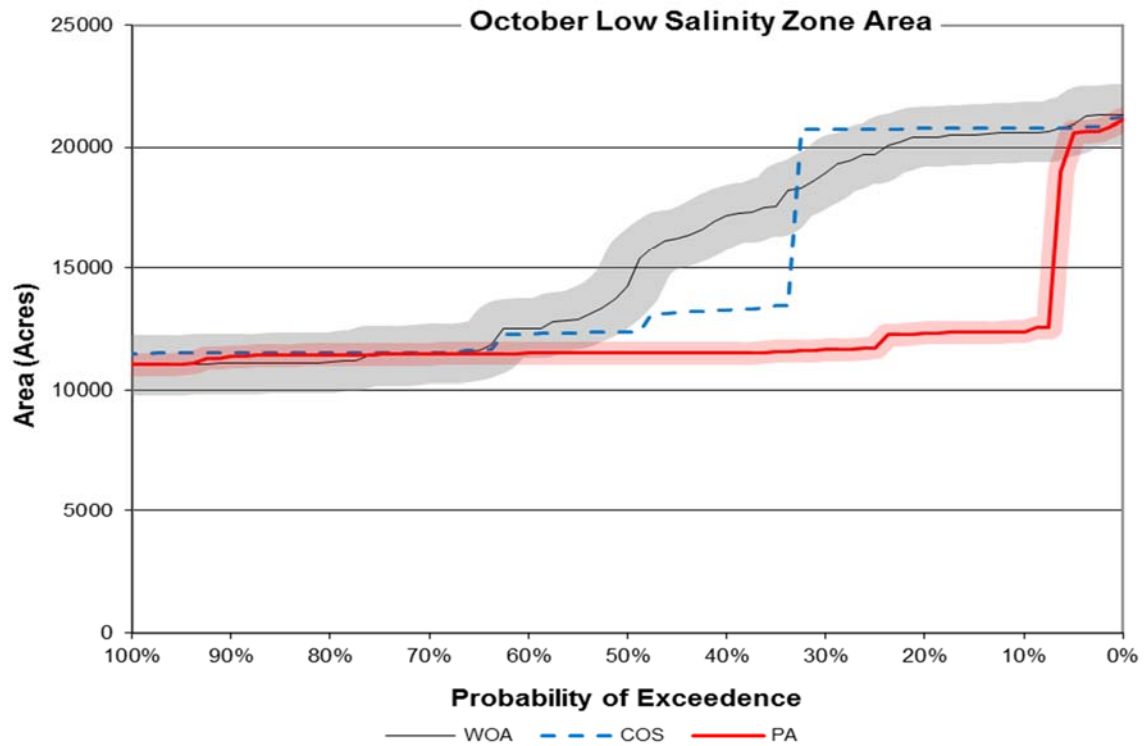


Figure 5.16-37. Mean Modeled Low Salinity Zone Area, October.

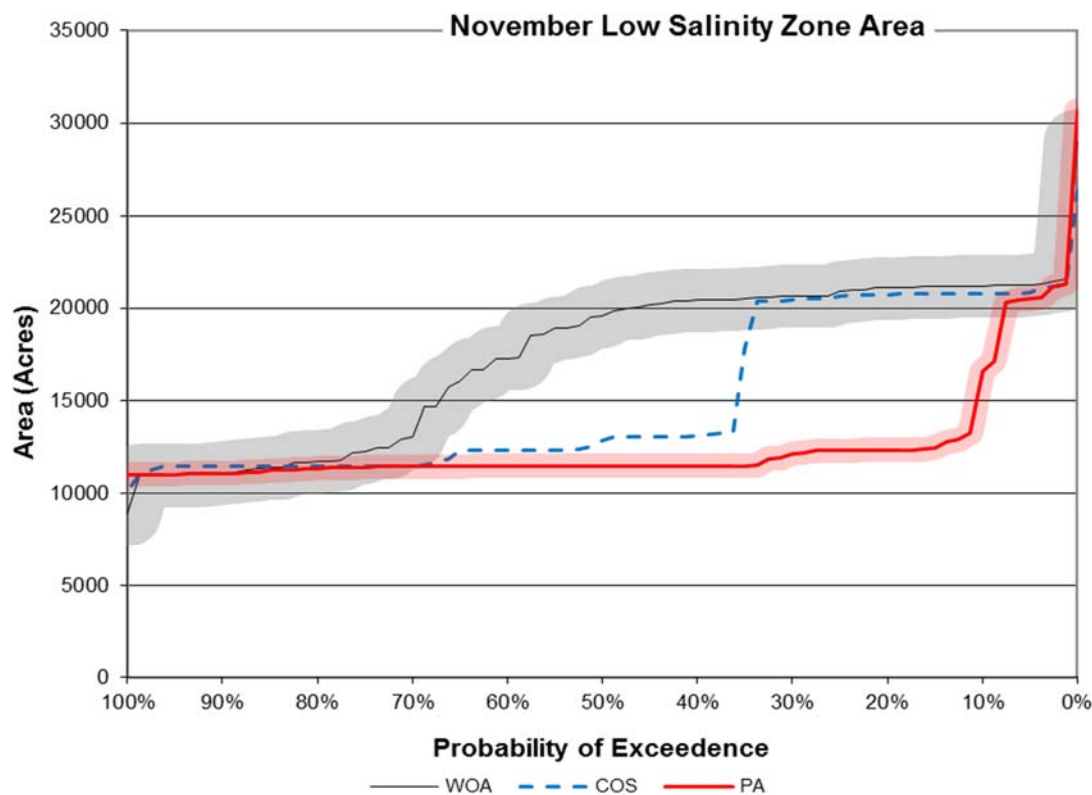


Figure 5.16-38. Mean Modeled Low Salinity Zone Area, November.

The overall potential reduction in the size of the low salinity zone and its general placement outside of Suisun Bay under the proposed action as summarized above from CalSim modeling has the potential to result in adverse impacts to Delta Smelt, per the hypothesis from the IEP MAST (2015) conceptual model (Figure 5.16-6).

5.16.3.1.4.3 Harmful Algal Blooms

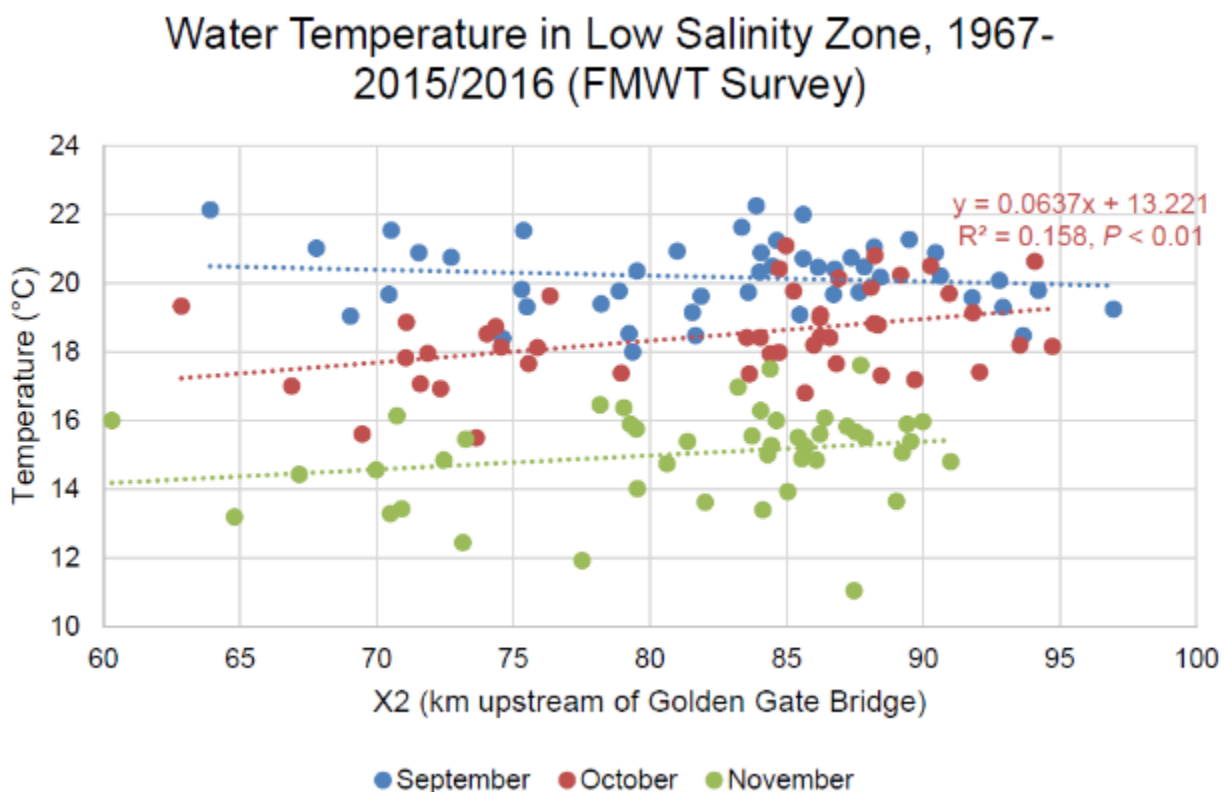
As described in more detail for juvenile Delta Smelt, differences in Delta flows, velocity, and water clarity could affect the occurrence of *Microcystis* blooms. Increases in harmful algal blooms resulting from the proposed action relative to without action could potentially result in negative impacts to subadult Delta Smelt, although this is uncertain.

5.16.3.1.4.4 Predation Risk

Turbidity could be affected by the proposed action relative to without action. Thus, potentially less sediment supply during the winter/spring could give less sediment for resuspension during the fall subadult period. With greater (more upstream) X2 under the PA (see Figure 5.16-33, 5.16-34, 5.16-35), the low salinity zone potentially could overlap areas with greater water clarity (i.e., lower turbidity) that are more likely to have wind-wave sediment resuspension (IEP MAST 2015, p.50), which could then translate into greater predation risk. The extent to which observed negative correlations between fall X2 and water clarity in the low salinity zone are the result of antecedent conditions (i.e., sediment supply

during high-flow months) is uncertain (ICF 2017, p.106), although recent science indicates that wind may control turbidity (Bever et al., 2018).

As previously described for other life stages, water temperature would not be expected to be greatly affected by the proposed action, as illustrated by the low to no correlation between water temperature in the low salinity zone and X2 (Figure 5.16-39). Any effects would be well within the tolerance of subadult Delta Smelt (Komorske et al. 2014).



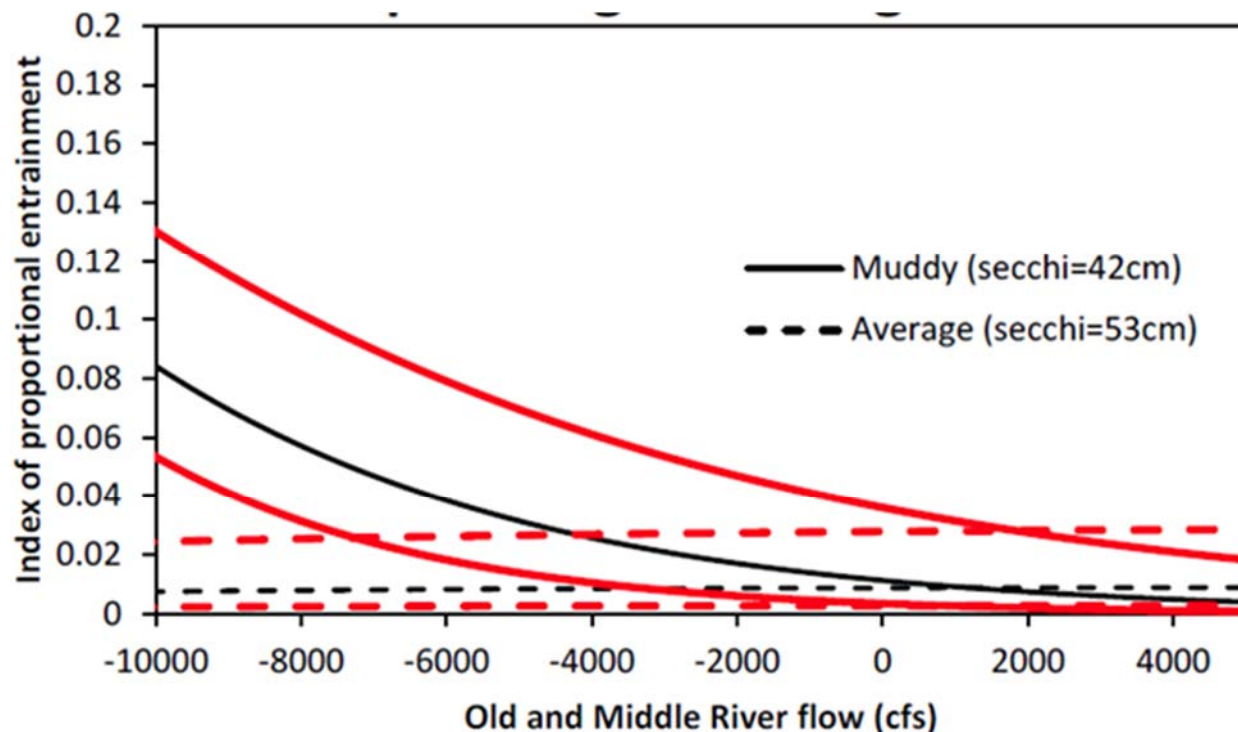
Source: ICF (2017, p.118). Note: Lines show regressions, but only October was statistically significant.

Figure 5.16-39. Mean Water Temperature in the Low Salinity Zone (Salinity = 1 to 6) from Fall Midwater Trawl Survey Data versus Mean X2, 1967 to 2015/2016

5.16.3.2 OMR Management

For adult Delta Smelt moving to spawn and transition to the egg/larval life stage, water diversions and flows (hydrology) together act to affect entrainment risk (Figure 5.16-3). In general, Delta Smelt salvage increases as increasing net OMR flow reversal (i.e., more negative net OMR flows) interacts with turbidity exceeding 10–12 NTU during December–March (USFWS 2008, Grimaldo et al. 2009). Analyses by Grimaldo et al. (2017) confirmed previous observations of relationships with OMR flows, and provided refined understanding of other factors influencing entrainment risk (expressed as number of adult Delta Smelt salvaged). Increased entrainment risk (defined as 50% of salvage) can occur following winter first flush events when precipitation increases flow and turbidity in the Delta and adult Delta Smelt move upstream into the Delta to spawn (Grimaldo et al. 2009; 2017). When water of higher turbidity (≥ 12

NTU) entering the Delta from the Sacramento River forms a continuous “bridge” between the central Delta (lower San Joaquin River) and Old and Middle Rivers, and negative OMR flows are relatively high, the risk of entrainment can increase. OMR flows alone do not predict entrainment risk; turbidity is also a key consideration, along with precipitation, exports and population size. For predictions of proportional loss of adult Delta Smelt during the post-2008 biological opinion period, using data for 2009–2015, proportional entrainment is predicted to be fairly insensitive to OMR flows at an average turbidity (Secchi depth), but steeply increases as OMR becomes more negative when turbidity is elevated (Figure 5.16-40).



Source: USFWS (2018). Note: Red lines indicate 95% Confidence Intervals.

Figure 5.16-40. Model Predictions of Adult Delta Smelt December–March Proportional Entrainment Index as a Function of Mean December–February Old and Middle River Flows and Secchi Depth During Delta Fish Surveys.

5.16.3.2.1 Adults to Eggs and Larvae (December - May)

5.16.3.2.1.1 Entrainment Risk

The without action conditions of no south Delta export would not entrain adult Delta Smelt. The lack of south Delta export pumping is reflected in OMR flows under the WOA scenario generally being positive (Figures 5.16-41, 5.16-42, 5.16-43, 5.16-44).

Based on the typical distribution of Delta Smelt, few individuals would be expected to occur in the south Delta (Figures 5.16-1 and 5.16-22). CalSim modeling suggests that OMR flows under the proposed action generally would be similar to current operations, reflecting the onset of OMR management after December 1 during which OMR generally would be $\geq -5,000$ cfs. As reflected in Figures OMR_Jan and OMR_Feb, OMR flows under the PA have the potential to be slightly more negative than COS, but

additional exports would only occur within the scope of protective criteria, which are described in the *OMR Management* section of the *Proposed Action* description. The monthly CalSim modeling does not reflect real-time criteria that are included in the proposed action, but does make assumptions to account for turbidity bridge avoidance actions in the overall monthly results. Overlapping protections also exist for NMFS-managed species, which could be triggered even when triggers have not occurred for Delta Smelt, and would offer incidental protection to Delta Smelt. Operation to the OMR flow criteria included in the proposed action would be expected to limit the risk of entrainment loss.

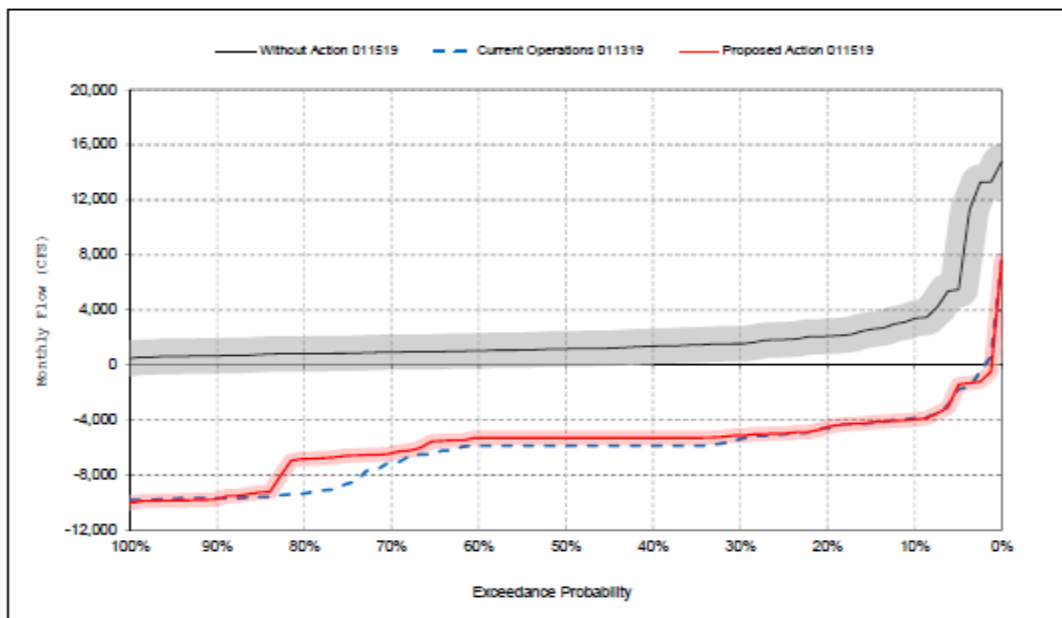


Figure 5.16-41. Mean Modeled Old and Middle River Flows, December

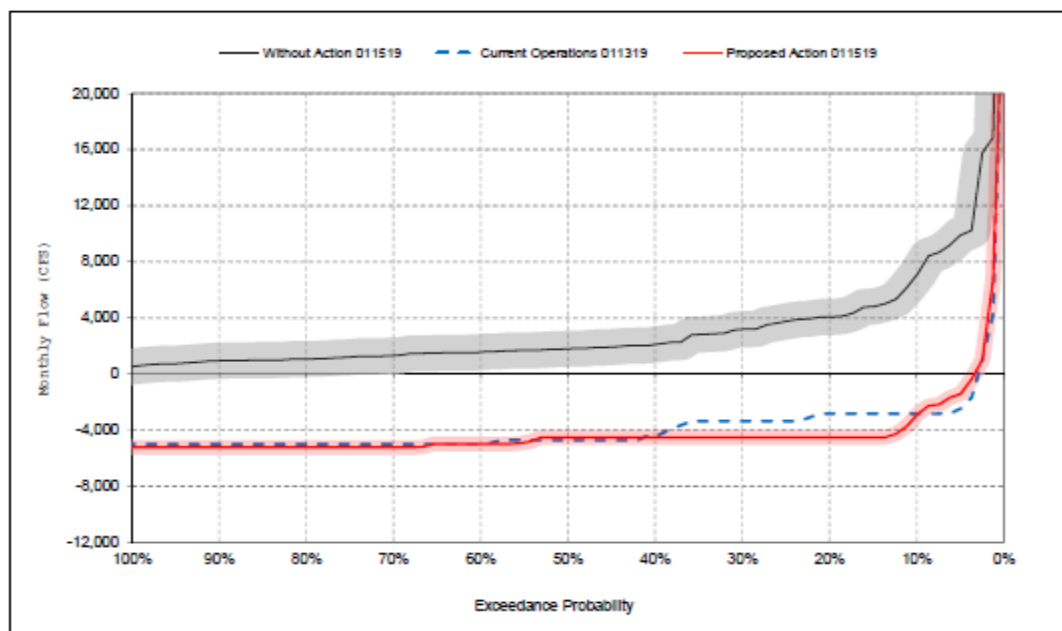


Figure 5.16-42. Mean Modeled Old and Middle River Flows, January.

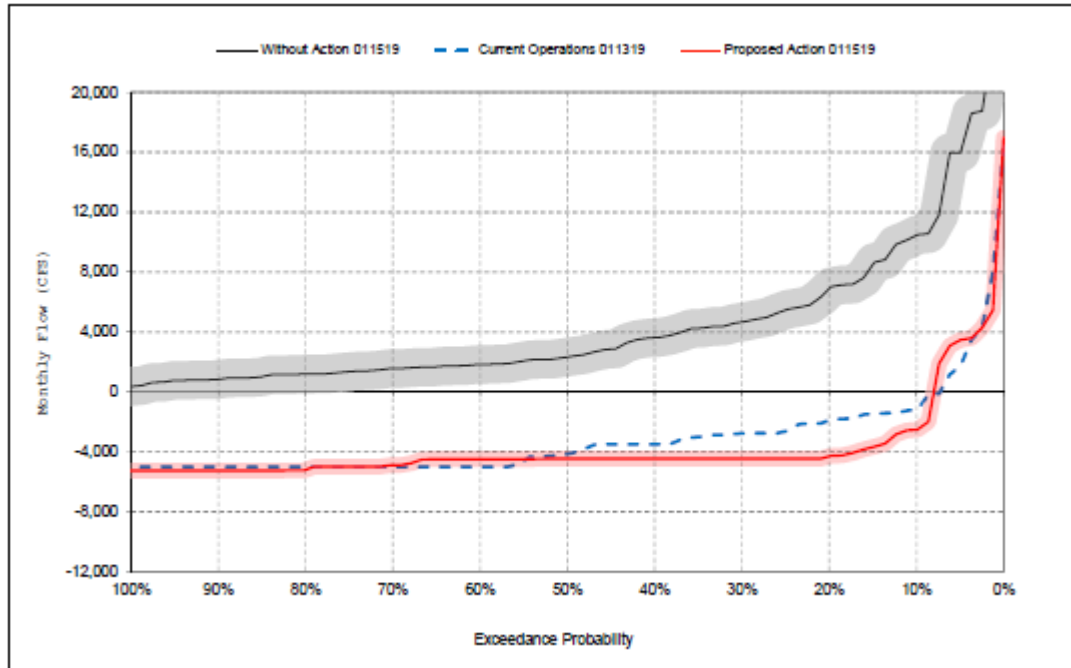


Figure 5.16-43. Mean Modeled Old and Middle River Flows, February.

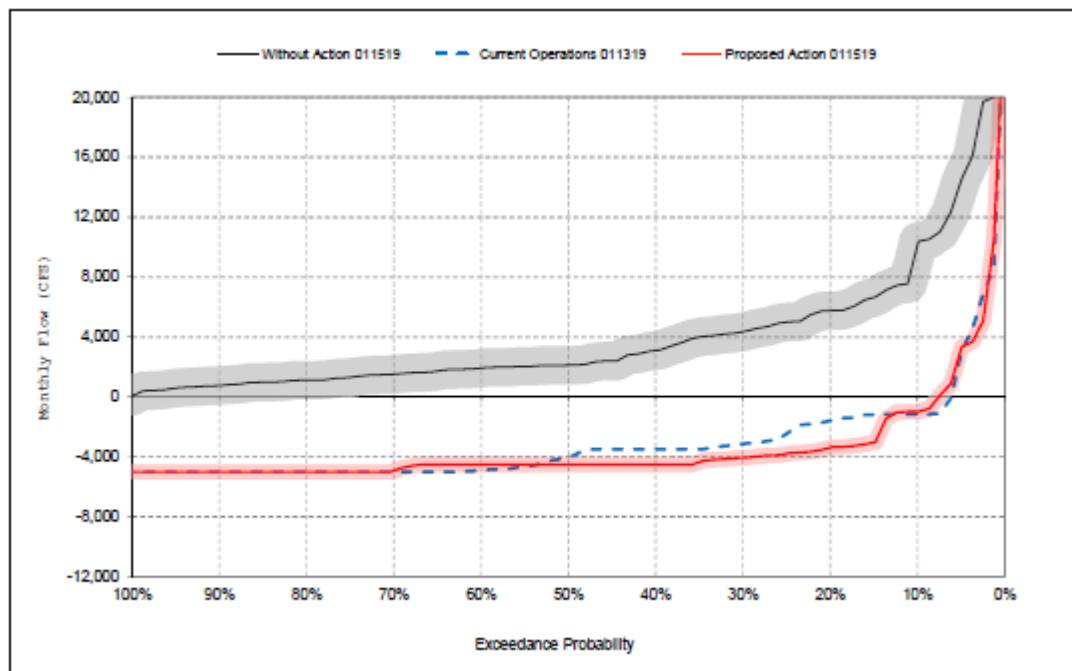


Figure 5.16-44. Mean Modeled Old and Middle River Flows, March.

5.16.3.2.2 Eggs and Larvae to Juveniles (March - June)

5.16.3.2.2.1 Entrainment Risk

The IEP MAST (2015) conceptual model suggests that larval and early juvenile Delta Smelt entrainment risk is related to exports and spring hydrology (Figure 5.16-4). Under without action conditions of no south Delta export pumping, there would be no entrainment of larval/early juvenile Delta Smelt at the south Delta exports for the CVP and SWP. The lack of south Delta export pumping is reflected in OMR flows under the WOA scenario generally being positive during March–June (Figures 5.16-44, 5.16-45, 5.16-46, 5.16-47). Current operations limit entrainment risk per the requirements of the 2008 biological opinion RPA Action 3. OMR flows are limited to protective levels $\geq -5,000$ cfs during the main period of larval/early-juvenile entrainment risk (March–June), as shown in the long-term modeling for the COS (Figures 5.16-44, 5.16-45, 5.16-46, 5.16-47).

Current operations management has kept salvage (take) of early juvenile Delta Smelt below the protective low limits prescribed in the 2008 biological opinion. However, salvage is inefficient for fish smaller than 30 millimeters in length. Therefore, larval juveniles less than 30 mm in size may not be accounted for accurately. As with adult Delta Smelt, CalSim modeling suggests that OMR flows under the PA generally would be similar to the OMR flows under COS in March (Figure 5.16-44), or generally be lower in April–June (Figures 5.16-45, 5.16-46, 5.16-47). As described further in the *OMR Management* section of the *Proposed Action by Basin* description, when larval or juvenile smelt are within the entrainment zone of the pumps based on monitoring group assessment and net flow in the lower San Joaquin River (QWEST) is negative, it is proposed that hydrodynamic models informed by survey data (e.g., EDSM or 20-mm Survey) would be run to estimate the percentage of larval and juvenile smelt that could be entrained, and operations would be adjusted such that modeling indicates that no greater than 10% loss of modeled larval and juvenile cohort Delta Smelt would be entrained. Similar to current operations, the proposed action would cease OMR management by the earlier of a) June 30, or b) when daily mean water temperature at Clifton Court Forebay reaches 25°C for three consecutive days—an indicator of poor habitat conditions and low likelihood of Delta Smelt presence in the south Delta (USFWS 2008, p.365)—and more than 95% of juvenile salmonids have migrated past Chipps Island (or Mossdale water temperatures have exceeded 72 degrees Fahrenheit for 7 days in June). Inclusion of these measures in the proposed action suggests that relatively few larval and juvenile Delta Smelt individuals would be lost to entrainment at the south Delta export facilities.

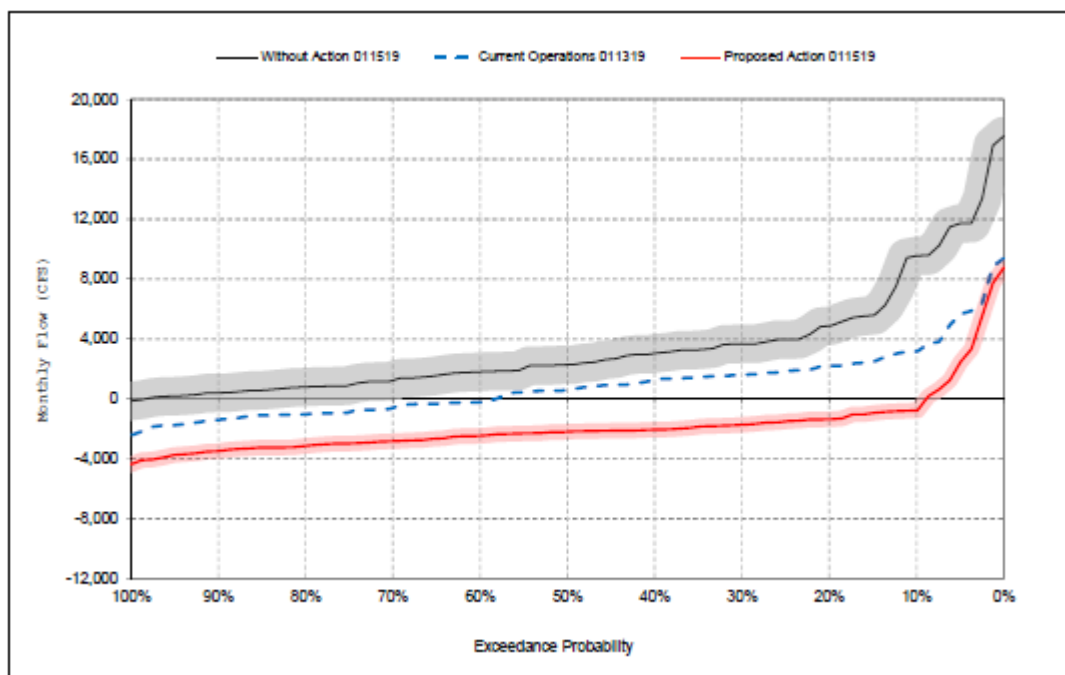


Figure 5.16-45. Mean Modeled Old and Middle River Flows, April.

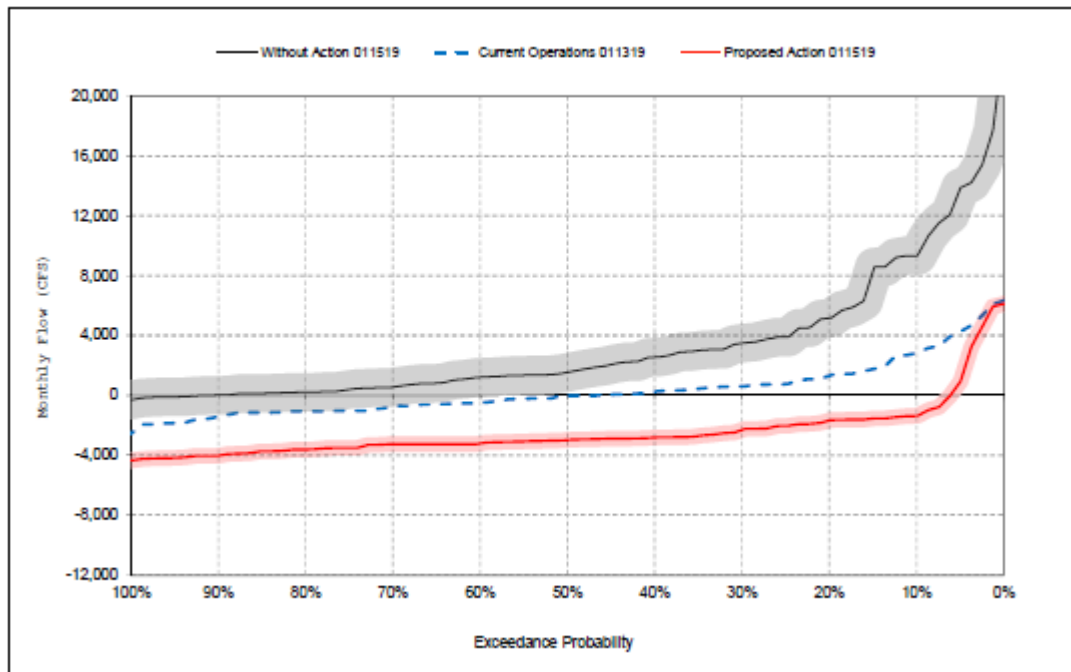


Figure 5.16-46. Mean Modeled Old and Middle River Flows, May.

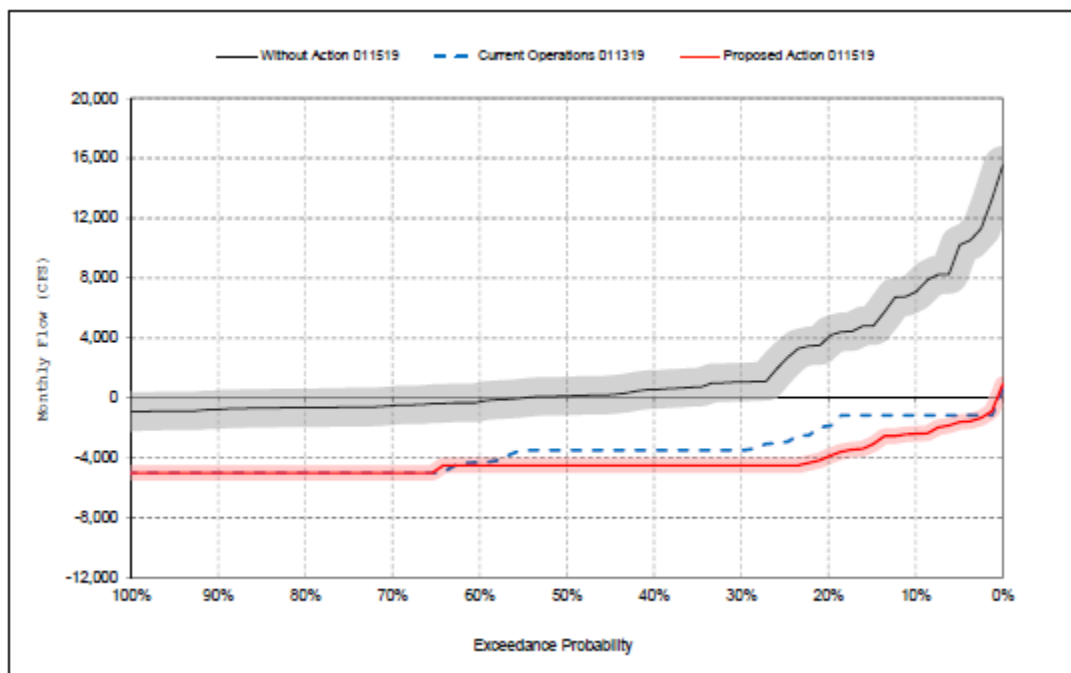


Figure 5.16-47. Mean Modeled Old and Middle River Flows, June.

5.16.3.3 Delta Cross Channel

5.16.3.3.1 Adults to Eggs and Larvae (December - May)

As discussed by USFWS (2017a, p.265), it is unknown what, if any, direct impacts occur to Delta Smelt as a result of opening or closing the DCC gates. USFWS (2017a, p.265) considered the region near the DCC gates to only be transiently used during movement of some adult Delta Smelt upstream. USFWS (2017a, p.265) suggested that it may be possible that opening or closing the DCC gates changes the migration path of some Delta Smelt, but noted that it is unknown if there may be a change in predation risk or likelihood of successful spawning, for example. During the adult Delta Smelt upstream migration period (principally December–March; USFWS 2017a, p.265), the DCC gates under the proposed action would largely be closed as a result of adherence to D-1641 criteria as well as real-time operations as a function of juvenile salmonid catch indices and projected water quality in the central/south Delta. Under without action conditions, DCC gates are permanently closed. USFWS (2017a, p.265) suggested that closure of the DCC would create more natural hydrology for migrating adult Delta Smelt by keeping flow in the Sacramento River and Georgiana Slough. Under the proposed action, the DCC gates are open for periods, possibly impacting Delta Smelt; however, there is limited occurrence of adult Delta Smelt near the DCC.

5.16.3.3.2 Eggs and Larvae to Juveniles (March - June)

Under the proposed action, the DCC would be expected to be largely closed during the March–June egg/larval transition period to juveniles. As described in more detail for adults, it is not known what effect the gates have on migration paths of Delta Smelt, but any effects would be expected to be limited given the low occurrence near the DCC (Figures 5.16-1 and 5.16-2; see also USFWS 2017a, p.159). Potential hydraulic effects on flows toward the south Delta export facilities would be taken into consideration when assessing south Delta entrainment risk, for example.

5.16.3.3.3 Juveniles to Subadults (June-September)

The distribution of juvenile Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the June–September transition from juveniles to subadults. The IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by this difference, which is a change in flow distribution rather than a change in overall summer hydrology, an environmental driver included in the conceptual model. More flow entering the lower San Joaquin River through the DCC presumably could lead to greater potential for flux of *P. forbesi* to the low salinity zone, given the importance of the San Joaquin River side of the Delta as a source of *P. forbesi* (Kimmerer et al. 2018c). However, the effect of south Delta exports on the flux of *P. forbesi* to the low salinity zone may be more important than any effect of the DCC, as suggested by QWEST flows (Figures 5.16-16 through 5.16-18).

5.16.3.3.4 Subadults to Adults (September - December)

As described for juvenile Delta Smelt, the distribution of subadult Delta Smelt is downstream of the DCC (Figures DS-1 and DS-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operation, the DCC would largely be open during the September–December transition from subadults to adults, prior to upstream migration as adults. It could be argued that an open DCC would provide more flow to the lower San Joaquin River and, therefore, increase the potential for flux of *P. forbesi* to the low salinity zone (Kimmerer et al. 2018c). However, as described for juvenile Delta Smelt, south Delta exports appear to be a more important effect than the effect of the DCC given the generally negative QWEST flows (Figure 5.16-18).

5.16.3.4 Temporary Barriers Program

5.16.3.4.1 Adults to Eggs and Larvae (December - May)

As discussed by USFWS (2008, p.225-226), the TBP under the proposed action has the potential to influence south Delta hydraulics by blocking flow entering the Delta from the San Joaquin River. Blocking this flow has the potential to increase entrainment risk of adult Delta Smelt during the later spring months after the barriers are installed. However, the Head of Old River barrier would not be installed under the proposed action. Adult Delta Smelt occurring in the vicinity of the barriers could be subjected to predation (USFWS 2008, p.226), although based on the typical distribution, few individuals would be expected to occur in the south Delta (Figures 5.16-1 and 5.16-2).

5.16.3.4.2 Eggs and Larvae to Juveniles (March - June)

As described for adult Delta Smelt, entrainment risk of larval Delta could be affected by the TBP, although the Head of Old River barrier would not be installed under the proposed action, thereby avoiding potential effects of that facility (USFWS 2008, p.225-226). The other barriers could also have effects such as trapping Delta Smelt upstream where they could be susceptible to entrainment, but effects would be limited given the low occurrence in the area (Figures 5.16-1 and 5.16-2).

5.16.3.4.3 Juveniles to Subadults (June-September)

Given occurrence outside of the south Delta, the TBP under the proposed action would not have direct effects on juvenile Delta Smelt, although USFWS (2008, p.226) suggested that there could be an effect on the flux of *P. forbesi* to the low salinity zone. Any such effect presumably would be small relative to the effect of south Delta exports on this flux, which was previously discussed in relation to seasonal operations.

5.16.3.4.4 Subadults to Adults (September - December)

As described for juvenile Delta Smelt, given occurrence outside of the south Delta, the TBP under the proposed action would not have direct effects on subadult Delta Smelt, although USFWS (2008, p.226) suggested that there could be an effect on the flux of *P. forbesi* to the low salinity zone. Any such effect presumably would be small relative to the effect of south Delta exports on this flux, which was previously discussed in relation to seasonal operations.

5.16.3.5 Contra Costa Water District Rock Slough Intake

Rock Slough is a relatively slow flowing, tidal waterway which ends at the Rock Slough Extension, approximately 1,700 feet upstream from the Rock Slough Intake. Rock Slough is generally poor habitat with relatively high water temperature and a prevalence of aquatic weeds (USFWS 2008; Reclamation 2016). Fish monitoring at the Rock Slough facilities, including the Rock Slough Headworks, RSFS, and Pumping Plant 1, from 1999 through 2018 has collected very few smelts of any life stage: two larval smelts, one delta smelt (8.3 mm TL collected May 2012) and one longfin smelt (7.3 mm TL collected March 2008); no juvenile smelts; and one adult smelt (66 mm FL delta smelt on February 2005) (Reclamation 2016; Tenera 2018b; ICF 2018). No smelts have been collected at the Rock Slough facilities since 2012.

Based upon poor habitat quality, the limited number delta smelt collected near the Rock Slough Intake, and the design criteria for the RSFS (approach velocity of 0.2 ft/sec), it is concluded that any near-field effect on hydrodynamics (i.e., near the Rock Slough Intake) and any entrainment of delta smelt at the

Rock Slough Intake would be negligible. The following sub-sections address “far-field” effects resulting from altered Delta hydrodynamics for each life stage.

5.16.3.5.1 Adults to Eggs and Larvae (Dec-May)

Rock Slough Intake is located on Rock Slough, approximately 3.5 miles west of the junction of Rock Slough and Old River, which is over 12 river miles north of the gates to the SWP Clifton Court Forebay. Given its location, the Rock Slough Intake does not affect net reverse flow in Old and Middle Rivers (OMR), and any effect that diversions at Rock Slough Intake would have in the Old and Middle River corridor would be to increase the northerly (positive) flow away from the Banks and Jones Pumping Plants.

However, diversions at the Rock Slough Intake could affect flows in the San Joaquin River at Jersey Point, which is approximately 14 river miles from the Rock Slough Intake (via the shortest route through Franks Tract). The following analysis quantifies the maximum effect of Rock Slough diversions on velocity in the San Joaquin River at Jersey Point. The maximum effect of Rock Slough diversions on the channel velocity would be the maximum diversion rate (350 cfs) divided by the minimum cross-sectional area of the channel. This calculation assumes that all water diverted at Rock Slough comes from the San Joaquin River at Jersey Point, which is a conservative assumption (i.e., overestimates the effect on velocity).

The cross-sectional area of the San Joaquin River at Jersey Point is approximately 60,500 square feet (sf), but varies depending on the tidal stage from approximately 56,000 sf to 68,000 sf as calculated from USGS measurements of flow and velocity at Jersey Point (Station: 11337190) every 15 minutes for Water Years 2014 through 2018 (see Winter-run section). The maximum effect of water diversions at Rock Slough Intake on velocity in the San Joaquin River at Jersey Point is calculated as 350 cfs divided by 56,000 sf, resulting in 0.00625 feet per second (ft/sec). For comparison, the most stringent fish screening requirement in the Delta (i.e., USFWS screening criteria for Delta Smelt) is 0.2 ft/sec, which is 32 times the maximum possible contribution from Rock Slough diversions. Furthermore, the actual effect is likely to be much lower than 0.00625 ft/sec because the water diverted at the Rock Slough Intake does not all come from the San Joaquin River west of Jersey Point.

Recognizing that CCWD owns and operates two additional intakes in the south Delta, this analysis examines the combined effect of all three intakes. CCWD’s Old River Intake and Middle River Intake have a physical capacity of 250 cfs at each intake. If CCWD were to divert at all three intakes at the maximum capacity at the same time, total CCWD diversions would be 850 cfs. The corresponding effect on velocity in the San Joaquin River at Jersey Point would be 0.015 ft/sec. The velocity threshold used to protect Delta Smelt from diversions in the vicinity of fish screens (0.2 ft/sec) is over 13 times greater than the maximum possible contribution from CCWD’s combined physical capacity. The water diversions at the Rock Slough Intake when combined with diversions at CCWD’s Old River Intake and Middle River Intake have a negligible effect on velocity in the San Joaquin River at Jersey Point.

Nonetheless, even extremely small changes in velocity can affect the movement of neutrally buoyant particles such as phytoplankton. To examine the effect on neutrally buoyant particles, Reclamation calculated the distance that a particle would travel due to the maximum permitted Rock Slough diversions over the course of a day. A change in velocity of 0.00625 ft/sec could move a neutrally buoyant particle approximately 540 ft over the course of the day (0.00625 ft/sec * 86,400 sec/day). For comparison, the tidal excursion on the San Joaquin River at Jersey Point during a flood tide (i.e., the distance a particle will travel tidally upstream during a flood tide) is about 34,000 ft on average (or 6.4 miles), which is about 63 times the distance that diversions at Rock Slough could move a particle at the same location over

the course of a full day. Therefore, the maximum possible contribution of diversions at Rock Slough on movement of neutrally buoyant particles such as phytoplankton is insignificant in comparison to the tidal excursion and mixing at this location.

Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact adult Delta Smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.2 Eggs and Larvae to Juveniles (March-June)

As described for adult Delta Smelt above, the maximum diversion rate at Rock Slough would have an insignificant effect on Delta hydrodynamics. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact larvae and juvenile Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.3 Juveniles to Subadults (June-September)

Juvenile Delta Smelt would not be expected to occur near the Rock Slough Intake in the south Delta (Figures 5.16-1 and 5.16-2) and so there would be no near-field individual or population-level effects from this diversion on this life stage. Furthermore, as described for adult Delta Smelt above, the maximum diversion rate at Rock Slough would have an insignificant effect on far-field Delta hydrodynamics. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact juvenile and subadults Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.5.4 Subadults to Adults (September-December)

Subadult Delta Smelt would not be expected to occur near the Rock Slough Intake in the south Delta (Figures 5.16-1 and 5.16-2) and so there would be no near-field individual or population-level effects from this diversion on this life stage. Although the diversions at the Rock Slough Intake under the proposed action are not likely to impact subadults and adult Delta smelt, the aggregate effects of all water diversion in the Delta, including exports at Jones and Banks Pumping Plants can affect channel velocity.

5.16.3.6 *North Bay Aqueduct*

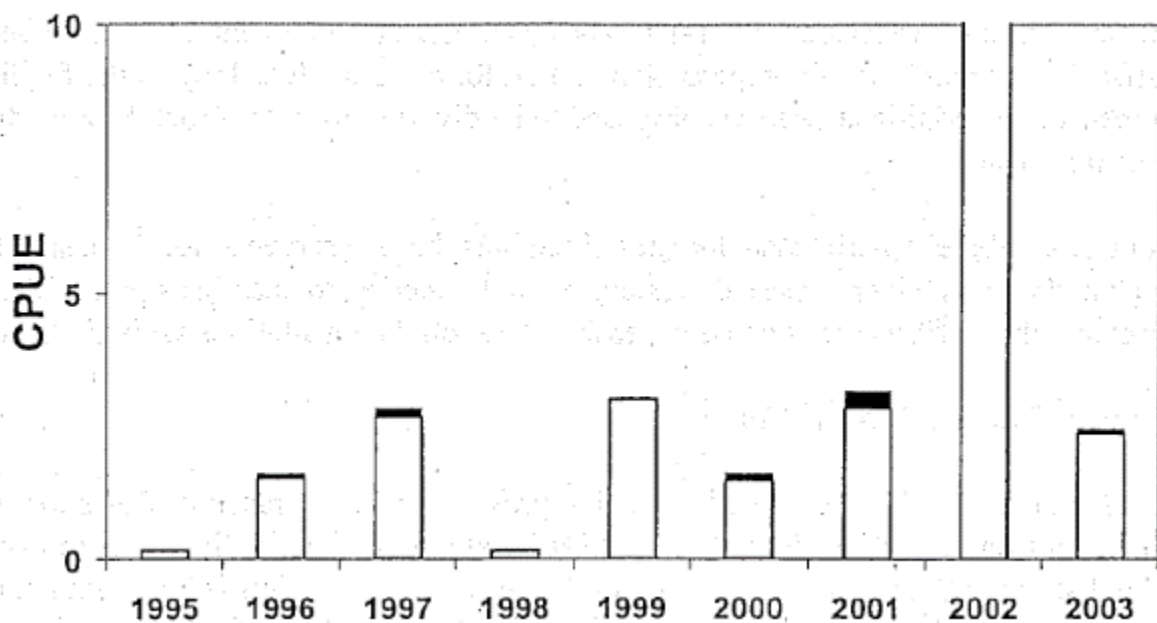
5.16.3.6.1 Adults to Eggs and Larvae (December - May)

Under without action conditions, there would be no pumping at the Barker Slough Pumping Plant (BSPP). Under the proposed action, operational criteria at the BSPP would be the same as under current operation. Consistent with modeling assessed in the 2008 biological opinion, the CalSim modeling this biological assessment assumes that the current operations and the proposed action divert approximately 71,000 acre-feet of water per year as part of SWP operations, based on contracted amounts. Actual diversions during 2009–2016 were lower (~33,000–50,000 acre-feet per year from the DAYFLOW database). As summarized by USFWS (2017a, p.269), the Cache Slough Complex from which the BSPP diverts water is an area of high adult Delta Smelt density (see also Figures 5.16-1 and 5.16-2). However, that does not mean catches are high everywhere in the complex. For instance, historical catch rates of Delta Smelt larvae in Barker Slough were consistently low during surveys undertaken following the issuance of the 1995 SWP/CVP biological opinion (USFWS 2005; Figure NBA_ds), indicating that a relatively small portion of the Delta Smelt population in the Cache Slough Complex is susceptible to entrainment/impingement from NBA diversions (USFWS 2017a, p.270). The BSPP intakes are screened to 3/32-inch opening, which excludes Delta Smelt >25 mm and therefore would be expected to preclude

the potential for adult entrainment (USFWS 2017a, p.269). Approach velocity of ~0.2 ft/s at two of the ten units minimizes impingement potential on the screens (USFWS 2017a, p.269-270), whereas impingement potential presumably is greater at the eight larger units with approach velocity of ~0.44 ft/s (California Department of Fish and Game 2009, p.3). As a result of the California Department of Fish and Game (2009) ITP for operations of the SWP, diversion rates are limited to 50 cfs from January 15 to March 15 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. These restrictions reduce NBA diversions during the period of potential adult Delta Smelt occurrence and the early part of the delta smelt spawning season as well. However, the North Bay Aqueduct may have effects on predation (e.g., near the fish screens) and food availability (entrainment of plankton) in addition to direct entrainment.

5.16.3.6.2 Eggs and Larvae to Juveniles (March - June)

Historical catch rates of larval and early juvenile Delta Smelt in Barker Slough were low (USFWS 2005; Figure 5.16-48), suggesting limited exposure to potential effects of the proposed action from the BSPP. The 3/32-inch openings of the BSPP intakes mean that individual larval and early juvenile Delta Smelt are susceptible to entrainment, but there would be relatively low occurrence in the area.



Source: USFWS (2005, p.181). Note: The NBA values are the mean annual CPUE for stations 720, 721, and 727. The nearby North Delta sites are the mean annual CPUE for stations 718, 722, 723, 724, and 726 (<https://www.wildlife.ca.gov/Portals/0/Images/Conservation/Delta/nbabase.gif>)

Figure 5.16-48. Delta Smelt Catch Per Unit Effort (CPUE; Fish Per Trawl) for North Bay Aqueduct Monitoring in Barker Slough (Dark Bars) Compared to Nearby North Delta Sites (Lindsay, Cache, and Miner Sloughs; White Bars).

5.16.3.6.3 Juveniles to Subadults (June-September)

Available monitoring suggests infrequent occurrence in Barker Slough (Figure NBA_ds), and the majority of juveniles reaching adulthood would tend to rear in the low salinity zone in most years (Bush 2017), suggesting limited exposure to potential effects of the proposed action from the BSPP. The 3/32-

inch openings of the BSPP intakes would be expected to exclude most juvenile Delta Smelt from entrainment.

5.16.3.6.4 Subadults to Adults (September - December)

The majority of subadults reaching adulthood would tend to rear in the low salinity zone in most years (Bush 2017), suggesting limited exposure to potential effects of the proposed action from the BSPP, and the 3/32-inch openings of the BSPP intakes would exclude subadult Delta Smelt from entrainment.

5.16.3.7 *Water Transfers*

As discussed in Spring-run Chinook Salmon section, Reclamation's proposed action to expand the transfer window to July to November could result in additional pumping of approximately 50 TAF per year in most water year types. As shown in Figures 5.16-1 and 5.16-2, larvae and sub-adults are the main lifestages of Delta Smelt found in the south Delta, and both of these lifestages would occur in the South Delta mostly in the spring. The water transfer window therefore does not overlap with anticipated Delta Smelt presence in the South Delta. However, an occasional Delta Smelt could potentially be exposed to increased pumping as result of water transfers, which could cause entrainment, or predation risk. Effects would be the same as those discussed for OMR management above.

5.16.3.8 *Clifton Court Forebay Aquatic Weed Program*

In the without action scenario, Clifton Court Forebay (CCF) gates are not operated and Banks Pumping Plant is not run, and therefore there would be no removal of aquatic weeds from CCF. This program does occur under current operations as removal of aquatic weeds is necessary for operation of the CVP and SWP to allow for drawing water into the pumping plants and avoiding physical blockage at the trashracks, reducing pumping rates to prevent pump cavitation.

5.16.3.8.1 Adults to Eggs and Larvae (December - May)

For control of aquatic weeds (predominantly *Egeria densa*) in CCF, the proposed action includes application of herbicides (see proposed action for more details) after water temperatures within CCF are above 25°C or after June 28 and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter, and mechanical harvesting as needed. Given the timing of the action, individual adult Delta Smelt would not be exposed to any toxic effects of the herbicides, as adult Delta Smelt would not be in CCF after water temperatures are above 25°C or after June 28 and before activation of Delta Smelt protection measures. Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore could coincide with occurrence of migrating adult Delta Smelt. Delta Smelt generally would not be expected to found near aquatic weeds (Ferrari et al. 2014), but could occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the CCF. Any potential adverse effects to individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds. However, as noted by USFWS (2017a, p.271), mortality in CCF is very high for adults (Castillo et al. 2012), so that any effects of weed control would be limited as Delta Smelt in CCF would already have deceased. In addition, as previously described in the *Entrainment Risk* section, south Delta exports would be managed to limit the occurrence and therefore entrainment risk of Delta Smelt at the south Delta export facilities, thus limiting the number of individuals entering CCF that could be exposed to the weed control program.

5.16.3.8.2 Eggs and Larvae to Juveniles (March - June)

Control of aquatic weeds in CCF with herbicides under the proposed action (i.e., after water temperatures within CCF are above 25°C or after June 28 and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter) would not affect larval Delta Smelt, given their life stage timing (March–June). Although mechanical removal activities under the proposed action could in theory affect larval Delta Smelt in CCF, they already have poor chances of survival in CCF (as discussed previously in the *Entrainment Risk* section) as salvage is only effective for larger fish.

5.16.3.8.3 Juveniles to Subadults (June-September)

Juvenile Delta Smelt occur in the low salinity zone or in the north Delta and not in the south Delta (Figures 5.16-1 and 5.16-2); there would not be effects on juvenile Delta Smelt from the CCF aquatic weed control program under the proposed action.

5.16.3.8.4 Subadults to Adults (September - December)

Subadult Delta Smelt occur in the low salinity zone or in the north Delta and not in the south Delta (Figures 5.16-1 and 5.16-2); there would not be effects on juvenile Delta Smelt from the CCF aquatic weed control program under the proposed action.

5.16.3.9 *Suisun Marsh Facilities*

Under the without action scenario, DWR would not operate the Suisun Marsh Salinity Control Gate, Roaring River Distribution System, Morrow Island Distribution System, or Goodyear Slough Outfall leading to a saltier Suisun Marsh and decreased Delta Smelt habitat. However, depending on the time of year, the without action scenario would result in much higher Delta outflow than the proposed action and current operations; thereby resulting in overall increases in Delta Smelt habitat.

5.16.3.9.1 Adults to Eggs and Larvae (December - May)

5.16.3.9.1.1 Suisun Marsh Salinity Control Gates

Operations of the SMSCG under the proposed action includes current operations (i.e., 17–69 days per year from October through May) plus an additional 60 days in June–September of above normal and below normal water years to benefit juvenile and subadult Delta Smelt. As such, the recent analysis of potential effects by USFWS (2017a, p.266-267) is relevant. Potential blockages of the migration of adult Delta Smelt individuals by SMSCG operations, previously the primary concern of USFWS (2008), were found to be of lesser concern by USFWS (2017a, p.267), given that Delta Smelt can spawn in Montezuma Slough (see adult distribution and frequency of occurrence in Figures 5.16-1 and 5.16-2). USFWS (2017a, p.267) also suggested that aggregation of predators such as Striped Bass near the SMSCG could increase predation rates, and operation of the SMSCG could increase risk of entrainment in diversions. There is limited risk of entrainment as the Roaring River Distribution System is screened, and little evidence for small diversions resulting in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.1.2 Roaring River Distribution System

Water diversion operations of the RRDS under the proposed action would not change relative to current operations (although draining of the RRDS to Grizzly Bay/Suisun Bay would change in summer/fall, in

coordination with the SMSCG action). As noted by USFWS (2017a, p.267-268), the RRDS is screened (3/32-inch opening), therefore excluding Delta Smelt of ~30 mm and larger and operated to maintain an approach velocity of 0.2 ft/s to minimize effects to Delta Smelt from entrainment, impingement, and screen contact.

Other effects of the Roaring River Distribution System could include increased predation near the fish screen and entrainment of plankton affecting food availability, as discussed above under North Bay Aqueduct. However, due to the relatively small capacity of the Roaring River Distribution System, these effects are anticipated to be small.

5.16.3.9.1.3 Morrow Island Distribution System

No changes in current MIDS operations are included in the proposed action. As discussed by USFWS (2017a, p.268-269), entrainment of individual adult Delta Smelt by the three MIDS unscreened 48-inch intakes could occur, but the effects would be expected to be limited to wet years (Enos et al. 2007), per spawner distributions found by Hobbs et al. (2005). No Delta Smelt were collected during entrainment sampling at MIDS in 2004-2006 (Enos et al. 2007). MIDS is often closed or diversions are small during the spring spawning period of adult Delta Smelt, which may offer protection given that Delta Smelt microhabitat occupancy tends to be in open water away from structures. Beach seine data has shown some Delta Smelt along the shore, which could be affected by MIDS.

Other effects of the Morrow Island Distribution System could include increased predation and negative effects on food availability through entrainment of plankton, as discussed above for the Roaring River Distribution System. However, due to the relatively small capacity of the Morrow Island Distribution System, these effects are anticipated to be small.

5.16.3.9.1.4 Goodyear Slough Outfall

Operation of the flap gates at the Goodyear Slough outfall under the proposed action would continue as under current operations. As discussed by USFWS (2017a, p.269), individual adult Delta Smelt could be entrained into Goodyear Slough by the flap gates' creation of a small southerly net flow, but the Goodyear Slough area is generally too saline for Delta Smelt and occurrence would only be likely in wet years (Enos et al. 2007, p.17).

The small southerly net flow could create other effects including such as increased predation near the flap gates. However, due to the relatively small capacity of the Goodyear Slough Outfall, these effects are anticipated to be small.

5.16.3.9.2 Eggs and Larvae to Juveniles (March - June)

5.16.3.9.2.1 Suisun Marsh Salinity Control Gates

As described for adult Delta Smelt, operations of the SMSCG under the proposed action would be unchanged from current operations during March–June. Gate operations could change movement patterns of larval Delta Smelt, potentially increasing risk of entrainment by diversions within Suisun Marsh, although existing modeling for RRDS suggests this risk to be limited as discussed in the life stage above.

5.16.3.9.2.2 Roaring River Distribution System

Effects to larval and young juvenile Delta Smelt from the RRDS under the proposed action would be limited and unchanged from current operations. Delta Smelt smaller than 30 mm could be susceptible to

entrainment, whereas slightly larger fish could be susceptible to impingement (USFWS 2017a, p.268). Available particle tracking modeling suggests that entrainment risk would be low (USFWS 2017a, p.268).

5.16.3.9.2.3 Morrow Island Distribution System

As noted for adult Delta Smelt, there would be no changes to current MIDS operations under the proposed action, and any potential effects (in particular entrainment) would be expected to be limited given that conditions are generally too saline for Delta Smelt (limiting exposure to wet years) and the MIDS intakes are often closed or diversions are small during the spring larval period (USFWS 2017a, p.268-269).

5.16.3.9.2.4 Goodyear Slough Outfall

As described for adult Delta Smelt, operation of the Goodyear Slough outfall under the proposed action would continue as under current operations. Larval Delta Smelt individuals could be entrained into Goodyear Slough by the flap gates' creation of a small southerly net flow. However, the Goodyear Slough area is generally too saline for Delta Smelt and occurrence would only be likely in wet years (Enos et al. 2007, p.17).

5.16.3.9.3 Juveniles to Subadults (June-September)

5.16.3.9.3.1 Suisun Marsh Salinity Control Gates

As summarized for adult Delta Smelt, operation of the SMSCG under the proposed action could affect individual juvenile Delta Smelt through increased entrainment at local diversions or predation near the gates. There is limited risk of entrainment as the Roaring River Distribution System is screened, and little evidence for small diversions resulting in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.3.2 Roaring River Distribution System

As discussed for adult Delta Smelt, juvenile Delta Smelt of ~30 mm and greater would be expected to be excluded from entrainment at RRDS under the proposed action, and the 0.2-ft/s approach velocity is protective of Delta Smelt.

5.16.3.9.3.3 Morrow Island Distribution System

No juvenile Delta Smelt were collected during entrainment monitoring at MIDS in 2004–2006 by Enos et al. (2007), and juvenile Delta Smelt of ~30 mm and greater would be excluded from entrainment associated with the MIDS under the proposed action.

5.16.3.9.3.4 Goodyear Slough Outfall

As described for adult Delta Smelt, only in wet years would the Goodyear Slough outfall under the proposed action be expected to have potential effects to individual juvenile Delta Smelt as a result of entrainment into Goodyear Slough.

5.16.3.9.4 Subadults to Adults (September - December)

5.16.3.9.4.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG could result in increased entrainment at local diversions of individual subadult Delta Smelt or predation near the gates. However, the RRDS will be screened under the proposed action and there is little evidence that small diversions result in considerable entrainment of juvenile Delta Smelt (Nobriga et al. 2004).

5.16.3.9.4.2 Roaring River Distribution System

As discussed for other life stages, Delta Smelt of ~30 mm and greater and therefore all subadults would be expected to be excluded from entrainment at RRDS associated with the proposed action, and the 0.2-ft/s approach velocity is protective of Delta Smelt.

5.16.3.9.4.3 Morrow Island Distribution System

No subadult Delta Smelt were collected during entrainment monitoring at MIDS in 2004–2006 by Enos et al. (2007) and those authors concluded that conditions are generally too saline, except for spawners (i.e., during the wet season) of wetter years. Therefore, effects of operation under the proposed action are expected to be negligible.

5.16.3.9.4.4 Goodyear Slough Outfall

As described for other life stages, only in wet years would the Goodyear Slough outfall under the proposed action be expected to have potential effects to individual Delta Smelt as a result of entrainment into Goodyear Slough. Given the seasonality of subadult occurrence during what is a low-flow portion of the year, exposure to the effects of Goodyear Slough outfall would be expected to be negligible.

5.16.3.10 Effects of Maintenance

Maintenance effects include crushing, impingement, noise, and harassment from in-water work to repair facilities. Implementation of the species avoidance and take minimization steps described in Appendix E, *Avoidance and Minimization Measures* would be anticipated to minimize potential negative effects to Delta Smelt from maintenance activities.

5.16.4 Effects of Conservation Measures

The following are proposed conservation measures that are intended to offset or reduce the effects of operations and maintenance under the proposed action. These conservation measures would only occur due to the implementation of the proposed action and are beneficial in nature. The following analysis examines the construction related effects of the measures but also the benefits to the population once completed. Conservation measures would not occur under the without action scenario.

While conservation measures are beneficial, they may involve construction, which may have temporary impacts to Delta Smelt. Actions involving construction (i.e., Delta habitat restoration, Yolo Bypass project, the small screen program, predator hot spot removal, habitat restoration, improvements to the Delta Cross Channel, Tracy Fish Facility, Skinner Fish facility, reconstruction of the lock at the upstream end of the Sacramento Deepwater Ship Channel, restoration of lower San Joaquin River spawning and rearing habitat, and construction of the Delta Smelt Conservation Hatchery) would not be expected to overlap the occurrence of adult Delta Smelt given the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (December–May; Figure 5.16-3). Therefore, construction-related effects under the proposed action are not expected to impact adult Delta Smelt.

In addition, larval Delta Smelt would not be expected to be exposed to the effects of construction associated with the proposed action, based on the timing of in-water construction (August–October) and the typical seasonal occurrence of this life stage in the Delta (March–June; Figure 5.16-4).

Juvenile and subadult Delta Smelt have the potential to be exposed to the effects of construction under the proposed action, based on the timing of in-water construction (August–October) and the occurrence of this life stage in the lower Sacramento River where some construction of conservation measures would occur. Effects to individual Delta Smelt could include temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. Such effects include some of the habitat attributes hypothesized to be of importance to this life stage (Figure 5.16-5). The risk from these potential effects would be minimized through application of measures such as those described in Appendix E, *Avoidance and Minimization Measures*.

5.16.4.1 Suisun Marsh Salinity Control Gates

5.16.4.1.1 Adults to Eggs and Larvae (December -May)

Adult Delta Smelt are not affected by the SMSGC operation under the proposed action as they are not generally in Suisun Marsh during June through September when the action would occur (see Figures 5.16-1 and 5.16-2).

5.16.4.1.2 Eggs and Larvae to Juveniles (March - June)

Larvae Delta Smelt are not affected by the SMSCG operation under the proposed action as they are not generally in Suisun Marsh during June through September when the action would occur (see Figures 5.16-1 and 5.16-2).

5.16.4.1.3 Juveniles to Subadults (June-September)

As described in the IEP MAST (2015) conceptual model, food availability and quality is a key component of the June–September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals (Figure 5.16-5). The proposed action includes SMSCG operations in 60 days during June–September of above normal and below normal water year types in order to increase Delta Smelt food availability and quality through increased access to, and provision of low salinity Delta Smelt juvenile habitat in, the relatively food-rich Suisun Marsh habitat. The operation of the SMSCG would be combined with operation of the RRDS in order to allow productivity from the RRDS to be exported to the Grizzly Bay/Suisun Bay area (as described for the Delta Smelt Resiliency Strategy; California Natural Resources Agency 2016). As described further below, this action can also provide benefit to the subsequent, subadult life stage.

Evidence from a pilot 2018 application of the SMSCG action provides support for predicted habitat benefits. The SMSCG were operated during August 2018 and it was found that Delta Smelt entered the marsh and, therefore, had access to more productive habitat, better water quality conditions (lower salinity and higher turbidity) occurred, and the benefits extended well beyond the period of gate operations (Sommer et al. 2018). Thus, the proposed SMSCG action potentially increases Delta Smelt habitat suitability in an area with relatively high food availability and growth potential, as reflected by Delta Smelt individual-level responses such as stomach fullness (Hammock et al. 2015). The 2018 pilot implementation of the SMSCG action illustrated that the action could provide salinity conditions in Suisun Marsh during below normal years that, from the perspective of Delta Smelt juveniles, were similar

to or better than in wet years (Sommer et al. 2018). This may be of particular importance during periods of several drier years in a row.

Seasonal operations of the SMSCG as part of the proposed action potentially provide a positive effect to Delta Smelt juveniles through increased food availability that would provide some offsetting of potential negative effects from seasonal water operations. The south Delta exports influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018a), with these potential negative effects probably being of particular importance on the San Joaquin River side of the Delta given the high density of *P. forbesi* there (Kimmerer et al. 2018b).

Potential effects from the proposed action related to the SMSCG action would be expected to have the potential to affect a sizable portion of the Delta Smelt population. Bush (2017) demonstrated that on average 77 percent of adult Delta Smelt either migrate to the low salinity zone as early juveniles or are resident in the low salinity zone throughout their lives. During and just after the August 2018 pilot implementation of the SMSCG action, EDSM data from surveys between August 6 and September 7 suggest an average of 20 percent (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM).

5.16.4.1.4 Subadults to Adults (September - December)

As described in more detail for Delta Smelt juveniles, the proposed SMSCG operation in June–September of above normal and below normal years has the potential to increase Delta Smelt habitat suitability through lower salinity in the relatively food-rich Suisun Marsh, in conjunction with export of food to Grizzly Bay/Suisun Bay through operation of the RRDS. As described for juvenile Delta Smelt, the IEP MAST (2015) conceptual model posited link between fall hydrology and clam grazing (Figure 5.16-6) was not supported by an examination of *P. amurensis* biomass and grazing rate during the fall (Brown et al. 2014, p.50-56), so it is unclear what effect differences in hydrology might have on clam grazing and food availability.

As applied during the pilot 2018 implementation of the proposed SMSCG action discussed previously, additional Delta outflow is required to ensure that Delta salinity is maintained within D-1641 required levels, and that there is no net effect on X2. It is expected that this requires a few tens of thousands of acre-feet of additional Delta outflow (Zhou 2018); the required amount in 2018 was 37,000 acre-feet (Sommer et al. 2018). As illustrated with modeling for representative above normal (2005) and below normal (2012) years, operation of the SMSCG in August coupled with outflow augmentation to prevent no net X2 effect leads to a small increase in the overall Delta Smelt abiotic habitat Station Index (Table 5.16-1), a metric that includes salinity, turbidity, and current velocity (Bever et al. 2016).

Table 5.16-1. Monthly-Averaged Delta Smelt Station Index for with and without Suisun Marsh Salinity Control Gates Reoperation With Outflow Augmentation Scenarios.

| Month | Year | Delta Smelt Station Index without SMSCG Reoperation | Incremental Change with SMSCG Reoperation With Outflow Augmentation |
|-----------|------|-----------------------------------------------------|---------------------------------------------------------------------|
| August | 2005 | 0.54 | 0.03 |
| | 2012 | 0.24 | 0.03 |
| September | 2005 | 0.48 | 0.04 |
| | 2012 | 0.20 | 0.01 |
| October | 2005 | 0.39 | 0.01 |
| | 2012 | 0.18 | 0.01 |

Source: Anchor QEA (2018, p.98-99). Notes: SMSCG Reoperation With Outflow Augmentation scenario shown in the table is the 'Reoperation + Variable Outflow' scenario from Anchor QEA (2018, p.8). Index shown is for entire area. SMSCG assumed to be operated in August.

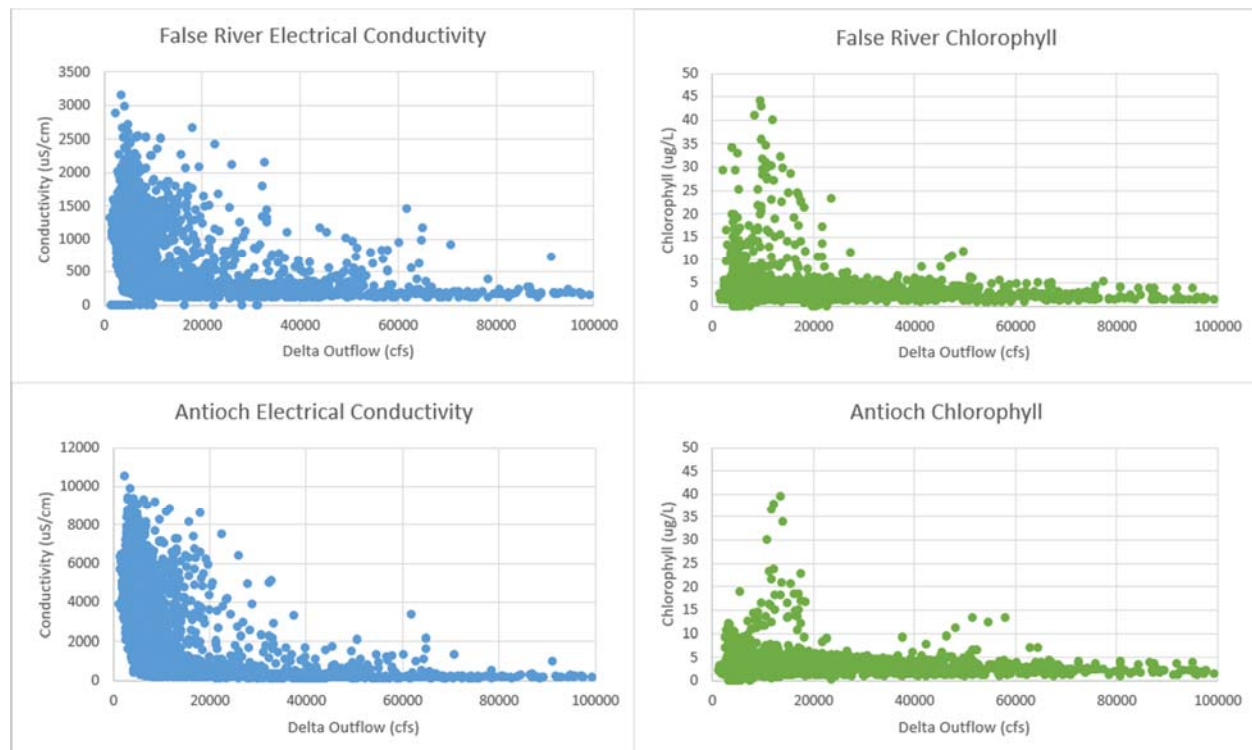
5.16.4.2 Fall Delta Smelt Habitat

Reclamation proposes to conduct actions from the list below to target creation of fall Delta Smelt habitat in September and October following above normal and wet years (IEP MAST 2015, p. 79). Fall Delta Smelt habitat would be measured using the physical and biological features of critical habitat; mainly Secchi depth, chlorophyll, water temperature, and salinity. The existing method of Feyrer et al. (2011) gives predictions of an abiotic habitat index as a function of X2, with the index essentially being the area of habitat (hectares) weighted by its suitability for Delta Smelt as a function of Secchi depth, specific conductance, and temperature. From this method, target habitat indices can be developed for fall following above normal (index = 4,835) and wet (index = 7,261) water years (IEP MAST 2015, p.83). With optimal conditions (i.e., habitat suitability = 1 for Secchi depth, specific conductance, and temperature), the habitat indices would be interpreted as 4,835 hectares of optimal habitat following above normal years and 7,261 hectares of optimal habitat following wet years. Use of a habitat index offers the benefit of incorporating the effects of other proposed actions that could influence variables other than just salinity (specific conductance). Reclamation would coordinate with USFWS 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 RRDS west-side drain. Achievement of these targets would be assessed using the UnTRIM Bay-Delta Model (DMA 2014) or another current multi-dimensional Delta model, applying the observed outflow and operations, in addition to other necessary inputs to be developed by Reclamation and DWR. The specific target habitat areal extent or index value will be refined from the initial proposal in consultation with USFWS and operational feasibility.

Potential actions under the proposed action to meet this goal would include:

- Operation of the Suisun Marsh Salinity Control Gate in coordination with the Roaring River Distribution System west-side drain in September and October of Above Normal and Wet years.
- Release of additional Delta outflow to move the low salinity zone to beneficial areas
- Increased food through managed wetlands
- Adding nutrients to the Delta
- Adding turbidity to the Delta through dredge material

The plots below in Figure 5.16-49 show raw daily electrical conductivity and chlorophyll from the sensors at False River (FAL), Antioch (ANH), and Mallard Island (MAL) from 2007 to the present. These physical parameters would be used as part of adaptive management to determine whether Reclamation has created Fall Delta Smelt Habitat under this action. Delta Outflow relates best to salinity, as expected, with slight relationships for the other variables. Chlorophyll is rarely above 10 ug/L at any of these stations, which per Mueller-Solger et al. (2002) is an indicator of conditions for good zooplankton growth.



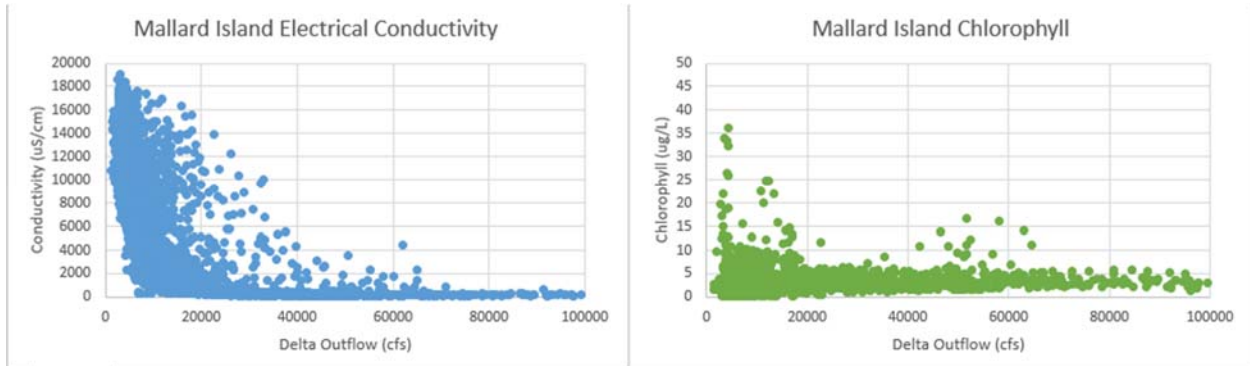


Figure 5.16-49. Raw daily electrical conductivity and chlorophyll from the sensors at False River, Antioch, and Mallard Island from 2007 onwards.

Figure 5.16-50 below shows average monthly July temperature at Mallard Island from 2000 – 2018 plotted versus Delta outflow. There is a very slight trend towards increasing temperature at higher Delta outflow, indicating concerns with releasing outflow to create Delta Smelt habitat, as it could increase temperatures. This correlation is unlikely to be statistically significant and it is uncertain whether or not there is a physical mechanism that could cause this effect.

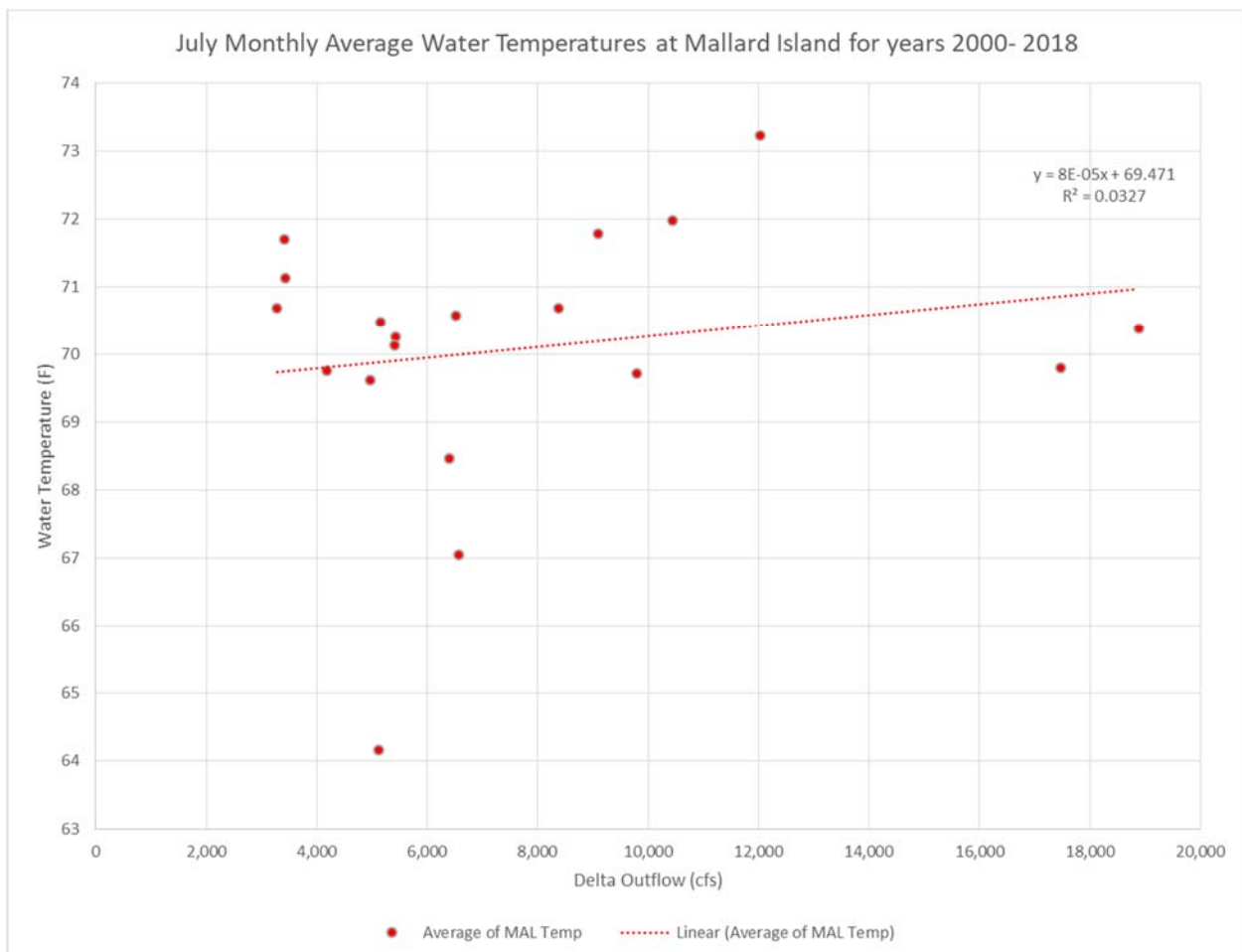


Figure 5.16-50. Average monthly July temperature at Mallard Island versus Delta outflow, 2000 – 2018.

Figure 5.16-51 shows turbidity by month and water year type. In wet years, turbidity generally drops at these stations in the May-June - presumably during periods of high snowmelt runoff. Turbidity is high in May and June at these stations in below-normal and dry water year types. January generally has high turbidity across water year types and stations, with precipitation runoff. This suggests that while high flows can mobilize sediment and increase turbidity, reservoir releases may not be the best method to control turbidity in the Delta. Natural rainfall events or other actions may be better tools. Turbidity is high in Below Normal years in August / September at Antioch because of an event in August/September 2010 when turbidity was above 100 NTU for weeks. Turbidity at Mallard Island is higher than the other two locations generally.

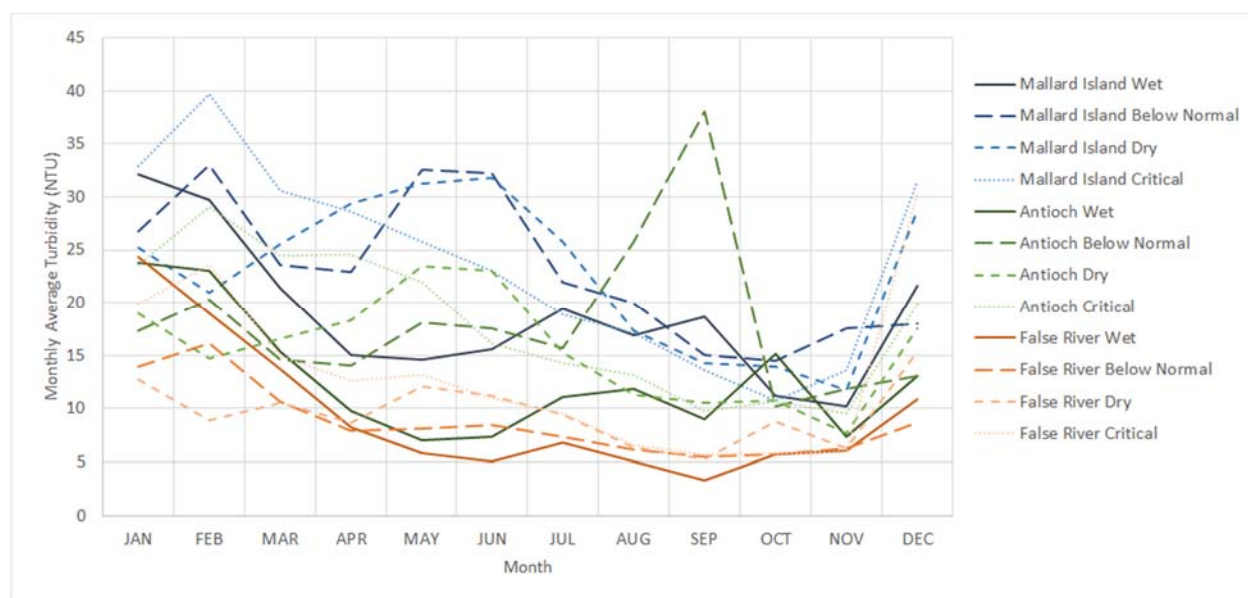
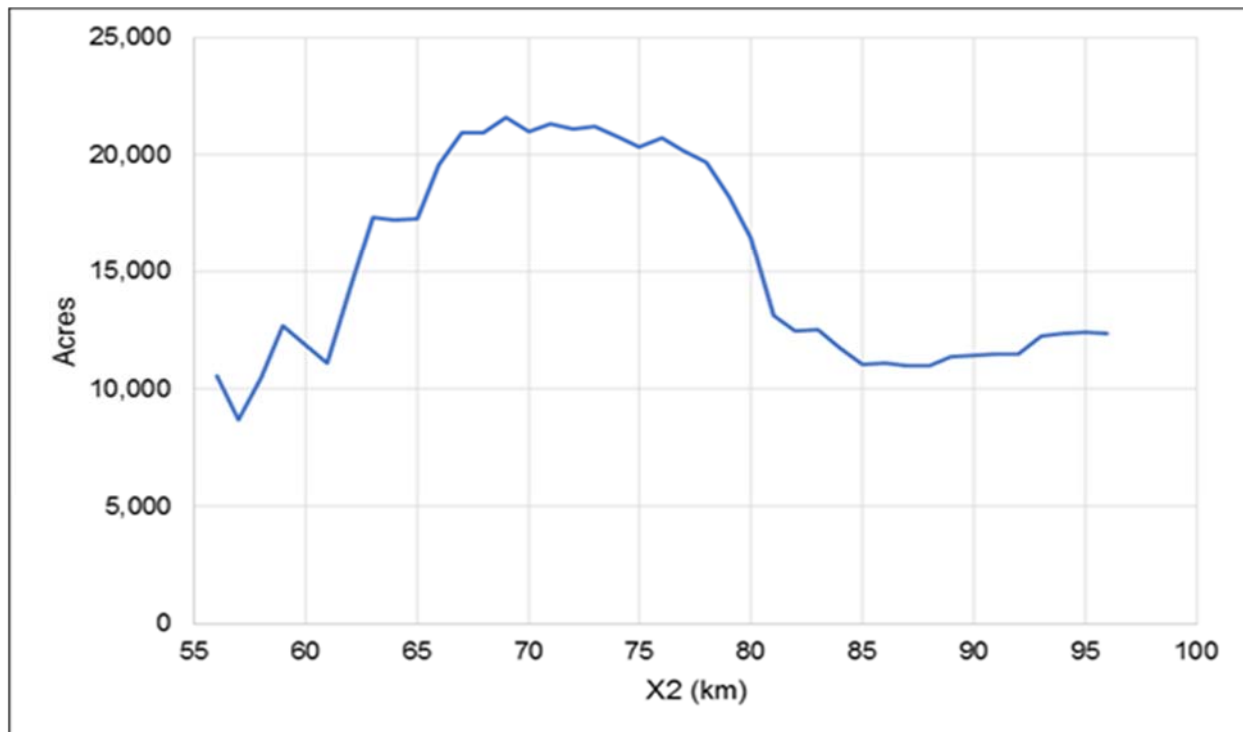


Figure 5.16-51. Monthly average turbidity by water year type, 2007-2018 (no Above Normal water years in that dataset; few years for each type)

In the Without Action, X2 is at 86 km on average in September and 84 km on average in October. Under the proposed action, X2 is at 92 km on average in September and October. As can be seen from Figure 5.16-52, there is very little difference in the acres of the low salinity zone between 84 and 92 km X2. Under the current operations scenario, X2 is at 86 km on average in September and 87 km on average in October, and is also within the same range of approximately 11,000 acres of low-salinity zone habitat as the proposed action and the without action. At X2 below 81 km, acres of low salinity zone increases, with a substantial water supply impact. Meeting Fall Delta Smelt Habitat physical and biological features using alternate mechanisms may allow smelt benefits not modeled in the proposed action.



Source: Brown et al. (2014, p.79).

Figure 5.16-52: Acres of low salinity zone (1-6ppt) versus X2 in kilometers from the Golden Gate Bridge

Fall Delta Smelt Habitat has no effect on Delta Smelt adults, eggs, larvae or juveniles. Fall Delta Smelt Habitat could benefit subadult to adult Delta Smelt by improving turbidity, food, low salinity zone area, or temperatures, depending on the actions Reclamation and DWR take to implement the action.

5.16.4.3 Clifton Court Predator Removal

Predator control efforts under the proposed action to reduce predation on listed fishes following entrainment into Clifton Court Forebay could reduce salvage-related loss of adult Delta Smelt. Entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt (that would likely have been salvaged or lost).

5.16.4.3.1 Eggs and Larvae to Juveniles (March - June)

Depending on the geartype of Clifton Court predator control efforts, predator control efforts under the proposed action may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.3.2 Juveniles to Subadults (June-September); Subadults to Adults (September - December)

Juvenile and subadult Delta Smelt do not occur in the south Delta (Figure 5.16-1).

5.16.4.4 *San Joaquin Steelhead Telemetry Study*

The San Joaquin Steelhead telemetry study does not affect Delta Smelt as it would be primarily in the San Joaquin River upstream, and also does not involve trapping or other mechanisms to affect Delta Smelt of any lifestage.

5.16.4.5 *Food Subsidies (Sacramento Deepwater Ship Channel, Colusa Basin Drain, and Roaring River Distribution System)*

These beneficial conservation measures would not occur under the without action scenario. The Colusa Basin Drain action was undertaken as a pilot implementation in 2016.

5.16.4.5.1 Adults to Eggs and Larvae (December -May)

Under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG has the potential to positively affect the food availability attribute posited to be of importance for adult Delta Smelt, thereby improving growth and survival (Figure 5.16-3). The timing of this action may be largely outside the adult Delta Smelt December–May time period given that increased SMSCG operations under the proposed action would occur in June–September of above normal and below normal years, although the Delta Smelt Resiliency Strategy notes that coordinated draining operations could benefit all Delta Smelt life stages (California Natural Resources Agency 2016, p.9).

Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have limited effects on adult Delta Smelt during December–May. Any adults that survive the spawning season could be affected.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer and therefore would have no effects on adult Delta Smelt during December–May. Any adults that survive the spawning season could be exposed to the action, but would not be affected by the increasing food. This action could also increase the mobilization of accumulated sediment in the channel, which could have historical pesticides in it, possibly affecting Delta Smelt.

5.16.4.5.2 Eggs and Larvae to Juveniles (March - June)

As described for adult Delta Smelt, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS draining to Grizzly Bay in conjunction with reoperation of the SMSCG under the proposed action has the potential to positively affect growth and survival of Delta Smelt larvae through increased food availability (Figure 5.16-4). The timing of this action may be largely outside the larval Delta Smelt March–June time period given that increased SMSCG operations under the proposed action would occur in June–September of above normal and below normal years, although the Delta Smelt Resiliency Strategy notes that coordinated draining operations could benefit all Delta Smelt life stages (California Natural Resources Agency 2016, p.9).

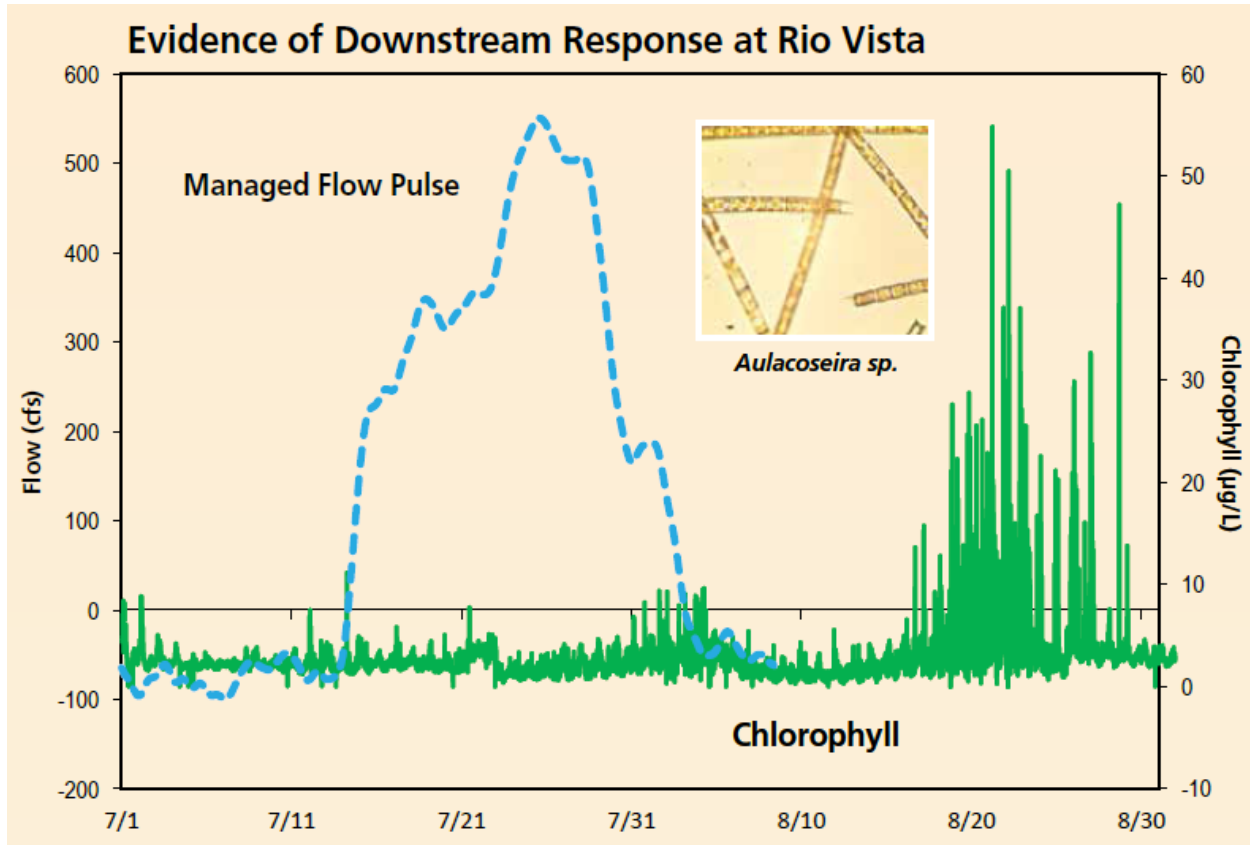
Provision of north Delta food subsidies by routing Colusa Basin drain water to the Cache Slough area through the Yolo Bypass would occur in summer/fall and therefore would have no effects on larval Delta Smelt during March–June.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer and, therefore, would have no effects on larval Delta Smelt during spring (March–June).

5.16.4.5.3 Juveniles to Subadults (June–September)

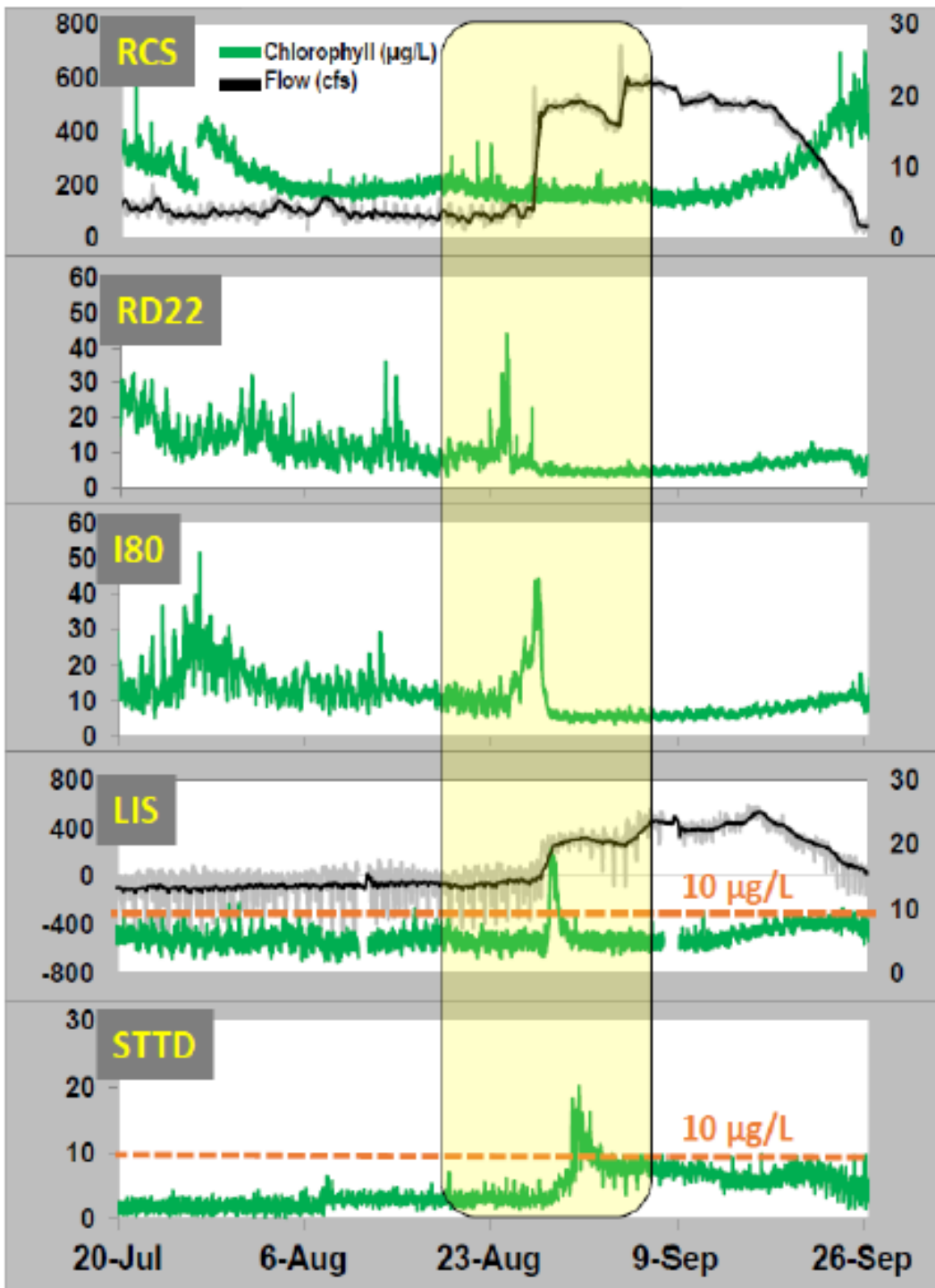
As noted for adult Delta Smelt, under the proposed action, provision of Suisun Marsh food subsidies through coordination of managed wetland flood and drain operations in Suisun Marsh and draining of RRDS to Grizzly Bay/Suisun Bay in conjunction with reoperation of the SMSCG has the potential to positively affect the food availability attribute posited to be of importance for juvenile Delta Smelt, thereby improving growth and survival (Figure 5.16-5). Increased SMSCG operations would occur in June–September of above normal and below normal years, and coordinated draining operations could benefit all Delta Smelt life stages, including juveniles (California Natural Resources Agency 2016, p.9). As described further in the analysis of conservation measure effects, during and just after the August 2018 pilot implementation of the SMSCG action, EDSM data from surveys between August 6 and September 7 suggest an average of 20% (range 0–100%) of juvenile Delta Smelt were in Suisun Marsh, although there is appreciable uncertainty in the estimates given low numbers of fish caught (USFWS 2018_EDSM).

Augmentation of flow from the Colusa Basin drain during summer/early fall could increase transfer of food web materials to the north Delta, thereby potentially increasing the food availability habitat attribute suggested hypothesized to be important for juvenile Delta Smelt (Figure 5.16-5). As previously described, an average of 23% of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The proportion of the population resident in the north Delta would be most likely to benefit from the north Delta food subsidies action. A pilot implementation of this action in 2016 found that primary production in the north Delta increased as a result of the action (Figure 5.16-53; as had been observed in previous years without pilot implementation; Frantzych et al. 2018), with enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018, p.2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action (Figure 5.16-53), could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass (Figure 5.16-54) and there was no increase at Rio Vista (Figure 5.16-55).



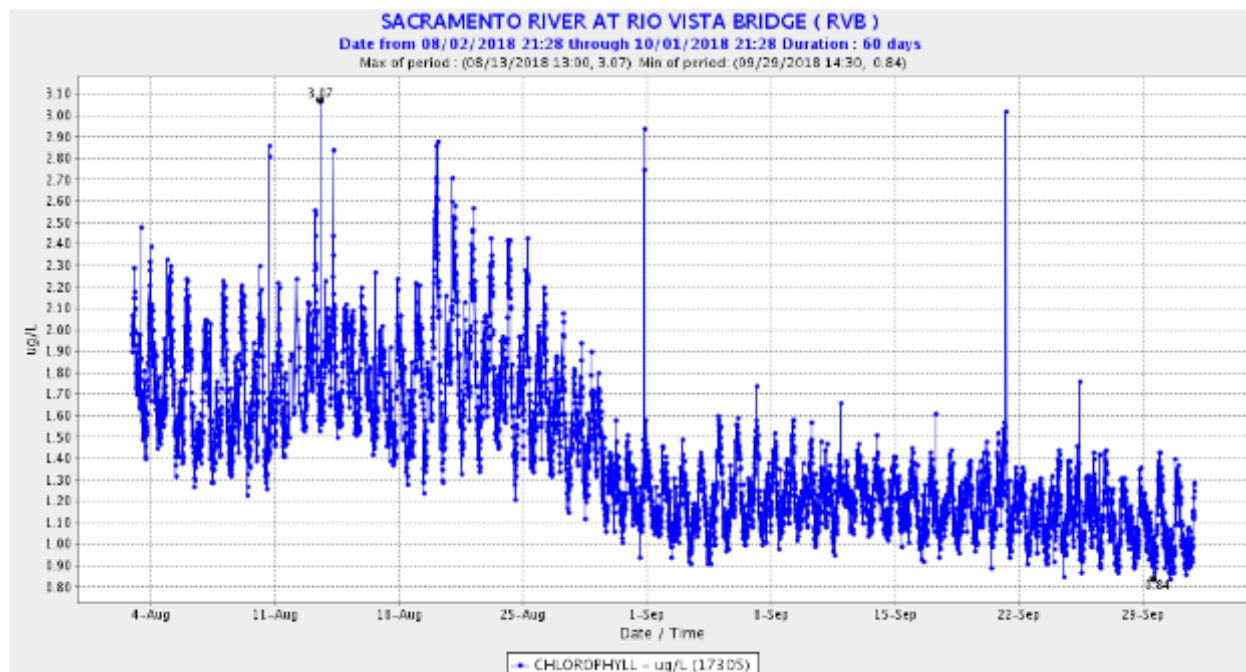
Source: California Natural Resources Agency (2017).

Figure 5.16-53. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration at Rio Vista During 2016 Pilot North Delta Food Subsidies Action.



Source: NCWA (2018). Note: Yellow box indicates flow pulse into Yolo Bypass from Colusa Basin Drain.

Figure 5.16-54. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration from North (RCS) to South (STTD) in the Yolo Bypass During 2018 Pilot North Delta Food Subsidies Action.



Source: California Data Exchange Center,

http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=17305&end=10%2F01%2F2018+21%3A28&geom=huge&interval=60&cookies=cdec01, accessed January 2, 2019.

Figure 5.16-55. Chlorophyll Concentration at Rio Vista Before, During, and After 2018 Pilot North Delta Food Subsidies Action.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system, together with nutrient additions, potentially would allow downstream transport of foodweb materials from the Ship Channel during the summer. This could provide a benefit to individual Delta Smelt juveniles through increased growth and survival per the food availability attribute suggested hypothesized to be important in the IEP MAST (2015) conceptual model (Figure 5.16-5). The efficacy of the proposed action has yet to be tested with pilot studies (Reclamation 2018).

5.16.4.5.4 Subadults to Adults (September - December)

As described for Delta Smelt juveniles, this action could positively affect an appreciable portion of Delta Smelt subadults given operation of the SMSCG potentially in September, in conjunction with RRDS draining to Grizzly Bay/Suisun Bay. The extent of the potential positive effect would be dependent on the scale of managed wetland operations that could be coordinated for draining to habitats occupied by subadult Delta Smelt.

Hydraulic reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River through modification of the West Sacramento lock system would allow downstream transport of foodweb materials from the Ship Channel during the summer. Therefore, the proposed action could result in positive effects on subadult Delta Smelt during early fall, if, as suggested by Reclamation (2018, p.2), any resulting phytoplankton/zooplankton bloom is self-sustaining for up to a month. The efficacy of the proposed action has yet to be tested with pilot studies.

5.16.4.6 *Habitat Restoration*

Completion of the 8,000 acres of habitat restoration would not occur under WOA. This action is currently underway, and the proposed action proposes to continue this ongoing work.

5.16.4.6.1 Adults to Eggs and Larvae (December - May)

Tidal habitat restoration associated with the proposed action has the potential to positively affect Delta Smelt adults through increased food availability, as well as also resulting in potential negative effects from contaminants, although the latter would be expected to be less than in areas previously used for agriculture. As previously noted, net export of food from restored areas may be limited (Lehman et al. 2010; Kimmerer et al. 2018c) and the greatest density of food export will be to areas within one tidal excursion of restored areas (Hartman et al. 2017, p.95).

5.16.4.6.2 Food Availability

The proposed action includes tidal habitat restoration of approximately an additional 6,000 acres. This tidal habitat restoration has the potential to increase food availability for Delta Smelt. For adult Delta Smelt, this relates directly to the food availability habitat attribute linked to the probability of spawning in the IEP MAST (2015) conceptual model (Figure 5.16-3). Recent studies indicate that net export of food from restored lands may be limited (Lehman et al. 2010; Kimmerer et al. 2018c), and the conceptual model indicates that the greatest density of food export will be to areas within one tidal excursion of restored areas (Hartman et al. 2017, p.95). Restored habitat may be occupied by adult Delta Smelt given suitable habitat features (Sommer and Mejia 2013).

5.16.4.6.3 Contaminants

Tidal habitat restoration under the proposed action has the potential to produce negative effects to Delta Smelt related to contaminants from the initial construction, although it also may reduce contaminant loading in the long term. As described in the recent biological opinion for the Yolo Flyway Farms restoration project, habitat restoration may result in an initial export of on-site contaminants (e.g., agricultural pesticides, organic pollutants and mercury) to downstream areas (USFWS 2017b). Contaminants would have the potential to negatively affect individual Delta Smelt or their prey (e.g., by reducing swimming ability (see brief review by IEP MAST 2015, p.66-67)). The potential for other contaminant issues (methylmercury) will be addressed through AMM10 *Methylmercury Management* (Appendix E, *Avoidance and Minimization Measures*). As mentioned above, pesticides like organophosphates and pyrethroids are likely to have a net loss after habitat restoration due to biomediation and sequestration of the pesticide in the restored habitat.

5.16.4.6.4 Eggs and Larvae to Juveniles (March - June)

As previously described for adult Delta Smelt, the additional approximately 6,000 acres of tidal habitat restoration in the north Delta under the proposed action has the potential to increase food availability for Delta Smelt. For larval/early-juvenile Delta Smelt, this relates directly to the food availability habitat attribute linked to the probability of growth and survival in the IEP MAST (2015) conceptual model (Figure 5.16-4). Recent studies indicate that net export of food from restored lands may be limited (Lehman et al. 2010; Kimmerer et al. 2018c), but the restored habitat may be occupied by larval/early juvenile Delta Smelt given suitable habitat features (Sommer and Mejia 2013) in which food could be accessed.

Contaminant related impacts are discussed above in the Adults to Eggs and Larvae section.

5.16.4.6.5 Juveniles to Subadults (June-September)

As previously described for the adult and larval/early juvenile Delta Smelt life stages, the additional approximately 6,000 acres of tidal habitat restoration under the proposed action could potentially increase food availability, which is also an important factor noted for juvenile Delta Smelt in the IEP MAST (2015) conceptual model (Figure 5.16-5). Export of food from restored areas may be limited.

5.16.4.6.6 Subadults to Adults (September - December)

As with the other life stages, habitat restoration under the proposed action has the potential to increase food availability, which is an important factor noted in the IEP MAST (2015) conceptual model. However, food export from restored areas may be limited.

5.16.4.7 *Predator Hot Spot Removal*

5.16.4.7.1 Adults to Eggs and Larvae (December - May)

Predator hot spot removal under the proposed action is primarily focused on providing positive effects to downstream-migrating juvenile salmonids but could also reduce predation of individual adult Delta Smelt. Although the action would not be limited to existing identified hot spots (e.g., those identified by Grossman et al. 2013), the existing hotspots that may be representative of where removal efforts may be most concentrated tend to mostly be at the periphery of Delta Smelt habitat; and all hotspots are limited in scale relative to overall available habitat. However, in these periphery areas it is possible that predation control could affect competitors of Delta Smelt, benefiting Delta Smelt.

5.16.4.7.2 Eggs and Larvae to Juveniles (March - June)

Although predator hot spot removal under the proposed action is expected to result in some benefits to Delta Smelt eggs and larvae, these benefits would be limited. The predator hot spot removal action would be most likely to reduce habitat for larger predators that are a threat to juvenile salmonids as opposed to smaller predators of Delta Smelt eggs/larvae such as silversides.

5.16.4.7.3 Juveniles to Subadults (June-September)

As discussed further for adult Delta Smelt, predation hot spots have limited spatial extent. Moreover, existing identified predation hot spots generally are on the margins of habitat that would be occupied by juvenile Delta Smelt.

5.16.4.7.4 Subadults to Adults (September - December)

As discussed further for adult Delta Smelt, existing identified predation hot spots generally are on the margins of habitat that would be occupied by subadult Delta Smelt. Also, predator hotspots have a limited spatial extent.

5.16.4.8 *Delta Cross Channel Operations and Improvements*

Under the proposed action, Reclamation would operate the DCC for improving central Delta salinity, and would close the DCC when fish may be impacted as described in the proposed action. Reclamation would also use modeling to predict when D-1641 salinity standards would be exceeded, and open the DCC to avoid the exceedances. This would result in increased instances when the DCC is open under the proposed action as compared to current operations. However, as part of DCC improvements, Reclamation

would construct a project to allow for diurnal or more frequent operation of the DCC than currently possible due to infrastructure limitations. This improved operational flexibility may allow future adjustments to DCC operations to benefit fish species in the Delta.

5.16.4.8.1 Adults to Eggs and Larvae (December - May)

As discussed by USFWS (2017a, p.265), it is unknown what, if any, impacts occur to Delta Smelt as a result of opening or closing the DCC gates. USFWS (2017a, p.265) considered the region near the DCC gates to only be transiently used during movement of some adult Delta Smelt upstream. USFWS (2017a, p.265) suggested that it may be possible that opening or closing the DCC gates changes the migration path of some Delta Smelt, but noted that it is unknown if there may be a change in predation risk or likelihood of successful spawning, for example. During the adult Delta Smelt upstream migration period (principally December–March; USFWS 2017a, p.265), the DCC gates would largely be closed as a result of adherence to D-1641 criteria as well as real-time operations as a function of juvenile salmonid catch indices and projected water quality in the central/south Delta. USFWS (2017a, p.265) suggested that closure of the DCC would create more natural hydrology for migrating adult Delta Smelt by keeping flow in the Sacramento River and Georgiana Slough. Potential far-field effects of the DCC on Delta hydraulics and how these could affect adult Delta Smelt entrainment risk would be considered when managing south Delta exports.

5.16.4.8.2 Eggs and Larvae to Juveniles (March - June)

Under the proposed action, the DCC would be expected to be largely closed during the March–June egg/larval transition period to juveniles. As described in more detail for adults, it is not known what effect the gates have on migration paths of Delta Smelt, but any effects would be expected to be limited given the low occurrence near the DCC (Figures 5.16-1 and 5.16-2; see also USFWS 2017a, p.159). Potential hydraulic effects on flows toward the south Delta export facilities would be taken into consideration when assessing south Delta entrainment risk, for example.

5.16.4.8.3 Juveniles to Subadults (June - September)

The distribution of juvenile Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2), so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the June–September transition from juveniles to subadults. The IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by this difference, which is a change in flow distribution rather than a change in overall summer hydrology, an environmental driver included in the conceptual model. More flow entering the lower San Joaquin River through the DCC presumably could lead to greater potential for flux of *P. forbesi* to the low salinity zone, given the importance of the San Joaquin River side of the Delta as a source of *P. forbesi* (Kimmerer et al. 2018c). However, the effect of south Delta exports on the flux of *P. forbesi* to the low salinity zone may be more important than any effect of the DCC, as suggested by QWEST flows (Figures 5.16-16 through 5.16-18).

5.16.4.8.4 Subadults to Adults (September - December)

The distribution of subadult Delta Smelt is downstream of the DCC (Figures 5.16-1 and 5.16-2) and so any near-field effects of the DCC would not occur. Under the proposed action and consistent with current operations, the DCC would largely be open during the September–December transition from subadults to adults, prior to upstream migration as adults. As noted for juvenile Delta Smelt, the IEP MAST (2015) conceptual model does not specifically address habitat attributes that would be affected by DCC gates

being opened vs. closed, but it could be argued that an open DCC would provide more flow to the lower San Joaquin River and therefore increase the potential for flux of *P. forbesi* to the low salinity zone (Kimmerer et al. 2018c). However, as described for juvenile Delta Smelt, south Delta exports appear to be a more important effect than the effect of the DCC given the generally negative QWEST flows (Figure 5.16-18).

5.16.4.9 Tracy Fish Facility Operations and Improvements

5.16.4.9.1 Adults to Eggs and Larvae (December - May)

The proposed action includes operating the TFCF, as well as TFCF improvements to reduce entrainment loss for salmonids through predator removal with carbon dioxide or angling. As summarized by USFWS (2017a, p.259), prescreen loss of adult Delta Smelt at the TFCF has not been quantified and whole facility salvage efficiency is low (Table 5.16-2; see also Sutphin and Svoboda 2016). Reduction in prescreen loss could improve salvage efficiency by reducing predation of adult Delta Smelt individuals.

Table 5.16-2. Factors Affecting Delta Smelt Entrainment and Salvage at the South Delta Export Facilities (Source: USFWS 2017a, p.259).

| Factor | Adults | Larvae < 20 mm | Larvae >20 mm and Juveniles | Source |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| Pre-screen loss (predation prior to encountering fish salvage facilities) | CVP: unquantified; SWP: 89.9–100% | Unquantified | CVP: unquantified; SWP: 99.9% (based on only one juvenile release) | SWP: Castillo et al. (2012) |
| Fish facility efficiency | CVP: 13%; SWP: 43–89% | ~0% | CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30% | CVP (Kimmerer 2008; adults only); SWP: Castillo et al. (2012) |
| Collection screens efficiency | ~100% | ~0% | <100% until at least 30 mm | USFWS (2011) |
| Identification protocols | Identified from subsamples, then expanded in salvage estimates | Not identified | Identified from subsamples, then expanded in salvage estimates | USFWS (2011) |
| Collection and handling | 48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control) | Unquantified | 48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%) | Morinaka (2013) |

| Factor | Adults | Larvae < 20 mm | Larvae >20 mm and Juveniles | Source |
|---------------------------------------------------------|----------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------|-----------------|
| Trucking and release (excluding post-release predation) | No significant additional mortality beyond collection and handling (above) | Unquantified | No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005 | Morinaka (2013) |

Under the proposed action, a number of programmatic actions are proposed to improve salvage efficiency of TFCF. These actions could positively affect adult Delta Smelt through greater salvage efficiency. The entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained.

5.16.4.9.2 Eggs and Larvae to Juveniles (March - June)

Larval Delta Smelt are unlikely to be salvaged and therefore the Tracy Fish Facility improvements under the proposed action would have no effects on this life stage.

5.16.4.9.3 Juveniles to Subadults (June-September)

Few if any juvenile and no subadult Delta Smelt would be expected to be exposed to the effects of operation of the carbon dioxide injection device or other Tracy Fish Facility improvements associated with the proposed action, given that these life stages are largely downstream of Tracy Fish Facility and juvenile entrainment risk during June would be managed to limit exposure to the facility.

5.16.4.9.4 Subadults to Adults (September - December)

Subadult Delta Smelt would not occur in the south Delta (Figure 5.16-1) and therefore there would be no effects from Skinner Fish Facility improvements under the proposed action on this life stage.

5.16.4.10 *Skinner Fish Facility Operations and Improvements*

5.16.4.10.1 Adults to Eggs and Larvae (December - May)

Skinner fish facility improvements from predator control efforts under the proposed action to reduce predation on listed fishes following entrainment into CCF could reduce salvage-related loss of adult Delta Smelt. However, entrainment risk under the proposed action would be managed to limit the potential for adult Delta Smelt to occur in the south Delta and be entrained. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost).

5.16.4.10.2 Eggs and Larvae to Juveniles (March - June)

Larval Delta Smelt are unlikely to be salvaged and therefore the Skinner Fish Facility improvements under the proposed action would have no effects on this life stage. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.10.3 Juveniles to Subadults (June-September); Subadults to Adults (September - December)

Juvenile and subadult Delta Smelt do not occur in the south Delta (Figure 5.16-1) and therefore there would be no effects from Skinner Fish Facility improvements under the proposed action on this life stage. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch Delta Smelt that would likely have been salvaged or lost.

5.16.4.11 Small Screen Program

Screening of small diversions (< 150 cfs) under the proposed action would be anticipated to have limited positive effects on individual adult Delta Smelt through reductions in entrainment. This life stage largely occurs outside of the main late spring-fall season when diversions typically occur (Siegfried et al. 2014), although there are a large number of small diversions. Based on factors such as observed limited entrainment of Delta Smelt at a small diversion in a field study (Nobriga et al. 2004) and the small hydrodynamic effect of such diversions, the DRERIP Delta Smelt conceptual model considered small diversions to be of minimal or no importance to Delta Smelt (Nobriga and Herbold 2009).

There may be some overlap of larval Delta Smelt with the main late spring-fall irrigation period for small diversions. Small diversion screening could reduce entrainment of sufficiently large (>20 mm or so) Delta Smelt larvae/early juvenile individuals. Similarly small diversion screening could reduce entrainment of Delta Smelt juveniles and subadults. However, entrainment by small diversions is posited to be of minimal importance to Delta Smelt (Nobriga and Herbold 2009).

5.16.4.12 Increased Production and Release from UC Davis Fish Culture and Conservation Laboratory (FCCL)

Under the proposed action, the existing UC Davis Fish Culture and Conservation Laboratory (FCCL) would be used to produce and release up to 50,000 adult Delta Smelt annually into the Sacramento-San Joaquin Delta to supplement the existing population. Release of cultured Delta Smelt to supplement the wild population would only be done following implementation of a number of risk reduction strategies (Table 5.16-3) and regulatory decisions made by USFWS and with genetic diversity in released cultured fish equivalent to that of the native stock. Supplementation of the wild population with hatchery-reared individuals could benefit individual adult Delta Smelt by making finding mates easier and, thereby, reducing the potential for Allee effects, which are declines in growth rate per fish at low population size (IEP MAST 2015, p.98). Given that wild Delta Smelt abundance may be of a similar magnitude—i.e., adult abundance in 2016–2018 as low as 16,000–48,000, with 95% confidence intervals of ~3,400–92,000 (see Figure 2.14-1 in Chapter 2)—as the abundance of adult fish that could be reared in the FCCL, the potential for benefits to the Delta Smelt are significant.

Potential negative effects of increased production at the FCCL include propagation and spread of invasive or nuisance species, which could affect Delta Smelt individuals through changes in food web structure. Increased production would be managed to avoid risks.

5.16.4.13 Delta Smelt Conservation Hatchery

Under the proposed action, Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta smelt in Rio Vista. The conservation hatchery would breed and propagate a stock of fish with equivalent genetic resources of the native stock and at sufficient quantities to effectively augment the existing wild population, so that they can be returned to the wild to reproduce naturally in their native habitat.

5.16.4.13.1 Adults to Eggs and Larvae (December -May)

Operation of the Delta Fish Species Conservation Hatchery has the potential to affect adult Delta Smelt in positive and negative ways, which are discussed here. By 2030, the likelihood of negative effects could be negligible.

5.16.4.13.1.1 Potential Positive Effects

The existing FCCL has a maximum capacity of just over 50,000 adult Delta Smelt. Operation of the Delta Fish Species Conservation Hatchery under the proposed action would substantially increase this capacity, although specific details are to be developed. Release of cultured Delta Smelt to supplement the wild population would only be done following implementation of a number of risk reduction strategies (Table 5.16-3) and regulatory decisions made by USFWS and with genetic diversity in released cultured fish equivalent to that of the native stock. Of particular importance will be the need to minimize hatchery domestication. Supplementation of the wild population with hatchery-reared individuals could benefit individual adult Delta Smelt by making finding mates easier and thereby reducing the potential for Allee effects, which are declines in growth rate per fish at low population size (IEP MAST 2015, p.98). Given that wild Delta Smelt abundance may be of a similar magnitude—i.e., adult abundance in 2016–2018 as low as 16,000–48,000, with 95% confidence intervals of ~3,400–92,000 (see Figure 2.14-1 in Chapter 2)—as the abundance of adult fish that could be reared in the Delta Fish Species Conservation Hatchery, the potential positive effect on adult Delta Smelt from release of Delta Smelt from the hatchery is high. Uncertainty in the potential positive effect stems from risks that would be reduced by a number of different strategies (Table 5.16-3).

Table 5.16-3. Risk Reduction Strategies for Implementation of Delta Smelt Culture at the Delta Fish Species Conservation Hatchery (Source: Lessard et al. 2018, p.9).

| Risk type | Risk factor | Risk reduction strategies |
|--------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ecological | Interspecific interactions | Scale and adjust (via adaptive management program) release numbers to optimize production while avoiding significant, density-related, intraspecific effects or interspecific ecological risks. Requires monitoring program and adaptive management decision loop on an annual basis. |
| | Intraspecific interactions | |
| | Pathogen transfer | Use best management practices to minimize or eliminate pathogen transfer; implement rigorous fish health screening and maintenance program. |
| | Lack of suitable habitat for reintroduction | Don't release hatchery-reared Delta smelt in areas where habitat conditions or capacity are insufficient (this is still an unknown for Delta Smelt spawning habitat). |
| | Lack of suitable spawning or early life habitat conditions | Experimentally release a range of life stages and use a monitoring and adaptive management program to guide decision-making on life stage releases to increase post-release survival for demographic enhancement of recipient wild population. |
| | Behavioral changes | Develop, refine, and employ best management practices that integrate hatchery-produced Delta Smelt with the natural genetic and life history diversity of wild Delta Smelt to minimize possible behavioral changes in progeny. |
| Demographic | Broodstock mining | Because the effect of broodstock mining depends on the likelihood that fish would reproduce successfully if left in the wild, consider reducing broodstock take during high water years. There is no risk if there is no natural production. |
| | Broodstock selection | Collect 100 wild broodstock annually (based on current take limit) across greatest available temporal and spatial ranges to maximize diversity of broodstock and resulting phenotypes, genotypes and adaptive plasticity among progeny groups. Broodstock requirement could change with scale of the hatchery and genetic diversity in the wild. |
| | Spawner disruption | Refine and implement most efficient means of wild broodstock collection to minimize disturbance to wild spawners/spawning in the river. |
| Genetic | Loss of diversity | If feasible, continue to annually supplement captive refuge population with 100 new wild-origin broodstock annually (based on current take limit). Broodstock requirement could change with scale of propagation and genetic diversity in the wild. |
| | Inbreeding depression | |
| | Selection | Continue to define and implement breeding matrices annually, using empirical genetic data to minimize kinship in broodstock crosses and resulting progeny groups, and to minimize risk of selection. |
| Uncertainty | Measurement error | Conduct hatchery supplementation in an experimental framework that includes a robust monitoring and evaluation program, relevant measurable benchmarks to evaluate benefits and risks, and a clear decision structure for future adaptive management. |
| | Process error | |
| | Implementation error | Promote and evaluate tools and techniques that facilitate improved evaluation of the contribution and survival of cultured fish in the wild. Review practices with expert hatchery evaluation team to ensure use of best available information, operations, and protocols to minimize implementation error. |

5.16.4.13.1.1.1 Potential Negative Effects

Potential negative effects of the Delta Fish Species Conservation Hatchery under the proposed action include propagation and spread of invasive or nuisance species, which could affect Delta Smelt individuals through changes in food web structure. Hatchery operations would require implementation of a Hazard Analysis and Critical Control Points plan, or similar control mechanism, which would include methods to prevent the introduction of invasive or nuisance species into the hatchery and operational practices that prevent the spread of these species within and outside of the facility, should prevention

efforts fail. Hatchery operations would include actions to minimize the spread of invasive or nuisance species by sampling to determine whether such species are present and, if so, taking extra precautions to prevent spread. Sampling would be conducted on a quarterly basis at locations such as intake structures, raceway head boxes, settling ponds, and any other areas of concern. If suspect or questionable snails or mussels are found, specimens would be sent to the regional invasive-species scientist for identification (California Department of Fish and Game 2015), so that hatchery operations are not anticipated to result in the spread of invasive or nuisance species.

Discharges of water from the Delta Fish Species Conservation Hatchery could affect adult Delta Smelt individuals through changes in water quality, including increased water temperature, decreased dissolved oxygen, changes in water chemistry (pH and salinity), increased nutrient inputs, increased suspended solids, and release of other undesirable constituents such as parasites, disease microorganisms, and related treatment chemicals, but all of these factors would be managed to minimize effects. Water for the hatchery would mostly be sourced from a groundwater well and is anticipated to be consistent with Sacramento River water temperature adjacent to the hatchery. Dissolved oxygen levels of discharge water would be monitored and kept above applicable criteria (5 mg/l), with filtration to reduced biological oxygen demand. Salinity and pH would not be expected to be greatly affected, as analysis of larger scale salmonid hatchery facilities in California found limited evidence for increases (ICF Jones and Stokes 2010). Nutrient inputs and other constituents would be limited because effluent would pass through a water treatment facility for filtration and disinfection. Discharge of suspended solids such as uneaten feed and biological waste would be limited through treatment at an onsite treatment system consisting of drum filters, an underground holding tank between rearing tanks and drum filters, and settling ponds. Should it be necessary, a portable system to treat effluent could also be installed for specific individual rearing tanks, or a centralized holding tank and activated carbon filtration system. Overall, groundwater and surface water quality used at the hatchery would be monitored to protect the health of the fish being reared, and discharged water would be treated in accordance with required permits and protocols. This, coupled with the very small size of the discharge (5.5–11 cfs) in relation to tidal flows in the Sacramento River near the hatchery location (peak tidal flows of $\pm 100,000$ cfs; <http://cdec.water.ca.gov/dynamicapp/QueryF?s=SRV>), suggests minimal effects.

Construction of the Delta Fish Species Conservation Hatchery in Rio Vista could benefit Delta Smelt through removal of creosote-treated wood pilings, that would remove a source of contaminants, as well as in-water structure that could provide habitat for predatory fishes. Potential negative effects would occur from operation of the marina and docks for research vessels, which could provide habitat for predatory fishes and increase predation on adult Delta Smelt. Loss of shallow-water habitat from construction of the facility could affect adult Delta Smelt spawning habitat availability, but would be compensated offsite at an appropriate mitigation ratio for the project footprint.

5.16.4.13.2 Eggs and Larvae to Juveniles (March - June)

Given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild individuals would be minimized. Following application of these risk reduction strategies, release of cultured larval Delta Smelt presumably would have little effect on wild individuals (in contrast to adults, for example, for which increased numbers of individuals could lead to increased spawning opportunities, for example). As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes, and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

5.16.4.13.3 Juveniles to Subadults (June-September)

As discussed for other life stages of Delta Smelt, given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild juvenile Delta Smelt would be minimized. Following application of these risk reduction strategies, release of cultured juvenile Delta Smelt presumably would have little effect on wild individuals, given that interspecific associations appear to not be strong: Bennett (2005, p.22) suggested that “[j]uveniles and adults may occur in loose aggregations rather than tight schools, judging from the patchiness of fish catch in the monitoring surveys”. As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

In-water construction work for the hatchery intake and outfall could result in effects to individual Delta Smelt such as temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. Such effects include some of the habitat attributes hypothesized to be of importance to this life stage (Figure 5.16-5). The risk from these potential effects would be minimized through application of AMMs (Appendix E, *Avoidance and Minimization Measures*). There is low potential exposure because of the in-water work window, minimized by application of AMMs, and the small scale of the in-water construction.

5.16.4.13.4 Subadults to Adults (September - December)

As discussed for other life stages, given appropriate application of risk reduction strategies (Table 5.16-3), potential negative effects from the Delta Fish Species Conservation Hatchery under the proposed action such as pathogen transfer from cultured to wild Delta Smelt would be minimized. Following application of these risk reduction strategies, release of cultured subadult Delta Smelt presumably would have little effect on wild individuals, given the loose aggregations rather than tight schooling behavior suggested by Bennett (2005, p.22). As discussed for adults, potential negative effects on individual Delta Smelt such as propagation and spread of invasive/nuisance species leading to food web changes, and discharge of hatchery effluent resulting in water quality effects, could occur but would be limited.

5.16.4.14 *Lower SJR Habitat Restoration*

5.16.4.14.1 Adults to Eggs and Larvae (December - May)

Under the proposed action, restoration of lower San Joaquin River spawning and rearing habitat for salmonids, including a large extent of floodplain habitat, would have the potential to produce food web materials that could be exported downstream to areas where Delta Smelt adults would occur, thereby positively affecting growth and survival per the IEP MAST (2015) conceptual model (Figure 5.16-3). However, transport downstream of productivity from this restoration to areas where Delta Smelt adults are likely to occur in greater numbers (See Figures 5.16-1 and 5.16-2) may be limited for two reasons. First, food web materials transported in flow entering the interior Delta through junctions such as Old River would be unlikely to move far downstream because of the prevailing hydrodynamics created by the south Delta export facilities (as shown by OMR reverse flows). In addition, river flows sufficiently large to inundate the floodplains frequently would tend to be somewhat limited in occurrence (ESA PWA 2012).

There would be no construction impacts of the Lower SJR habitat restoration under the proposed action on Delta Smelt, as Delta Smelt do not occur upstream in the San Joaquin River.

5.16.4.14.2 Eggs and Larvae to Juveniles (March - June)

As discussed in more detail for adult Delta Smelt, potential food availability effects on Delta Smelt may be low from Lower San Joaquin River spawning and rearing habitat restoration under the proposed action because enhanced productivity from inundated floodplains may occur relatively infrequently and export downstream may be limited by the hydrodynamic effects of the south Delta export facilities.

5.16.4.14.3 Juveniles to Subadults (June-September)

There would be no effects from food material production and export as a result of lower San Joaquin River spawning and rearing habitat restoration under the proposed action because the winter/spring inundation period of this habitat would not overlap the Delta Smelt juvenile period (June–September).

5.16.4.14.4 Subadults to Adults (September - December)

As noted for juvenile Delta Smelt, there would be effects from food material production and export as a result of lower San Joaquin River spawning and rearing habitat restoration including floodplain habitat under the proposed action because the winter/spring inundation period of this habitat would not overlap the Delta Smelt subadult period (September–December, prior to transition to adulthood and movement triggered by the initial first flush of precipitation and flow).

5.16.4.15 *Effects of Monitoring*

5.16.4.15.1 Adults to Eggs and Larvae (December - May)

A number of monitoring activities described in Appendix E – ROC Real Time Water Operations Charter, in the section *Monitoring Program for Core CVP and SWP Operation* would have the potential to capture adult Delta Smelt. USFWS (2017, p.186) suggested that historically, take of Delta Smelt in survey collections was low compared to estimated population abundance, but that given the combination of recent population decline and substantial increase in survey effort, scientific take of Delta Smelt may be reaching a relevant fraction of Delta Smelt in some seasons. A summary by USFWS (2017, p.195) showed, for example, that the total number of juvenile and adult Delta Smelt captured in IEP studies (which form much of the basis for the monitoring program) per year ranged from 447 in 2016 to 4,713 in 2005 (Table 5.16-4). Corresponding estimates of adult population size in these years were 477,775 in 2005 and 16,159 in 2016, which, accounting for the fact that not all individuals shown in Table 5.16-4 were adults, that the percentage collected was < 1% in 2005 and < 2.8% in 2016. As noted by USFWS (2017, p.186), some surveys have been modified to limit incidental catches of Delta Smelt. Although Table 5.16-4 does not account for other surveys that would capture individual adult Delta Smelt, in particular EDSM (take for EDSM is about 0.5% to 1% per year), it is anticipated that through consideration of overall potential take, sampling effort in monitoring activities would be limited. Importantly, monitoring would enable effects of the proposed action to be limited, e.g., by informing real-time operations for OMR adjustment.

Table 5.16-4. Number of Juvenile and Adult Delta Smelt Individuals (≥20-mm Fork Length) Captured from 2005 to 2016 for Interagency Ecological Program Studies (Source: USFWS 2017, p.195).

| Survey | Year | | | | | | | | | | | |
|---------------------------------------------------------------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Fall Midwater Trawl | 28 | 39 | 27 | 21 | 32 | 54 | 344 | 47 | 21 | 11 | 7 | 7 |
| Townet Survey | 120 | 83 | 45 | 0 | 0 | 2 | 318 | 28 | 0 | 1 | 23 | 6 |
| SF Bay Study | 85 | 21 | 64 | 45 | 20 | 49 | 181 | 95 | 77 | 43 | 51 | 6 |
| 20-mm | 15 | 0 | 2 | 1 | 2 | 5 | 8 | 63 | 9 | 1 | 0 | 2 |
| Yolo Bypass | 4 | 17 | 4 | 26 | 88 | 19 | 31 | 133 | 134 | 46 | 50 | 18 |
| Broodstock Collections (FCCL) | 2297 | 2418 | | 70 | 23 | 80 | | 2 | 198 | | | |
| Delta Juvenile Fish Monitoring | 761 | 954 | 245 | 119 | 136 | 445 | 956 | 710 | 464 | 301 | 245 | 103 |
| New Technologies and Release Sites, Element 2 (Electrofishing) | | | | 2 | | | | | | | | |
| Indicators to Predict Adverse Effects to Salvaged Delta Smelt | 64 | | | | | | | | | | | |
| Fish Predation in the CHTR Phase | 19 | | | | | | | | | | | |
| Acute Mortality Associated with CHTR | | 28 | | | | | | | | | | |
| Directed Fish Collections | 5 | 371 | 4 | | | | | | | | | |
| Upper estuary zooplankton | | | | | | 1 | 2 | 2 | 0 | 1 | 0 | 0 |
| Investigation of Antioch and Pittsburg Power Plants | | | | 2 | 14 | | 0 | | | | | |
| Spring Kodiak Trawl | 1311 | 473 | 708 | 339 | 671 | 659 | 445 | 1204 | 339 | 356 | 107 | 260 |
| Morrow Island Distribution | 2 | 1 | | | | | | | | | | |
| UCD Suisun Marsh | 2 | 1 | 3 | 1 | 4 | 2 | 22 | 10 | 6 | 7 | 3 | 0 |
| Smelt Larva Survey | | 1 | 0 | 0 | 2 | 0 | 2 | 10 | 4 | 0 | 2 | 0 |
| Mossdale Spring Trawl | | | | | | 1 | | | 0 | 0 | 0 | 0 |
| Fish Community Monitoring | | | 3 | 3 | 8 | | 9 | | | | | |
| Effects of Largemouth Bass on Delta Ecosystem | | | | | | 5 | | | | | | |
| Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency | | | | 189 | 10 | | | | | | | |
| Smelt Migration Study (AKA First Flush)** | | | | | | 659 | | 822 | | | | |
| Gear Efficiency Evaluation in Support of Delta Smelt Modeling | | | | | | | | 721 | 863 | 890 | 185 | 0 |
| FRP Tidal Wetland Monitoring Study | | | | | | | | | | | 0 | 2 |
| USGS Early Warning | | | | | | | | | | | 0 | 42 |
| USGS Physical and Biological Drivers | | | | | | | | | | | | 1 |
| TOTAL | 4713 | 4407 | 1105 | 818 | 1010 | 1981 | 2318 | 3847 | 2115 | 1657 | 673 | 447 |

*Smelt Migration sampling in year 2010 includes one day of sampling in 2011

5.16.4.15.2 Eggs and Larvae to Juveniles (March - June)

A number of monitoring activities under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter*, in section *Routine Operations and Maintenance on CVP Activities* would have the potential to capture larval Delta Smelt. A summary by USFWS (2017, p.195) showed, for example, that the total number of larval Delta Smelt captured in IEP studies (which form much of the basis for the monitoring program) per year ranged from 108 in 2015 to 1,564 in 2012 (Table 5.16-5). There are no estimates of overall larval population size in these years, but given that a) estimates of adult Delta Smelt captured were < 1–3% of the adult population, b) the total number of individual larvae captured was of similar or lower order magnitude as the number of adults captured per year (i.e., hundreds to thousands of individuals per year), and c) the population size of larvae would logically be appreciably greater than that of adults (Bennett 2005, p.12), then the overall population-level loss of larval Delta Smelt would be expected to be much lower than that of adults. Additional monitoring activities such as EDSM may increase the population-level capture above that suggested by the above analysis, but it would not be anticipated that this would be a substantial increase. Importantly, and as noted for adult Delta Smelt, monitoring would enable effects of the under the proposed action to be limited by informing real-time operations for OMR adjustment.

Table 5.16-5. Number of Larval Delta Smelt Individuals (<20-mm Fork Length) Captured from 2005 to 2016 for Interagency Ecological Program Studies (Source: USFWS 2017, p.194).

| Survey | Year | | | | | | | | | | | |
|---------------------------------------------------------------------|------------|-------------|------------|------------|------------|-------------|-------------|-------------|-------------|------------|------------|------------|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Fall Midwater Trawl | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Townet Survey | | | 10 | 82 | 49 | 198 | 470 | 246 | 171 | 75 | 0 | 0 |
| SF Bay Study | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| South Delta fish investigations 20-mm* | 8 | | 277 | | | | | | | | | |
| Yolo Bypass | 644 | 978 | 135 | 274 | 435 | 633 | 1162 | 1076 | 1125 | 256 | 99 | 126 |
| Delta Juvenile Fish Monitoring | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Directed Fish Collections | 14 | | | | | | | | | | 0 | 0 |
| Upper estuary zooplankton | | | 2 | | | | | | | | | |
| Investigation of Antioch and Pittsburg Power Plants | | | 2 | 17 | | 10 | 3 | 3 | 5 | 1 | 0 | 0 |
| Spring Kodiak Trawl | | | | 17 | 10 | 1 | 1 | | | | | |
| Morrow Island Distribution | 26 | | | | | 1 | | 1 | 2 | 53 | 3 | 26 |
| UCD Suisun Marsh | | | 1 | | | | | | | | | |
| Smelt Larva Survey | | | | | | | | | | 2 | 0 | 0 |
| Mossdale Spring Trawl | | 79 | 274 | 0 | 0 | 6 | 3 | 238 | 118 | 24 | 6 | 8 |
| Fish Community Monitoring | | | | | | | | | | | 0 | 0 |
| Pilot Mark-recap to Estimate Pre-screen Loss and Salvage Efficiency | | | | 22 | | | | | | | | |
| Gear Efficiency Evaluation in Support of Delta Smelt Modeling | | | | | 111 | | | | | | | |
| FRP Tidal Wetland Monitoring Study | | | | | | | | | 85 | 147 | 0 | 0 |
| USGS Early Warning | | | | | | | | | | | 0 | 0 |
| USGS Physical and Biological Drivers | | | | | | | | | | | | 0 |
| TOTAL | 692 | 1057 | 701 | 412 | 615 | 1049 | 1639 | 1564 | 1506 | 558 | 108 | 161 |

*20mm Study reports larvae and juveniles together (age-0). Age-1+ reported as adults.

5.16.4.15.3 Juveniles to Subadults (June-September)

As described for adult Delta Smelt, capture of Delta Smelt in recent years may be a greater percentage of the population than historically occurred as a result of lower population size and greater survey effort. However, as concluded for adult Delta Smelt, impacts across all surveys would be considered when determining sampling effort in order to limit potential negative effects.

5.16.4.15.4 Subadults to Adults (September - December)

As described for adult Delta Smelt, capture of Delta Smelt in recent years may be a greater percentage of the population than historically occurred as a result of lower population size and greater survey effort. However, as concluded for adult Delta Smelt, impacts across all surveys would be considered when determining sampling effort in order to limit potential negative effects.

5.17 Delta Smelt Critical Habitat

USFWS (2017a, p.298-299) summarized the primary constituent elements (PCEs) as defined in the critical habitat rule. These include physical habitat (i.e., spawning substrate and possibly depth variation in relation to pelagic habitat), water (i.e., water of suitable quality, including certain conditions of temperature, turbidity, and food availability, which can be degraded by high entrainment risk and contaminant exposure, for example), river flow (transport flow to facilitate spawning migrations and transport of offspring to low salinity zone rearing habitats), and salinity (the low salinity zone nursery habitat, which generally increases as Delta outflow increases and X2 decreases). Volume of low salinity zone does not necessarily translate to increased survival as habitat may not be the limiting factor on Delta

Smelt. Multiple other abiotic and biotic factors also affect Delta Smelt at all times. The analysis below considers potential positive and negative effects to these PCEs by various life stage habitat functions used by USFWS (2017a, p.304-323), i.e., spawning habitat (physical habitat), larval and juvenile transport habitat (river flow), rearing habitat (salinity), and adult migration habitat (physical habitat and river flow).

5.17.1 PCE 1 – Physical Habitat

With respect to the physical habitat PCE of Delta Smelt critical habitat, the proposed action could potentially reduce the supply of sand for spawning substrate during the high-flow winter/spring period relative to the without action. As suggested by a sedimentation conceptual model provided by Schoellhamer et al. (2012, p.4), lower Sacramento River sediment samples have a greater percentage of sand than lower San Joaquin River sediment, probably because of larger river floods and greater sand supply from the Sacramento River watershed. As Schoellhamer et al. (2012, p.4) went on to note: “At Rio Vista, Thompson and others (2000) observed that large floods increased the percent of sand on the bed (up to nearly 100% from nearly 0%)...During the intervals between floods, finer sediment deposited, the bed sediment became finer...At two other sites in the Sacramento and San Joaquin rivers, however, the fraction of sand varied over a similar range but appeared unrelated to flow, perhaps because of spatial heterogeneity.” Thus, while there is the potential for a negative effect of the proposed action on supply of sand spawning substrate, the extent of this potential effect is uncertain given likely site-specific differences and the lack of relationships predicting sandy substrate spawning habitat as a function of flow. Implementation of tidal and channel margin restoration through adaptive management may provide additional Delta Smelt spawning habitat (USFWS 2017, p.111), which would contribute to reducing the potential negative effect of the proposed action.

Construction of proposed facilities and other actions—principally the Delta Fish Species Conservation Hatchery, as well as some of the programmatic actions—under the proposed action has the potential to reduce the extent of physical habitat in terms of spawning substrate. The extent of this loss is dependent on site-specific conditions. It is anticipated that construction of tidal habitat restoration would more than address any loss of physical habitat from the proposed action, given the need to include areas meeting likely Delta Smelt spawning habitat characteristics in the restored areas (USFWS 2017, p.111).

5.17.2 PCE 2 – Water

Potential positive effects to food availability may occur from SMSCG operations under the proposed action during June–September of above normal and below normal water years (reducing salinity to improve habitat conditions in the relatively food-rich Suisun Marsh) and tidal restoration (an additional approximately 6,000 acres).

Relative to the without action scenario, reduced winter-spring inflow to the Delta under the proposed action has the potential to reduce sediment supply and therefore turbidity during winter-spring, as well as during summer/fall when resuspension of sediment supplied in the winter/spring is important. Under the proposed action, greater South Delta exports, less spring Delta outflow, and possibly agricultural barriers have the potential to negatively affect food availability in the low salinity zone by reducing *E. affinis* in spring and reducing the subsidy of *P. forbesi* from the lower San Joaquin River to the low salinity zone in summer/fall.

During summer/fall, there is the potential for effects to flow, velocity, and water clarity under the proposed action to negatively affect the water quality PCE relative to the without action scenario by increasing the potential for harmful algal blooms, although this is uncertain.

Effluent from the Delta Fish Species Conservation Hatchery under the proposed action could have a negative effect on water quality, although such effects would be minimized through factors such as filtration, and the effluent discharge rate would be small. Water temperature effects from operations of the proposed action are expected to be minor.

Tidal habitat restoration will benefit other PCEs, but could result in increased exposure to contaminants and noise and vibration from in-water work. Tracy Fish Facility improvements, the Delta Fish Species Conservation Hatchery, and programmatic actions under the proposed action have benefits to the species, but include increased exposure to contaminants and noise and vibration from in-water work. These temporary potential negative effects would be avoided, minimized, and mitigated using project-specific measures including those described in Appendix E, *Avoidance and Minimization Measures*.

5.17.3 PCE 3 – River Flow

The proposed action directly influences the river flow PCE for adult migration and larval and juvenile transport of Delta Smelt as a result of south Delta exports. As described previously, OMR reverse flows would be managed to minimize impacts to Delta Smelt by avoiding turbidity bridges, and allowing more positive OMR flows during integrated early winter pulse protection. Limited negative effects on river flow for adult migration and larval and juvenile transport which could result in entrainment also would stem from proposed action operations of the Suisun Marsh Facilities and Ag Barriers. The proposed action operations of the Rock Slough Intake and the North Bay Aqueduct will not affect OMR as these facilities are located outside of the OMR region. Rock Slough Intake and the North Bay Aqueduct could have minimal effects on river flow in the vicinity of each intake (near-field effects), but such effects are mitigated by operations that meet low approach velocity at the fish screens. Finally, Rock Slough Intake and the North Bay Aqueduct have negligible effect on far-field Delta hydrodynamics. Potential negative effects on river flow could occur as a result of tidal restoration effects on channel hydrodynamics, although modeling and design of restoration would be done so as to minimize such effects.

It is not anticipated that construction components of the proposed action would affect river flow.

5.17.4 PCE 4 – Salinity

The proposed action has the potential to positively and negatively affect the salinity PCE related to the low salinity zone nursery habitat for Delta Smelt. As described previously, operations of the SMSCG in June–September of above normal and below normal years have the potential to provide lower salinity and therefore positively affect habitat conditions for juvenile and subadult Delta Smelt in the Suisun Marsh, with additional Delta outflow provided to avoid movement of X2 upstream as a result of SMSCG operation.

South Delta exports and water flow into the Delta under the proposed action have the potential to affect the low salinity zone rearing habitat. USFWS (2017a, p.307–316) assessed this in terms of the proportion of CalSim-modeled months (June–December) that the low salinity zone (i.e., salinity at or below 6) would be outside of Suisun Bay, as indicated by $X2 \geq 85$ km (DMA 2014, p.38). Performing this analysis in the context of the proposed action suggests that relative to the WOA, there could be positive effects to low salinity zone rearing habitat during June–September (lower percentage of years with $X2 \geq 85$ km), no effect in October, and negative effects in November–December (higher percentage of years with $X2 \geq 85$ km; Figure 5.17-1). To the extent that tidal restoration (i.e., the additional approximately 6,000 acres as part of tidal habitat restoration) provides new low salinity zone habitat that is occupied by rearing Delta Smelt, this could provide some offsetting of potential reductions resulting from operations.

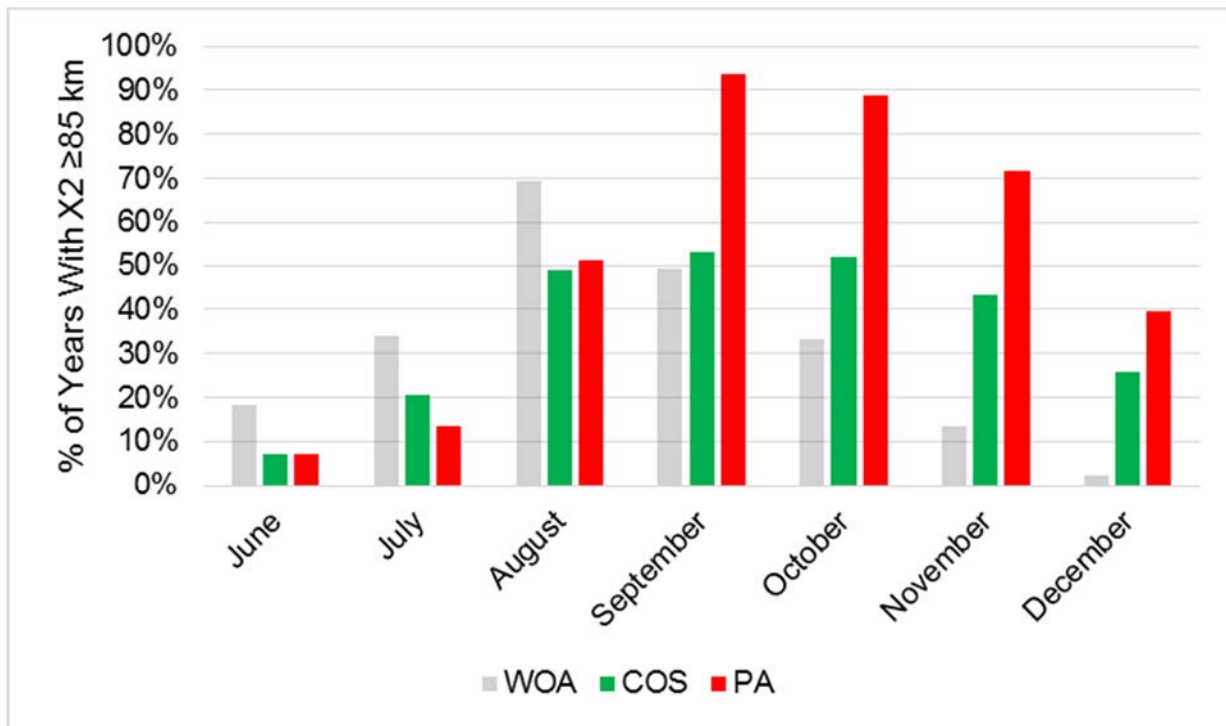


Figure 5.17-1. Percentage of Years With Mean X2 ≥ 85 km, June–September.

It is not anticipated that construction components of the proposed action would affect salinity.

5.17.5 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Delta Smelt critical habitat.

5.17.6 Effects of Monitoring Activities

The activities under the proposed action described in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation* would be expected to have limited effects on Delta Smelt critical habitat. The physical habitat PCE could be affected by placement of equipment such as anchors holding the acoustic receiver network or by benthic sampling as part of the Environmental Monitoring Program, but the effects would be very small relative to the extent of critical habitat. The water quality PCE could be minimally affected, for example, by trawling or benthic gear contacting the substrate and disturbing sediment, although again these effects would be expected to be limited. As described in the section discussing effects of monitoring on Delta Smelt, capture of individual Delta Smelt would occur but would be limited by consideration of take limits in relation to population status.

5.18 Coho Salmon, Southern Oregon/Northern California Coastal ESU

The proposed action provides beneficial effects to Coho Salmon due to higher flows and lower temperatures in the summer and fall, as compared to WOA. The proposed action affects Coho Salmon in the spring as compared to WOA, by reducing flows during egg incubation, fry emergence, and decreasing available habitat for juvenile rearing through less inundated area in natal habitats on the Trinity River.

The ongoing implementation of the Trinity River Restoration Program ROD, included in the proposed action but previously consulted on, helps to address these effects. In addition, releases of flow from Grass Valley Creek to encourage Coho spawning and rearing will reduce the impacts of lower spring flows on Coho Salmon in other natal habitats in the upper Trinity River basin.

5.18.1 Lifestage Timing

Coho Salmon enter the Klamath/Trinity River Basin as sexually mature adults and disperse into the various tributaries to spawn. In the Trinity River, adults return from September to December (Figure 5.18-1) and spawn from November to January (Leidy and Leidy 1984; USFWS and Hoopa Valley Tribe 1999). Juvenile Coho Salmon spend up to one year in the Trinity system prior to emigration to the ocean. Spawning generally occurs in low gradient tributaries rather than the mainstem of the Trinity River (NMFS 2014). Coho Salmon fry emerge from the gravel the following spring from February to May. Juveniles rear in the Trinity system through the summer and winter (age 0). Coho smolts emigrate from the system in their second spring (age 1). Their extended freshwater residency prior to emigration (compared to Chinook salmon) makes them vulnerable to adverse summer water temperature and scarcity of low water velocity, off-channel habitat during winter (NMFS 2014).

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Adult Migration and Holding | | | | | | | | | ■ | ■ | ■ | ■ |
| Spawning | ■ | | | | | | | | | | ■ | ■ |
| Egg Incubation | ■ | ■ | ■ | ■ | | | | | | | ■ | ■ |
| Fry Emergence | | ■ | ■ | ■ | ■ | | | | | | | |
| Juvenile Rearing | | | | | | | | | | | | |
| Age 0 | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Age 1 | ■ | ■ | ■ | | | | | | | | | |
| Smolt Outmigration | | ■ | ■ | ■ | | | | | | | | |

Figure 5.18-1. Life History Schedule of Trinity River Salmonids based on Leidy and Leidy (1984)

5.18.2 Conceptual Model Linkages

There is no conceptual model for Coho Salmon which describes in detail the hypothetical mechanistic pathways that underlie the relationships between environmental stressors and salmonid survival comparable to the “Salmon and Sturgeon Assessment of Indicators by Life stage” as has been developed for Winter-run Chinook salmon in the Sacramento River (Windell et al 2017). But, adapting a general conceptual model based on Windell et al. (2017) (Figure 5.18-2) provides a framework for assessing the effects of the proposed action on SONCC Coho.

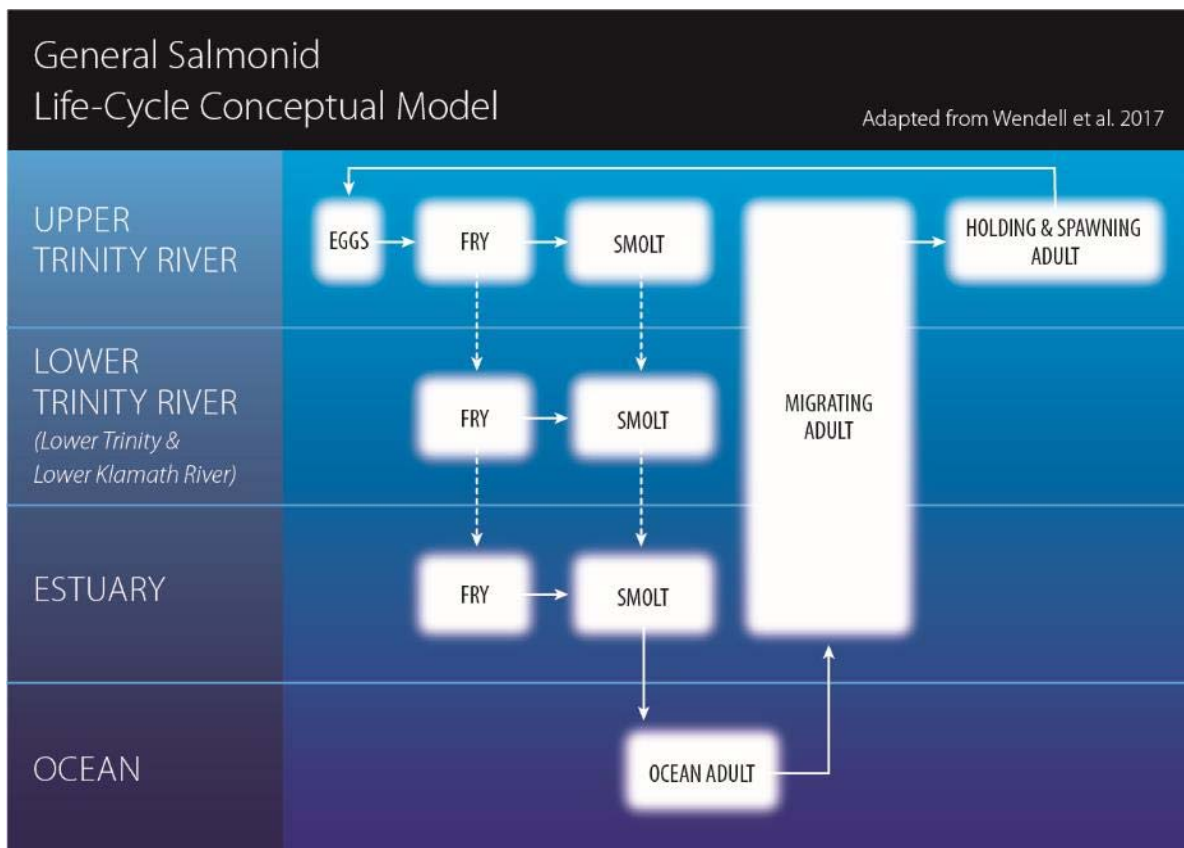


Figure 5.18-2. Conceptual Model of Habitat use by Life Stage

According to NMFS (2014), adverse hatchery effects are a very high stressor on SONCC Coho in the Trinity River. Altered hydrologic function and lack of channel and floodplain structure are also very high or high stressors in the lower and upper Trinity River. One of the most important ecological requirements of Coho Salmon is cold, clean, well oxygenated water. Increased water temperature, changes in pH above or below optimum levels, reduced dissolved oxygen, increased nutrient loading, and increased extent or duration of turbidity all may affect Coho Salmon. Water temperature influences Coho Salmon growth and feeding rates (partly through increased metabolism) and development of embryos and alevins (McCullough 1999), as well as timing of life-history events such as freshwater rearing, seaward migration (Holtby and Scrivener 1989), and upstream migration and spawning (Spence et al. 1996). Increased water temperature can be detrimental to the survival of most life stages of Coho Salmon, but summer-rearing juveniles are the most likely to be affected by elevated water temperatures. Elevated water temperature can result in increased levels of stress hormones in Coho Salmon, often resulting in mortality (Ligon et al. 1999). Increased water temperature, even at sub-lethal levels, can inhibit migration, reduce growth, stress fish, reduce reproductive success, inhibit smoltification, contribute to outbreaks of disease, and alter

competitive dominance (Elliott 1981). Environmental changes include altered timing and magnitude of high and low flows, alteration of temperature and dissolved oxygen levels, and changed cues for seasonal migration. EPA (2003) recommends 13 degrees Celsius or 55 degrees Fahrenheit for salmonid spawning and egg incubation (November to April for Coho), 61 degrees Fahrenheit for juvenile rearing (year-round), 64 degrees for non-core juvenile rearing, and 68 degrees for adult migration (September – December).

The juvenile life stage of the lower Klamath population of Coho Salmon is limited by the lack of quality rearing habitat. Juvenile summer rearing habitat is impaired mostly from subsurface flow conditions in the tributaries caused by heavy sediment loads and winter rearing habitat is severely lacking because of channel simplification, disconnection from the floodplain, degraded riparian conditions, poor large wood availability, and an estuary which has been altered and reduced in size due to development, channelization, and diking. Poor water quality of the mainstem Klamath River (e.g., high water temperatures resulting from degraded riparian conditions and water withdrawals upstream) affects both juveniles and adult Coho Salmon.

5.18.3 Effects of Operations and Maintenance

Under WOA Trinity and Lewiston dams would remain in place but would not be operated to store water and diversion of Trinity Basin water into the Sacramento River system would not occur. This scenario would restore much of the pre-dam hydrograph dominated by late spring snow melt hydrology. Lewiston Dam would remain in place and continue to impound sediment behind the dam as well as block upstream passage.

Under WOA, temperatures would be above juvenile holding temperature thresholds in the mainstem Trinity River. Much of the refugia habitat was blocked by Lewiston Dam or degraded by land use practices and sedimentation (USFWS and HVT 1999). Thus, under WOA juvenile Coho would need to find refuge habitat downstream in the Lower Klamath reach or in tributary streams. High water temperatures in September could also create barriers to upstream migrating adults and or reduce the amount of suitable holding habitat available for use prior to spawning.

5.18.3.1 Seasonal Operations

Environmental changes of altered hydrology include altered timing and magnitude of high and low flows, alteration of temperature and dissolved oxygen levels, and changed cues for seasonal migration. In terms of the timing and magnitude of high and low flows, the proposed action is the same as COS with the addition of the Grass Valley Creek Flows (see subsequent section discussing *Grass Valley Creek Flows*). The proposed action would result in much lower flows from October through April, and higher flows from May through September relative to WOA. As Coho Salmon spawn from February to April, this reduction in flow would reduce the amount of available spawning habitat and increase competition, with detrimental effects on Coho Salmon. Competition with hatchery fish released from Trinity River Hatchery limits rearing and spawning capacity in the Upper Trinity River for naturally produced Coho (NMFS 2014). For those redds that are laid, higher survival of Coho Salmon eggs and emerging alevins is expected under the proposed action relative to WOA due to reduced fine sediment in the channel substrate, and an increased food base for these fish due to increased macroinvertebrate production. See Figures 5.18-3 and Figure 5.18-4.

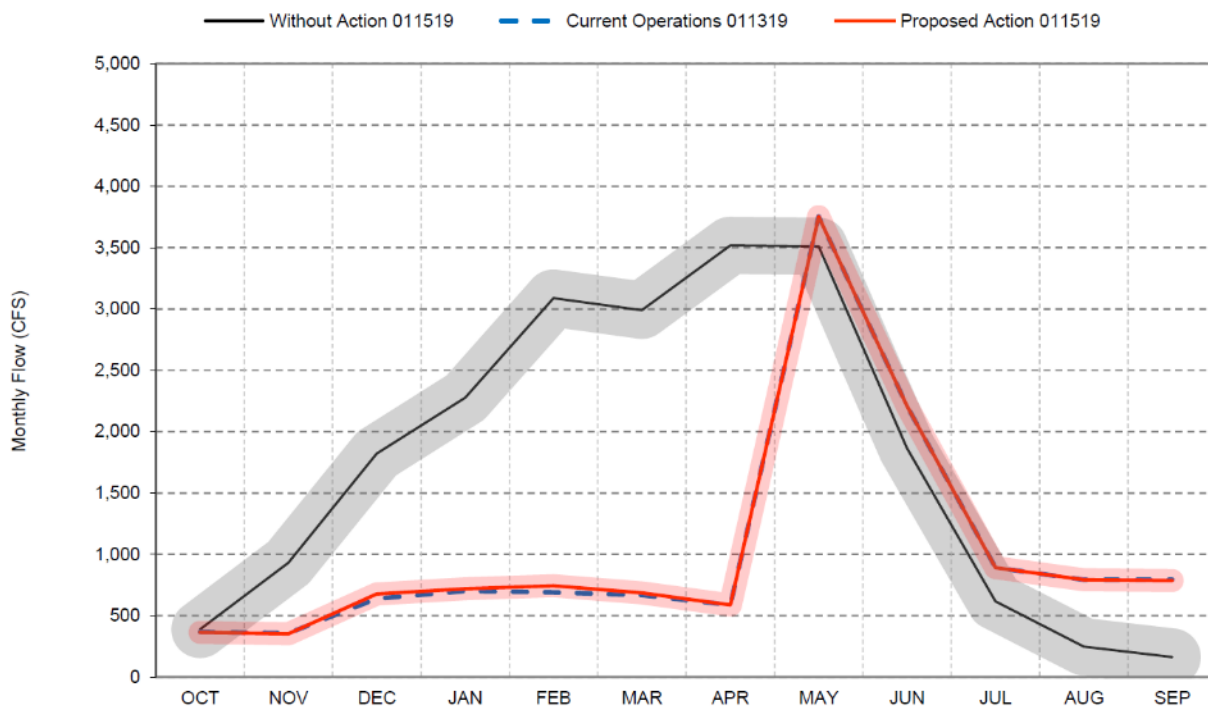


Figure 5.18-3. Average Monthly Flow below Lewiston for the Proposed Action, without Action, and Current Operations

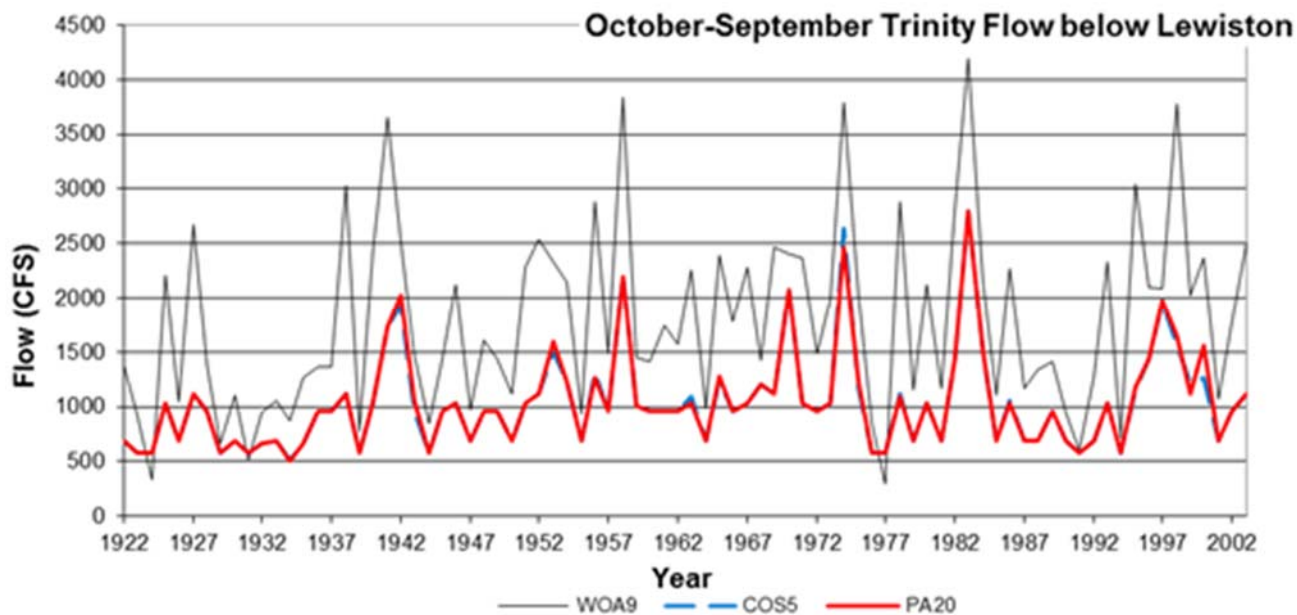


Figure 5.18-4. CalSIMII Simulated Annual Flow in the Trinity River below Lewiston Dam under the Without Action (WOA9), Current Operations (COS5) and Proposed Action (PA20) Scenarios

As discussed in the conceptual model section above, increased water temperature can be detrimental to the survival of most life stages of Coho Salmon, but in the SONCC Coho Salmon ESU summer-rearing juveniles are the most likely to be affected by elevated water temperatures. Increased water temperature, even at sub-lethal levels can inhibit migration, reduce growth, stress fish, reduce reproductive success, inhibit smoltification, contribute to outbreaks of disease, and alter competitive dominance (Elliott 1981). EPA (2003) recommends 13 degrees Celcius or 55 degrees Fahrenheit for salmonid spawning and egg incubation (November to April for Coho), 61 degrees Fahrenheit for juvenile rearing (year-round), 64 degrees for non-core juvenile rearing, and 68 degrees for adult migration (September – December).

Compared to WOA, the proposed action would result in higher water temperatures during November - April, and much lower water temperatures from May through October. Higher water temperatures during the winter are not expected to negatively impact Coho Salmon life stages, since water temperatures are expected to stay within the suitable range for these life stages (below 55 degrees, see figures below). Conversely, significantly lower water temperatures during the summer and fall months should provide a benefit to over summering juvenile Coho Salmon rearing. Under the proposed action, temperatures are below 55 degrees year-round nearly all of the time, except for in some Critical years. This is a substantial benefit of the proposed action as compared to WOA.

See Figures 5.18-5 and 5.18-6.

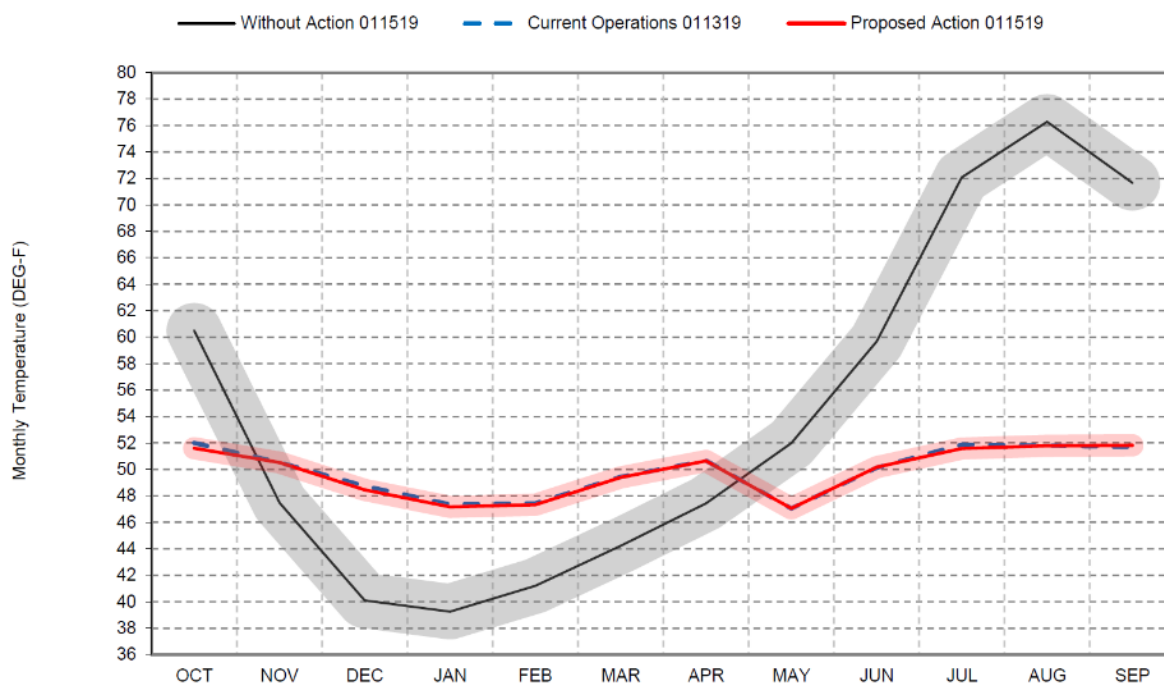


Figure 5.18-5. Monthly Mean Temperatures in the Trinity River below Lewiston Dam under the Proposed Action, without Action, and Current Operations

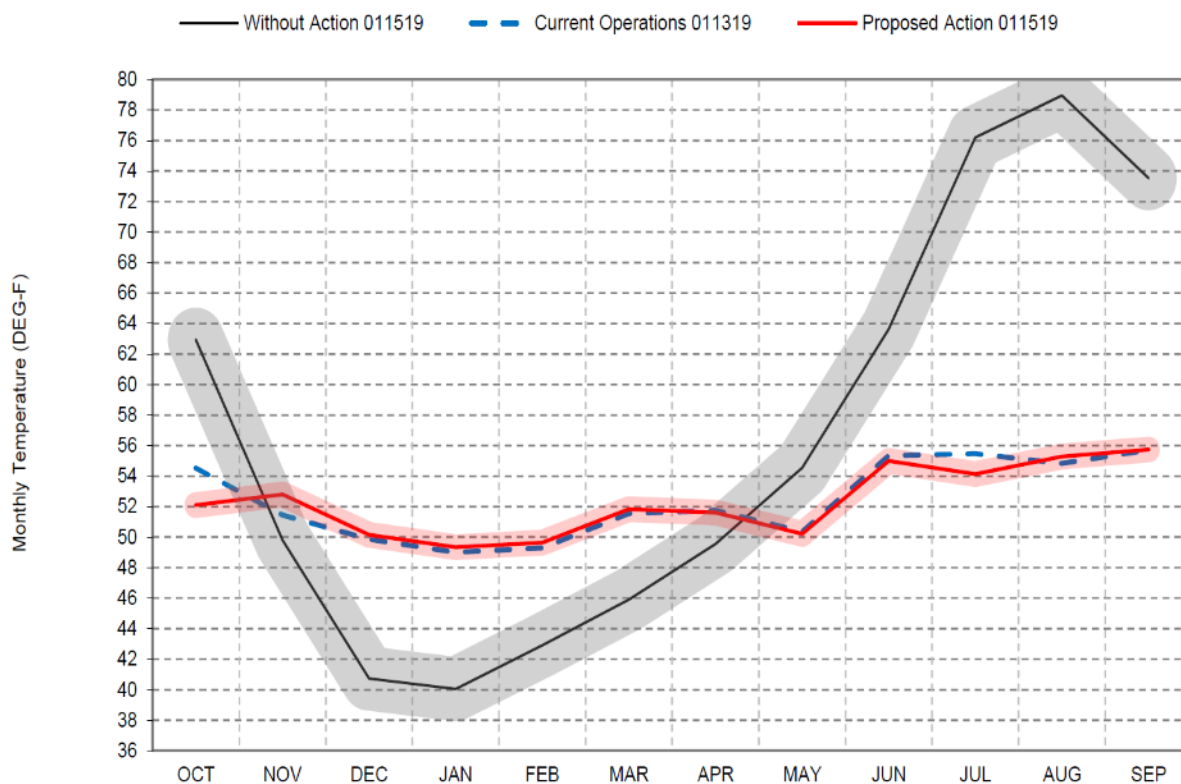


Figure 5.18-6. Critical Water-year Type Mean Temperatures in the Trinity River below Lewiston Dam under the Proposed Action, without Action, and Current Operations

5.18.3.2 Grass Valley Creek Flows

The addition of Grass Valley Creek Flows under the proposed action is also a benefit to Coho Salmon relative to WOA. Grass Valley Creek is being used by Coho Salmon throughout most its 10.8 miles of stream length between the dam and confluence with the Trinity River. Grass Valley Creek is considered to be the major source of fine sediment into the Trinity River but conditions have improved as a result of construction of Buckhorn Dam and Hamilton sediment ponds that trap fine sediment. Reclamation proposes to release flow to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Flow will also be provided in the dam outflow channel in October and November to provide adult Coho Salmon sufficient flow for upstream migration and spawning to the extent feasible. Relative to WOA, the proposed changes under the proposed action to the Grass Valley Creek flow should enhance habitat conditions for adult and juvenile Coho Salmon in the stream below the dam and contribute to increased production of Coho Salmon from Grass Valley Creek.

5.18.4 Conservation Measures

Conservation measures under the proposed action described in the Winter-run Chinook Salmon section would not overlap with the Coho Salmon spatial distribution and, therefore, are not expected to affect Coho Salmon.

5.19 Coho Critical Habitat, Southern Oregon/Northern California Coastal ESU Critical Habitat

Prior to the construction of the TRD, the Trinity River was an unregulated, meandering, dynamic alluvial river within floodplain habitat. High flows periodically changed the size, shape, and location of river bars. Flow regulation by the TRD removed nearly all high flows that were responsible for forming and maintaining dynamic alternate bar sequences that supported development of rearing habitat in the mainstem trinity. No longer scoured by winter floods downstream of the TRD, streambank (riparian) vegetation encroached into the river channel and formed riparian berms along the channel margins. Reduced flows, loss of coarse sediment impounded by the dam, and riparian encroachment caused the mainstem of the river downstream from the TRD to change from a series of alternating riffles and deep pools that provided high-quality salmonid habitat to a largely monotypic run habitat confined between riparian berms (a trapezoid-shaped channel). The loss of alluvial features and diverse riverine habitats reduced the quantity and quality of salmonid habitats and the populations that relied upon them (USFWS and HVT 1999).

5.19.1 Seasonal Operations

Under the WOA, uncontrolled flows would be released to the Trinity River, however the dam would continue to impound sediment. Without sediment to rebuild the bar, pool, and riffle habitat that supports coho spawning and rearing, the uncontrolled flow would likely continue to degrade habitat that has been designated as critical for the conservation of SONCC Coho.

Compared to WOA, the proposed action would improve habitat by continuing implementation of a normal (reduced) hydrograph, and restoration of functioning alluvial river and connected floodplain habitat. Because the expected outcome of implementation of the proposed action is improved fish habitat conditions (including necessary Coho Salmon habitat), the value of critical habitat for both the survival and recovery of SONCC Coho Salmon will not be appreciably diminished.

5.20 Eulachon, Southern DPS

Eulachon occur in the Klamath River watershed and, therefore, could be subjected to effects from seasonal operations of Lewiston Dam; there would be no effects from any other components of the proposed action. Adult Eulachon typically spawn at age 2-5 in the lower portions of rivers. As described in Chapter 2, Eulachon spawning generally occurs between December and June, with larvae being transported to the estuary and ocean by spring freshets.

Climate change is ranked as the highest threat to Eulachon, with dams and diversions the second most important threat to the Klamath River population of Eulachon. Operation of Trinity Reservoir, as well as associated changes in the Klamath River, have shifted the spring peak flow of the lower Klamath River from its historical peak in April to its current peak in March, one full month earlier (NRC 2004, as cited in Gustafson et al. 2010). Habitat-related effects to Eulachon as a result of the continued operations of Trinity Reservoir has the potential to affect Eulachon spawning behavior; egg viability; and larvae and juvenile growth, development, and survival. However, the principal habitat-related effects to Eulachon as a result of the continued operations of the dams are the hydrological effects on the estuary-plume environment, which is utilized by Eulachon larvae and juveniles for rearing and maturation. The April through July period coincides with Eulachon larval ocean entry and residence timing, and changes in flows during this period are likely to affect the chemical and physical processes of the estuary-plume

environment (NMFS 2008a). Studies highlight the connection between river-derived nutrients, coastal upwelling, chemical and physical process in the estuary–plume environment, primary productivity, and the importance of the estuary–plume environment to Eulachon, especially Eulachon larvae and juveniles. However, there is no direct data on the link between decreases in freshwater inputs into the estuary–plume environment and effects on Eulachon larvae and juveniles to assess the significance of effects.

In general, Eulachon would spawn at low water levels before spring freshets (Lewis et al. 2002, as cited in Willson et al. 2006). In many rivers, the spawning reach is more or less limited to the part of the river that is influenced by tides (Lewis et al. 2002, as cited in Willson et al. 2006). However, Eulachon are reported to go as far as 80 km up the Susitna River (Barrett et al. 1984, Vincent-Lang and Qeral 1984; as cited in Willson et al. 2006), possibly because of a low gradient (Lewis et al. 2002, Ref. 269). Eulachon once ascended more than 160 km in the Columbia River system. There is some evidence that water velocity greater than 0.4 m/s begins to limit upstream movements, at least for a segment of the Eulachon population (Lewis et al. 2002, as cited in Willson et al. 2006).

Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al. 1954, Eulachon Research Council 2000, Prince Rupert Forest Region 1998, Bishop et al. 1989b, Lewis et al. 2002, WDFW/ODFW 2001, Spangler 2002; as cited in Willson et al. 2006).

Spawning is reported to occur at temperatures from 4° to 10°C; colder temperatures may stop migration (WDFW/ODFW 2001), at least in some rivers. run timing (as estimated from harvest rates) in the Fraser River tended to be earlier in years with somewhat warmer temperatures ($r = -0.47$; Ricker et al. 1954, as cited in Willson et al. 2006). Incubation is temperature-dependent, and so incubation times can differ among rivers and years. Egg survival is greatly influenced by salinity: exposure to salt water, especially salinity greater than 16 ppt, can be lethal (Farara 1996 cited in Lewis et al. 2002, as cited as cited in Willson et al. 2006). Major temperature changes also affect survival (e.g., a change from 5° to 11°C; Lewis et al. 2002, as cited in Willson et al. 2006). Peaks in larval outmigration are thought to occur during periods of relatively stable water temperatures and at low light intensities (Spangler 2002, as cited in Willson et al. 2006).

Thus, the proposed action could affect the transitions between adults and egg/larvae, and between egg/larvae and juveniles[1]. Seasonal operations of Lewiston Dam in winter and spring are of relevance for potential effects on Eulachon. Under WOA, based on observed data in the Klamath River from 1962-2003 and CalSim modeled results for WOA, Trinity River flow provides between 6% (September) to 19% (May) of the flow in the Klamath River (Figure 5.20-1). For the period from 1962–2003, under WOA, flow in the Trinity River at Lewiston as a percentage of observed flow in the Klamath River near Klamath has ranged from 0–15% in January to 11% to 47% in May (Table 5.20-1). Therefore, under WOA, flow from the Trinity River at Lewiston forms a small percentage (mean of 10%) of flow entering the lower Klamath River during December–April and a larger percentage in May and June (17%).

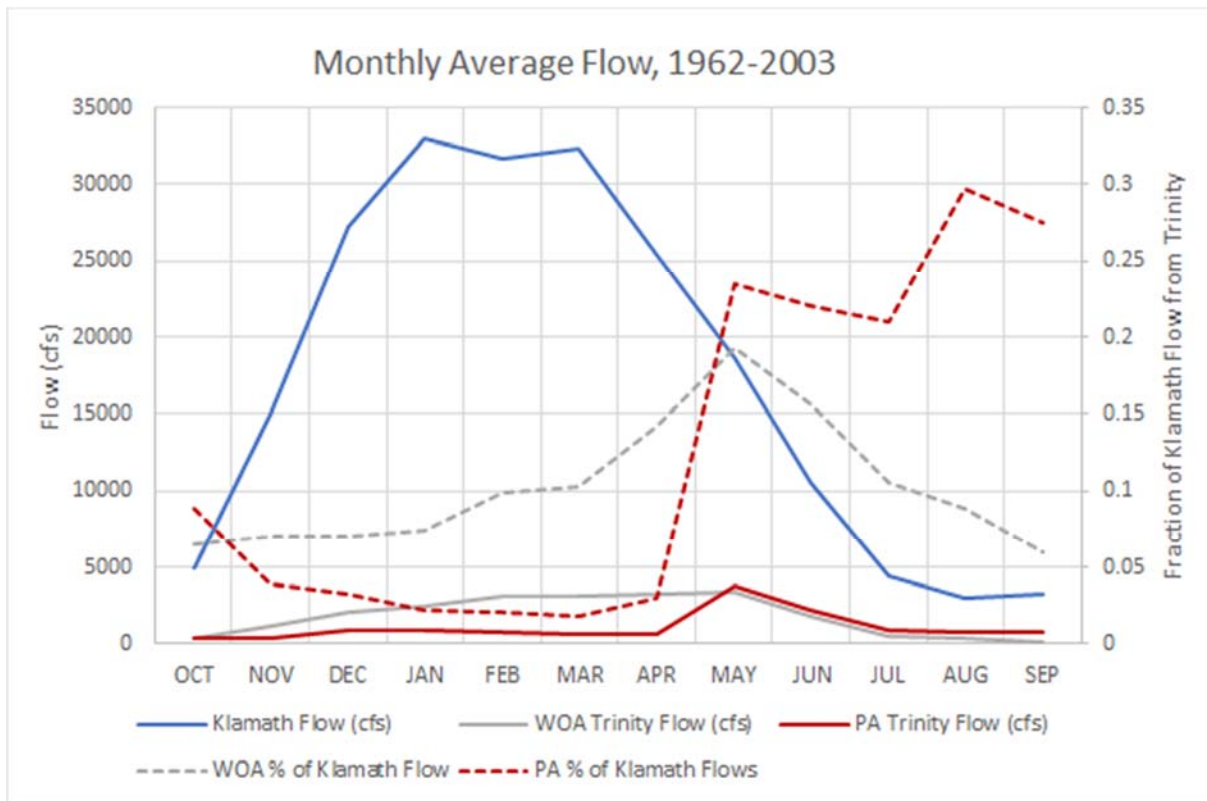


Figure 5.20-1. Monthly Average Klamath Flow (Observed) and Trinity Flow (Modeled).

Table 5.20-1. Modeled Flow in the Trinity River at Lewiston as a Percentage of Observed Flow in the Klamath River near Klamath, 1962-2003. (WOA / PA)

| | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Max | 0.18 / 0.18 | 0.15 / 0.07 | 0.2 / 0.11 | 0.26 / 0.09 | 0.34 / 0.11 | 0.43 / 0.47 | 0.41 / 0.5 |
| 95% | 0.18 / 0.18 | 0.15 / 0.07 | 0.2 / 0.11 | 0.26 / 0.09 | 0.34 / 0.11 | 0.43 / 0.47 | 0.41 / 0.5 |
| 75% | 0.08 / 0.04 | 0.1 / 0.03 | 0.14 / 0.02 | 0.12 / 0.02 | 0.19 / 0.04 | 0.22 / 0.3 | 0.21 / 0.32 |
| 50% | 0.07 / 0.02 | 0.08 / 0.01 | 0.09 / 0.01 | 0.11 / 0.01 | 0.14 / 0.02 | 0.19 / 0.24 | 0.14 / 0.21 |
| 25% | 0.05 / 0.01 | 0.06 / 0.01 | 0.07 / 0.01 | 0.08 / 0.01 | 0.11 / 0.01 | 0.17 / 0.16 | 0.12 / 0.14 |
| 5% | 0.03 / 0.01 | 0.03 / 0 | 0.05 / 0.01 | 0.06 / 0.01 | 0.08 / 0.01 | 0.13 / 0.13 | 0.09 / 0.09 |
| Min | 0.01 / 0 | 0.01 / 0 | 0.04 / 0 | 0.05 / 0 | 0.07 / 0.01 | 0.12 / 0.11 | 0.07 / 0.05 |
| Mean | 0.07 / 0.03 | 0.07 / 0.02 | 0.1 / 0.02 | 0.1 / 0.02 | 0.14 / 0.03 | 0.19 / 0.23 | 0.16 / 0.22 |

For the December–June period of concern for Eulachon, CalSim modeling suggests that the proposed action scenario would reduce flows in December to April, but actually would increase flows in May and June. This pattern is essentially identical for the current operations COS scenario in relation to the WOA scenario. The patterns suggest that Trinity River flow changes would occur during the spawning migration period (December–April, with the main historical period being March–April; NRC 2004, p.275), with little or no effect to flow in the Trinity River expected during the later egg incubation and larval downstream migration period, which occurs around one month after spawning (NRC 2004, p.275). The extent to which the limited December–April flows may negatively affect Eulachon is uncertain, given the lack of quantitative relationships between biological performance and flow. However, as discussed above, studies have shown effects on food in the estuary-plume environment, shifts in timing of spring freshets, and temperature affect Eulachon. Incubation is temperature-dependent, and major temperature changes affect survival (e.g., a change from 5° to 11°C; Lewis et al. 2002, as cited in Willson et al. 2006).

The most recent status review update noted that there have been catches of Eulachon in the Klamath River during surveys in recent years, whereas prior to that, runs were rare or sporadic for several decades (Gustafson 2016, p.13). The Klamath subpopulation appears to be much smaller than the Columbia, Fraser, and British Columbia subpopulations, some of which can number in the tens to hundreds of millions (NMFS 2017 Eulachon, p.73).

See Figures 5.20-2, Figure 5.20-3, Figure 5.20-4, Figure 5.20-5 and Figure 5.20-6.

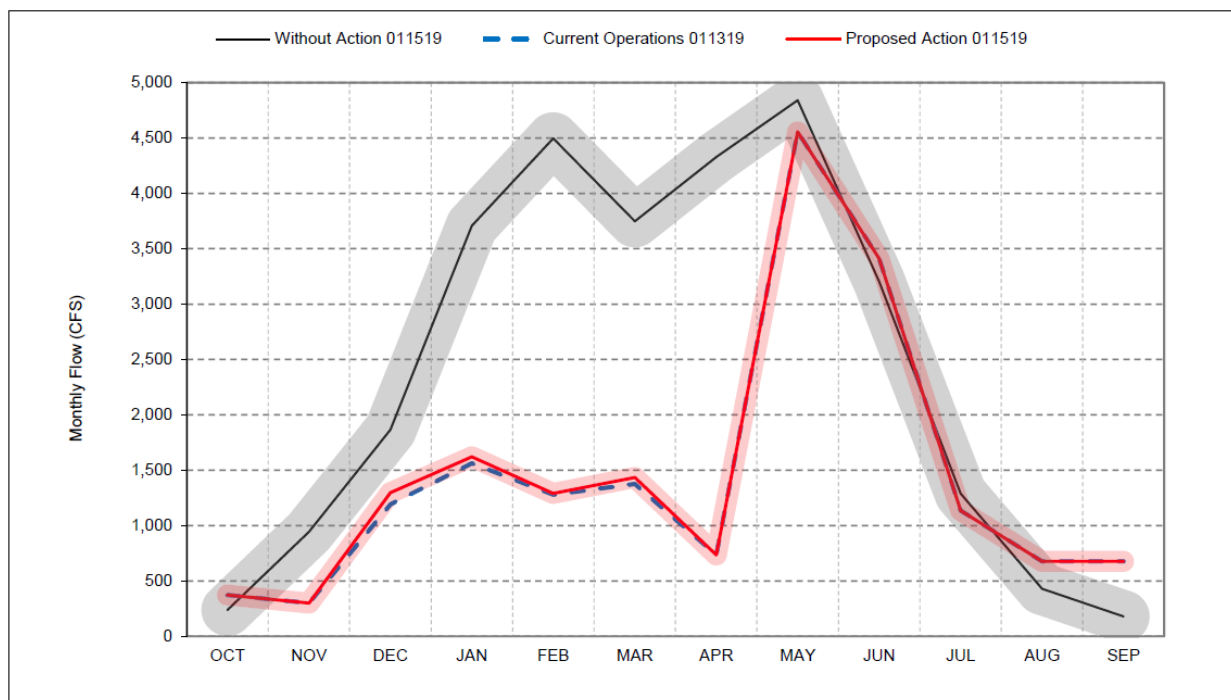


Figure 5.20-1. Mean Modeled Flow in the Trinity River Below Lewiston, Wet Years.

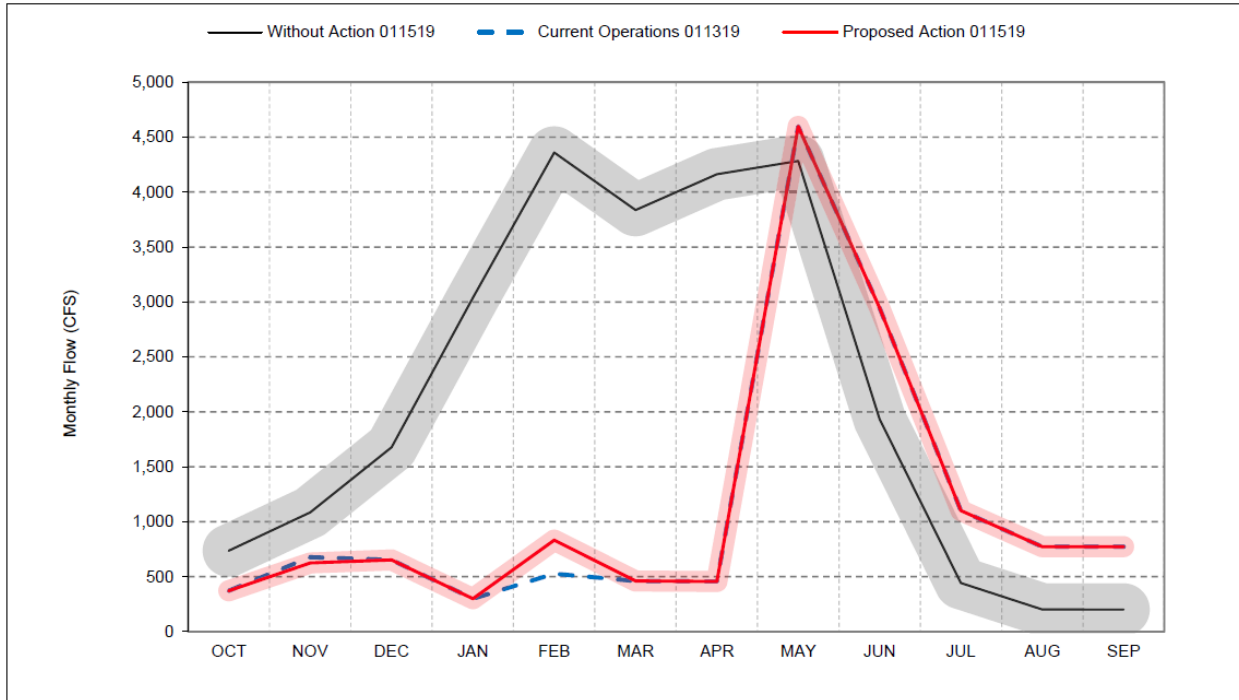


Figure 5.20-2. Mean Modeled Flow in the Trinity River Below Lewiston, Above Normal Years.

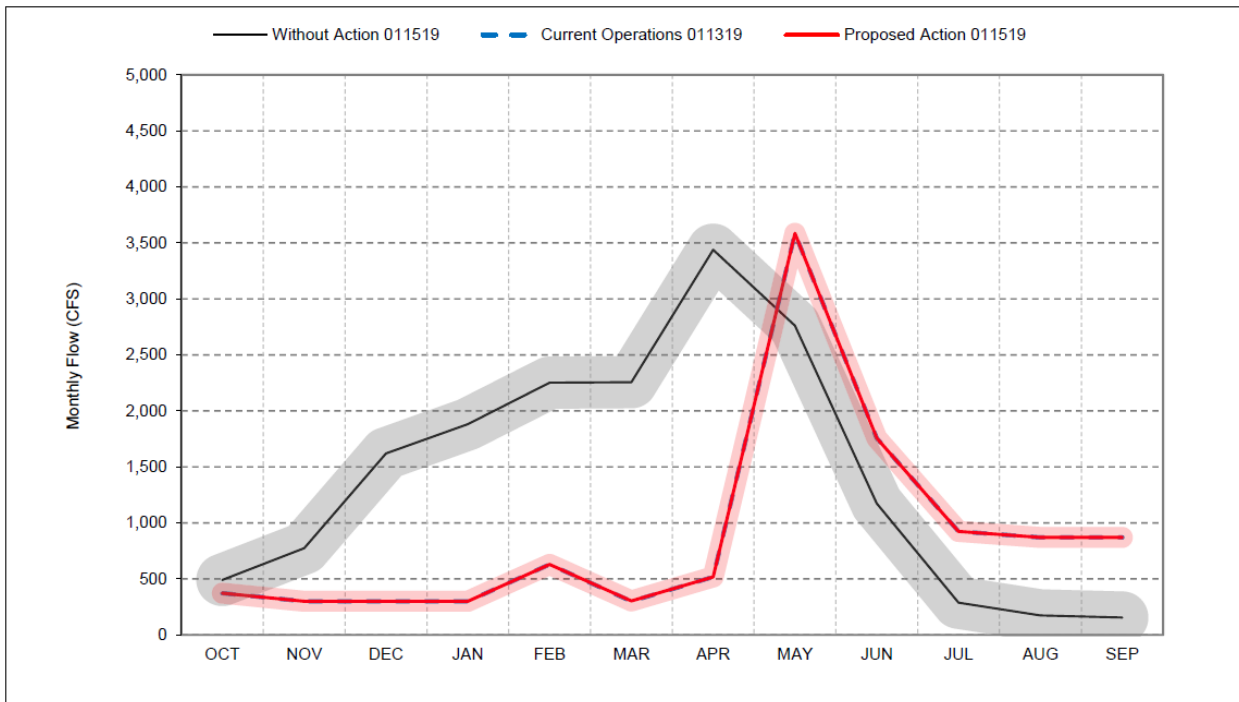


Figure 5.20-3. Mean Modeled Flow in the Trinity River Below Lewiston, Below Normal Years.

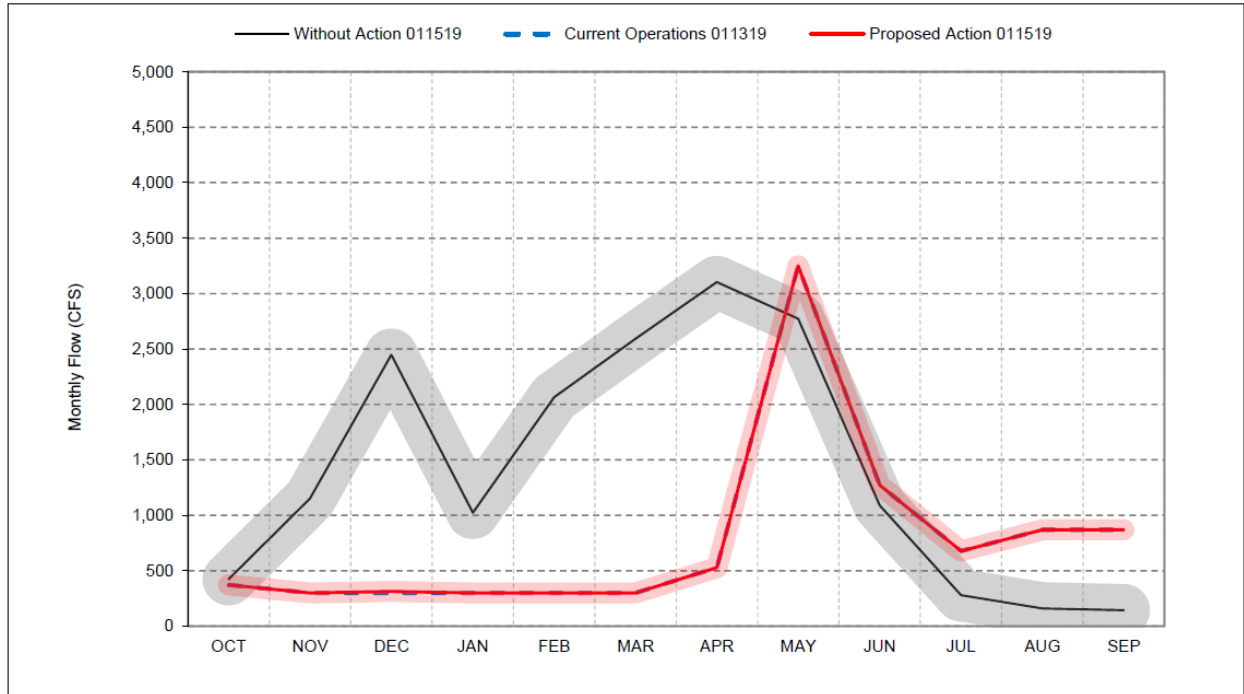


Figure 5.20-4. Mean Modeled Flow in the Trinity River Below Lewiston, Dry Years.

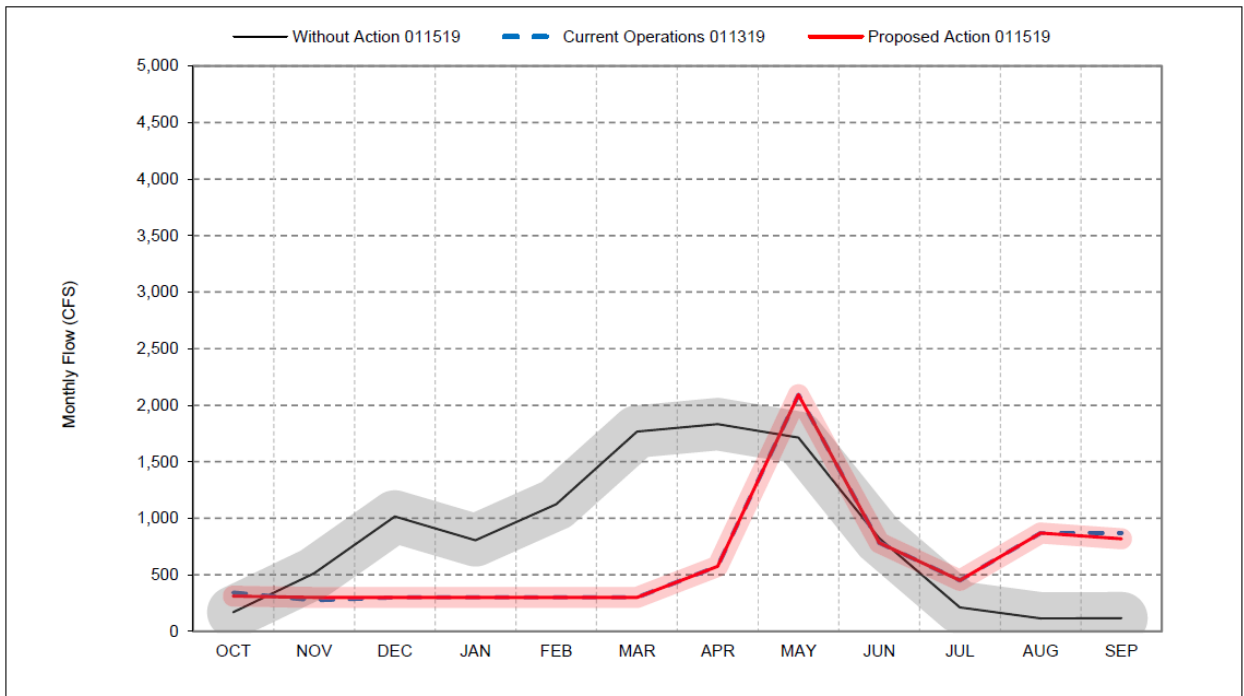


Figure 5.20-5. Mean Modeled Flow in the Trinity River Below Lewiston, Critically Dry Years.

Under the proposed action, Trinity River at Lewiston flows would contribute between 1,000 to 4,000 cfs less to flow entering the lower Klamath River than WOA during December–April, reducing flows to approximately 300 cfs in most years. The timing coincides with Eulachon spawning and larvae being transported to the estuary and ocean. Under WOA, flows from the Trinity River provide, on average, 10% of the flow of the Klamath River, with the greatest percentage in May. Flows under the proposed action in the lower Klamath River could be reduced from 0% to nearly 23% compared to WOA in December - April of some years, with the average less than 10%. While the proposed action substantially reduces flow in December - April, and the proposed action slightly reduces flows in May of Wet water year types, the proposed action overall slightly increases flows from the Trinity River in May as compared to WOA, which is the month when the Trinity River provides the largest portion of the Klamath River flows. As previously noted, it is uncertain the extent to which there may be negative effects because of these differences, given the lack of quantitative relationships between biological performance and flow, but mechanisms include food transport and temperature.

Eulachon in the Klamath River generally spawn March–April (NRC 2004, p.275). Adult Eulachon require rapid changes in temperature of 6-8 C to experience mortality (Blahm and McConnell, 1971). Temperature modeling data for the proposed action are not available for the lower Klamath River where Eulachon spawn, but temperature averages in the Trinity River below Lewiston between December-April under the proposed action are not appreciably different than the WOA in the months of March and April (see Figure 5.20-7 and Figures 1-1 to 1-6 in the HEC-5Q modeling summary in Appendix D, *Modeling*), which, given that spawning sites for Eulachon have been found up to 52 F/11 C (see review by Willson et al. 2006), and the modest contribution of Trinity River water to the lower Klamath River (i.e., perhaps 20% under WOA; see discussion above) suggests that effects on spawning temperature would be limited.

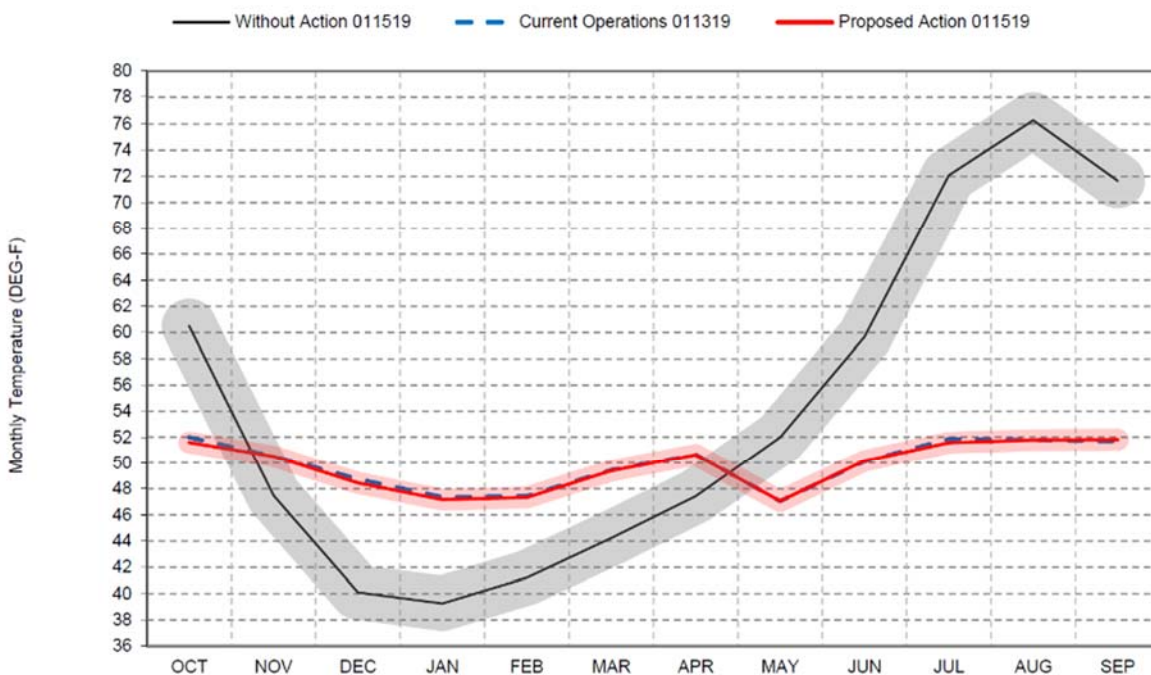


Figure 5.20-6. Mean Modeled Temperature in the Trinity River Below Lewiston

5.21 Eulachon, Southern DPS Critical Habitat

5.21.1 Freshwater Spawning and Incubation Sites

As described in the *Aquatic Status of the Species and Designated Critical Habitat for Eulachon, Southern DPS*, the physical or biological features (PBFs) include water flow, quality and water temperature conditions and substrate supporting spawning and incubation. As previously noted, flow during December–April under the proposed action is lower than under the WOA scenario; Figures 5.20-2 – 5.20-5 5.20-6). As previously stated, there is a lack of quantitative relationships between flow and Eulachon biological performance.

5.21.2 Freshwater and Estuarine Migration Corridors

As described in the *Aquatic Status of the Species and Designated Critical Habitat for Eulachon, Southern DPS*, the PBFs include freshwater and estuarine migration corridors free of obstruction and with water flow, quality and water temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted. The proposed action does not physically obstruct migration corridors—Eulachon only occur in the lower 8 miles or so of the tidal Klamath River (NRC 2004, p.275)—but could reduce water flow during December–April, which includes the main historical period of spawning migration (March–April; NRC 2004, p.275). As previously noted, larval downstream migration occurs around one month after spawning, and, therefore, their exposure to reduced flows would be limited.

5.21.3 Nearshore and Offshore Marine Foraging Habitat

The proposed action would not be expected to have negative effects on the nearshore and offshore marine foraging habitat PBFs of Eulachon critical habitat.

5.22 Analytical Approach – Terrestrial Species

This section analyzes potential effects from the proposed action on terrestrial listed species, including riparian brush rabbit, riparian woodrat, salt marsh harvest mouse, California Rigway’s rail, least Bell’s vireo, western yellow-billed cuckoo, giant garter snake, valley elderberry longhorn beetle, soft bird’s-beak, Suisun thistle, vernal pool fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, and California least tern. This section also analyzes effects of the proposed action on listed species’ designated critical habitat.

5.22.1 Wildlife and Plant Species

5.22.1.1 Range Maps and Species Occurrences

To determine which project components could affect federally listed terrestrial species, reclamation reviewed species range maps to assess which project components overlap the species’ ranges as depicted in Chapter 2 range map figures. All the range maps originated from the following data sources.

- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. California Tiger Salamander Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 24, 2019.

- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Clapper Rail Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Giant Garter Snake Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Least Tern Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 24, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Salt-Marsh Harvest Mouse Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- California Department of Fish and Wildlife California Interagency Wildlife Task Group. 2016. Yellow-Billed Cuckoo Range. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: January 2, 2019.
- U.S. Geological Survey Gap Analysis Project. 2018. San Joaquin Valley Wood Rat Range. Available: <https://gapanalysis.usgs.gov/species/data/download>. Accessed: January 15, 2019.
- Carol W. Witham, Robert F. Holland and John Vollmar. 2014. Changes in the Distribution of Great Valley Vernal Pool Habitats from 2005 to 2012. Available: <https://vernalpools.org/2012CVPIA/2012RemapVernalPoolsFINAL.zip>. Accessed: August 27, 2017.
- U.S. Fish and Wildlife. 2005. Vernal Pool Core Areas.

Where the species' range overlaps the general area of effect for a proposed project component, Reclamation then assessed whether the species' current range includes the area. For all species except giant garter snake and California red-legged frog, Reclamation assumed the range maps reflect the current species' range for all except California red-legged frog and giant garter snake: for these species, the range maps include the historic range and Reclamation based species potential on more recent occurrences and information on locations where the species are believed to be extirpated.

5.22.1.2 Land Cover Data and Species Models

Reclamation used existing land cover data and, where available, species habitat models to assess which habitat components would affect federally listed species' habitat. Reclamation used the following data sources to make these determinations:

- Aerial Information Systems, Inc. 2011. Delta Vegetation and Land Use. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets/200_299/ds292.zip. Accessed: December 10, 2018.
- U.S. Geological Survey. 2017. NHD Flowline. Available: <http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/NHD/State/HighResolution/GDB>. Accessed: May 4, 2017.
- U.S. Geological Survey. 2017. NHD Area. Available: <http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/NHD/State/HighResolution/GDB>. Accessed: May 4, 2017.

- Geographic Information Center, Chico Research Foundation. 2016. Vegetation - Great Valley Ecoregion. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets/2600_2699/ds2632.zip. Accessed: November 11, 2017.
- Chico State University and California DWR. 2001. Legal Delta Boundary. Available: ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets. Accessed: December 11, 2018. BDCP species models.

Table 5.23-1 lists each of the project components and indicates the federally listed species that may be affected by each, based on the analysis described above.

5.22.1.3 Avoidance and Minimization Measures, Effects Estimates

Reclamation developed avoidance and minimization measures with the first goal being to avoid effects on federally listed species, and the second goal being to minimize unavoidable effects. Reclamation analyzed each project component to determine whether it could fully avoid effects on federally listed species. If effects were determined to be unavoidable, or potentially unavoidable, Reclamation estimated the potential effects on each species.

The approach Reclamation used to estimate potential effects differed by project component, since the amount and source of information differed by project component. Project footprints were available for most of the spawning and rearing habitat restoration projects. For other habitat restoration projects, hypothetical footprints were used to estimate effects. These hypothetical footprints had been developed for BDCP, California WaterFix, and California Ecorestore. Reclamation also used information from existing environmental documents where available.

Precise, site-specific project information was unavailable for most of the project components. As such, the impact acres provided are intended to place upper limits on species effects to assist USFWS in making no-jeopardy determinations for each of the species.

5.22.2 Wildlife and Plant Critical Habitat

The analyses of potential effects on species' designated critical habitat follow the species analyses. Potential effects to primary constituent elements (PCEs)/physical and biological features (PBFs) of critical habitat are analyzed for western yellow-billed cuckoo and valley elderberry longhorn beetle. These analyses often draw on the foundation provided in the species analyses. Analysis of effects to critical habitat is guided by consideration of recent analyses by USFWS (2017a) and NMFS (2017), which included refined interpretation of critical habitat PCEs/PBFs relative to the original descriptions at the time critical habitat was designated.

In general, riparian vegetation would establish and grow more successfully during winter under the WOA scenario, but the low summer WOA flow could result in the loss of this vegetation. Therefore, the effect of the proposed action relative to the WOA on riparian habitat is uncertain.

5.23 Effects on Covered Wildlife and Plant Species

This section provides the results of the effects analysis for covered wildlife and plant species. Section 5.22, Analytical Approach, describes the methods used for this analysis. The project components that may

affect each species are indicated in Table 5.23-1. The maximum allowable habitat loss for each species is provided in Table 5-Terrestrial.

Construction actions affecting terrestrial species are covered programmatically in this BA. As part of the subsequent site-specific consultation, Reclamation will provide a memo describing the action in detail, including where, when and how.

5.23.1 Riparian Brush Rabbit

The riparian brush rabbit occurs in the Stanislaus River and San Joaquin River watershed, and project components within these watersheds may affect this species as follows.

5.23.1.1 *Stanislaus River Watershed*

5.23.1.1.1 Proposed Flow Changes

For the purposes of the wildlife and plant species analyses, “proposed flow changes” constitute the expected effects of implementing the proposed action compared to WOA. Differences in flow management between the proposed action and WOA would have the potential to affect a covered wildlife or plant species if flow changes were to directly affect the species, directly alter habitat availability or quality, or result in vegetation changes that would alter habitat availability or quality. The great majority of stream channels within the action area are linear channels confined by levees or other engineered works that provide negligible habitat for covered wildlife or plant species. However, there is potential to affect such species at those sites where habitat has not been removed by channel alteration, or where habitat has been restored, or where habitat is expected to be restored during the proposed term of the proposed action. In the first two of these cases, existing habitat shows evidence of adaptation to anthropogenic modifications to the ecosystem that date back decades, and in many cases over a century. These modifications include hydrologic changes associated with water manipulation; topographic changes associated with flood control, agriculture, restoration site construction, and other causes; and biological changes associated with the introduction of non-native species. Implementation of the proposed action generally results in higher flows in the fall and lower flows in the spring than WOA, and very minor potential changes relative to COS and are small relative to normal month-to-month and year-to-year variability in the system. Lower flows in the spring under the proposed action compared to WOA could potentially result in less riparian vegetation recruitment, such as cottonwood seed dispersal. However, flows under the proposed action would generally be more stable compared to WOA and would not alter the timing and magnitude of hydrologic vegetation and peak flow incidents such that erosion and potential loss of riparian vegetation occurs.

For example, CalSim results show average maximum flows in the Sacramento River below Keswick in April under the proposed action would be 30,893 cfs, compared to 56,209 cfs under WOA (see Appendix D, *Modeling*). With average maximum spring flows such as these the proposed action is more likely to negatively affect riparian vegetation recruitment compared to WOA. These maximum spring flows under WOA are not likely to destabilize the existing ecosystem or cause substantial disturbances to riparian vegetation as they are similar to average maximum flows during different times of the year compared to the proposed action and COS. Higher flows in the fall under the proposed action compared to WOA could result in reduced drought stress in riparian or wetland vegetation.

Table 5.23-1. Terrestrial: Terrestrial Project Components

| Watershed | Title¹ | Riparian Brush Rabbit | Riparian Woodrat | Salt Marsh Harvest Mouse | CA Ridgway's Rail | Western Yellow-Billed Cuckoo | Least Bell's Vireo | Giant Garter Snake | Valley Elderberry Longhorn Beetle | Suisun Thistle | Soft Bird's-Beak | Vernal pool fairy shirmp | Vernal pool tadpole shrimp | California tiger salamander | California red-legged frog | California least tern |
|------------------|-------------------------------------------------------|------------------------------|-------------------------|---------------------------------|--------------------------|-------------------------------------|---------------------------|---------------------------|------------------------------------------|-----------------------|-------------------------|---------------------------------|-----------------------------------|------------------------------------|-----------------------------------|------------------------------|
| Upper Sacramento | Spawning and Rearing Habitat Restoration | | | | | X | X | X | X | | | | | | X | |
| Upper Sacramento | Battle Creek Salmon and Steelhead Restoration Project | | | | | | | | X | | | | | | | |
| Upper Sacramento | Colusa Basin Drain Food Web Routing | | | | | X | X | X | X | | | | | | | |
| Upper Sacramento | Seasonal Operations | | | | | X | X | X | X | | | | | | | |
| Feather River | FERC Flows | | | | | X | | | X | | | | | | | |
| American River | Spawning and Rearing Habitat Restoration | | | | | X | | | X | | | | | | | |
| American River | 2017 FMS and "Planning Minimum" | | | | | X | | | X | | | | | | | |
| Bay-Delta | Delta Fishes Conservation Hatchery | | | | | | | | | | | | | X | | |
| Bay-Delta | Delta Cross Channel Improvements | | | | | | | X | | | | | | | | |

¹ Only project components with potential to affect federally listed terrestrial species are listed.

| Watershed | Title¹ | Riparian Brush Rabbit | Riparian Woodrat | Salt Marsh Harvest Mouse | CA Ridgway's Rail | Western Yellow-Billed Cuckoo | Least Bell's Vireo | Giant Garter Snake | Valley Elderberry Longhorn Beetle | Suisun Thistle | Soft Bird's-Beak | Vernal pool fairy shirmp | Vernal pool tadpole shrimp | California tiger salamander | California red-legged frog | California least tern |
|-------------------------|------------------------------------------|------------------------------|-------------------------|---------------------------------|--------------------------|-------------------------------------|---------------------------|---------------------------|------------------------------------------|-----------------------|-------------------------|---------------------------------|-----------------------------------|------------------------------------|-----------------------------------|------------------------------|
| Bay-Delta | Tidal Habitat Restoration | | | X | X | | | X | X | X | X | X | X | X | | X |
| Bay-Delta | Suisun Marsh Salinity Control Gates | | | X | X | | | | | X | X | | | | | |
| Bay-Delta | OMR Management | | | X | X | | | X | X | X | X | | | | | |
| Stanislaus | Spawning and Rearing Habitat Restoration | | | | | X | X | | X | | | | | | | |
| Stanislaus | Stepped Release Plan | X | X | | | X | X | | X | | | | | | | |
| San Joaquin River Lower | Spawning and Rearing Habitat Restoration | X | X | | | X | X | | X | | | | | | | |

5.23.1.1.1.1 Effects of Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in February and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of riparian brush rabbit habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual riparian brush rabbits. Conversely, differences between the proposed action and WOA are large, with substantial reductions in flows in February, March, June and July, potentially causing drought stress in riparian or wetland vegetation, and increases in flows from August to October, which should allow for greater riparian growth than under WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.1.1.1.2 Spawning and Rearing Habitat

Gravel will be placed in-stream, therefore will not result in loss or disturbance of riparian brush rabbit habitat. Access to the enhancement site by vehicles, workers, and equipment may disturb habitat or disrupt normal behavioral patterns of riparian brush rabbits in the vicinity of the activity, in the absence of avoidance and minimization measures. BOR will implement AMM-RBR/RWR to completely avoid adverse effects on riparian brush rabbit from spawning adaptive management.

Enhancement of salmonid rearing habitat along the lower Stanislaus River may involve modification of river banks or creation of side channels in or near riparian habitat. This could result in loss of riparian brush rabbit habitat. In the absence of AMMs, this could also result in disruption of normal riparian brush rabbit behavioral patterns and injury or mortality of individuals through use of heavy equipment in occupied habitat. Reclamation will implement AMM-RBR/RWR however, to avoid occupied riparian brush rabbit habitat. Reclamation will remove no more than 10 acres of suitable but unoccupied riparian brush rabbit habitat.

5.23.1.2 Lower San Joaquin River Watershed

5.23.1.2.1 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of riparian brush rabbit habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual riparian brush rabbits. Conversely, differences between the proposed action and WOA are large, with flows in February and May-June in particular much lower than under WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.1.3 Lower San Joaquin Spawning and Rearing Habitat

5.23.1.3.1 Habitat Loss or Conversion

5.23.1.3.1.1 Permanent Habitat Loss

This proposed action component will involve a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. Levee construction could result in removal or conversion of riparian brush rabbit habitat. Levee construction may result in the permanent removal of approximately 45 acres of riparian habitat and 25 acres of associated grassland habitat for the riparian brush rabbit along the lower San Joaquin River. Reclamation will ensure that riparian brush rabbit habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian brush rabbit.

5.23.1.3.1.2 Temporary Habitat Loss

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of suitable riparian habitat and 20 acres of adjacent grassland habitat. Temporarily disturbed areas will be restored as riparian and grassland habitat within 1 year following completion of construction activities. Although the effects are considered temporary, several years may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. Most of the riparian vegetation within the species' range is early- to midsuccessional, and this species prefers riparian scrub that is early successional; therefore, the replaced riparian vegetation is expected to meet habitat requirements for the riparian brush rabbit within the first few years after the initial restoration activities are complete.

5.23.1.3.1.3 Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The potentially inundated areas may consist of suitable riparian brush rabbit habitat. Based on a hypothetical footprint of floodplain restoration used for BDCP, floodplain restoration will result in periodic inundation of approximately 265 acres of riparian habitat and 425 acres of associated grassland habitat for the riparian brush rabbit ([to be developed]). Although they consist of small patches and narrow bands of riparian vegetation, many of the areas potentially affected are in proximity to, or contiguous with, habitat with recorded occurrences of riparian brush rabbits. The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more). Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian brush rabbits occupy these areas and cannot escape flood waters.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian brush rabbit. This includes avoiding flooding in areas known to be occupied by riparian brush rabbit. The adverse effects of periodic inundation on the riparian brush rabbit in suitable habitat that may become occupied in the future will be further minimized through construction and maintenance of flood refugia to allow riparian brush rabbits to escape flood conditions through the creation of flood refugia mounds with thick cover vegetation and on the landward sides of the newly constructed levees (Kelly et al. 2011).

5.23.1.3.1.4 Construction-Related Effects

Construction-related effects on the riparian brush rabbit include construction-related injury or mortality and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities,

and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

5.23.1.3.1.5 Construction-Related Injury or Mortality

Reclamation will avoid disturbance of occupied riparian brush rabbit habitat and therefore will avoid construction-related injury or mortality of this species.

5.23.1.3.1.6 Construction-Related Effects on Adjacent Habitat

Construction of setback levees for floodplain restoration may result in noise and visual disturbance to the riparian brush rabbit. This effect will be avoided or minimized through establishment of nondisturbance buffers as described in AMM-RBR/RWR.

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect the riparian brush rabbit in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) under *AMM2 Construction Best Management Practices and Monitoring*.

5.23.2 Riparian Woodrat

The riparian woodrat occurs in the Stanislaus River and San Joaquin River watershed, and project components within these watersheds may affect this species as follows.

5.23.2.1 Stanislaus River Watershed

5.23.2.1.1 Spawning Adaptive Management

Gravel will be placed in-stream, therefore will not result in loss or disturbance of riparian woodrat habitat. Access to the enhancement site by vehicles, workers, and equipment may, however, disturb habitat or disrupt normal behavioral patterns of riparian woodrats in the vicinity of the activity, in the absence of avoidance and minimization measures. Reclamation will implement AMM-RBR/RWR, to completely avoid adverse effects on riparian woodrat from spawning adaptive management.

5.23.2.1.2 Rearing Adaptive Management

Enhancement of salmonid rearing habitat along the lower Stanislaus River may involve modification of river banks or creation of side channels in or near riparian habitat. This could result in loss of riparian woodrat habitat. In the absence of AMMs, this could also result in disruption of normal riparian woodrat behavioral patterns and injury or mortality of individuals through use of heavy equipment in occupied habitat. Reclamation will implement AMM-RBR/RWR, however, to avoid occupied riparian woodrat habitat. Reclamation will remove no more than 10 acres of suitable but unoccupied riparian woodrat habitat, and will offset this loss through restoration of suitable habitat or preservation of occupied habitat.

5.23.2.1.3 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between the proposed action and COS are negligible, on the order of a few percent increase in flow in February and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of riparian woodrat habitat in the Stanislaus watershed, and there is no apparent

mechanism by which these changes could result in harm to individual riparian woodrats. Conversely, differences between the proposed action and WOA, with flows in February, March, June and July much lower than flows under the WOA, and higher flows from August to October. However, existing vegetation has established in response to COS flows, and so while WOA would have increased riparian vegetation than today, the proposed action would not impact it as it does not exist. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.2.2 Lower San Joaquin River Watershed

5.23.2.2.1 Lower San Joaquin Spawning and Rearing Habitat (Steady Finance)

5.23.2.2.1.1 Habitat Loss or Conversion

5.23.2.2.1.1.1 Permanent Habitat Loss

This proposed action component will involve a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. Levee construction could result in removal or conversion of riparian woodrat habitat. Based on a hypothetical footprint developed for BDCP, levee construction may result in the permanent removal of approximately 41 acres of riparian woodrat habitat along the lower San Joaquin River. Reclamation will ensure that riparian woodrat habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

AMM-RBR-RWR requires avoidance of habitat occupied or assumed to be occupied by riparian woodrat.

5.23.2.2.1.1.2 Temporary Habitat Loss

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of suitable riparian woodrat habitat. Temporarily disturbed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, several years (10 - 20) may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected.

5.23.2.2.1.2 Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The potentially inundated areas may consist of suitable riparian woodrat habitat. Based on a hypothetical footprint of floodplain restoration used for BDCP, floodplain restoration will result in periodic inundation of approximately 200 acres of riparian woodrat habitat (Table 5-Terrestrial). The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more). Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian woodrats occupy these areas and cannot escape flood waters.

AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian woodrat. This includes avoiding flooding in areas known to be occupied by riparian woodrat. The adverse effects of periodic inundation on the riparian woodrat in suitable habitat that may become occupied in the future will be further minimized through construction and maintenance of flood refugia to allow riparian woodrats to escape flood conditions, with patches of riparian trees, as described in the Draft Habitat

Assessment Guidelines & Survey Protocol for the Riparian Brush Rabbit and the Riparian Woodrat (USFWS, available at <https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/>).

5.23.2.2.1.3 Construction-Related Effects

Construction-related effects on the riparian woodrat include construction-related injury or mortality and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

5.23.2.2.1.3.1 Construction-Related Injury or Mortality

Reclamation will avoid disturbance of occupied riparian woodrat habitat and therefore will avoid construction-related injury or mortality of this species.

5.23.2.2.1.3.2 Construction-Related Effects on Adjacent Habitat

Construction of setback levees for floodplain restoration may result in noise and visual disturbance to the riparian woodrat. This effect will be avoided or minimized through establishment of nondisturbance buffers as described in AMM-RBR-RWR.

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect the riparian woodrat in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) under *AMM2 Construction Best Management Practices and Monitoring*.

5.23.2.2.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of riparian woodrat habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual riparian woodrats. Conversely, differences between the proposed action and WOA are large, with much lower flows in February and May-June than WOA, and higher flows in the fall than WOA. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.3 Salt Marsh Harvest Mouse

The salt marsh harvest mouse occurs in Suisun Marsh, and the components of the proposed action that may affect this species are in the Bay-Delta watershed only.

5.23.3.1 *Bay-Delta Watershed*

Project components within the Bay-Delta watershed that could affect salt marsh harvest mouse are those occurring in Suisun Marsh. These include Suisun Marsh salinity control gates and Chipps Island restoration. Potential effects of each of these components on the salt marsh harvest mouse and the measures to avoid, minimize, or offset these effects are described below.

5.23.3.1.1 Suisun Marsh Salinity Control Gates

Under the proposed action the Suisun Marsh Salinity Control Gates (SMSCG) will be operated between June and September for no more than 60 days in above-normal and below-normal Sacramento Valley Index year types. The gates would be operated to minimize seawater intrusion into Montezuma Slough and decrease salinities overall to expand the extent of suitable habitat for Delta smelt. Other than this proposed change in SMSCG operations, gate operations would be unchanged from current conditions and salinities will not be substantially changed.

UnTRIM modeling of the proposed operation of the SMSCG found salinity decreases up to 2 PSU in Montezuma Slough in August and September in dry and below-normal water years (GEI 2018). Because of the limited temporal scale of the proposed action (60 days), the limited temporal overlap between the proposed action and the typical flooding regime for diked wetlands, the variability of existing salinities as well as the variability created between years when the proposed action is implemented and years when it is not; the salinity variability in the winter and spring (when there are no effects from the proposed action but when diked wetland flooding occurs), and the requirements to maintain adherence with RWQCB water quality requirements, the effects from SMSCG operations are presumed insignificant to the vegetation community. Thus, effects on the salt marsh harvest mouse are also considered insignificant. That is, effects to the vegetation community as a result of reduced salinities by no more than 2% in above-normal and below normal water years are not expected to affect salt marsh harvest mouse habitat to the extent that take would occur.

5.23.3.1.1.1 Tidal Habitat Restoration

The USFWS, in their 2008 biological opinion, required Reclamation to “to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh” to address adverse impacts on Delta smelt and its habitat. DWR has since been performing this action at a variety of restoration sites (Table 5.23-2). None of these projects has yet been certified by USFWS as meeting any portion of the 8,000 acre requirement, but the total acreage of the projects shown in Table 5-DSHR is 12,309 acres, and DWR staff, based on site-specific consultations with USFWS completed to date, consider it likely that completion of these restoration projects will provide mitigation acreages sufficient to fulfill the USFWS habitat creation requirement. As shown in Table 5.23-2, only a subset of these projects are included in the proposed action; the remainder have either completed ESA consultation and are being implemented pursuant to the terms and conditions of a project-specific biological opinion, or are being separately consulted under a lead agency other than Reclamation, and will be transferred to DWR ownership following completion of the restoration work.

Table 5.23-2. DWR Tidal Restoration Projects to secure Compliance with the 2008 USFWS Requirement for 8,000 Acres of Delta Smelt Habitat

| Project | Status | Approx. Acres (4) | In Proposed Action |
|-------------------|-----------------|--------------------------|---------------------------|
| Decker Island | Done | 140 | No (1) |
| Lindsey Slough | Done | 0 | No (3) |
| Yolo Flyway Farms | Done | 300 | No (1) |
| Dutch Slough | In construction | 660 | Yes (6) |

| Project | Status | Approx. Acres (4) | In Proposed Action |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------|---------------------------|
| Tule Red | In construction | 610 | No (1) |
| Winter Island | 2019 construction | 553 | Yes |
| Hill Slough | 2019 construction | 750 | Yes (5) |
| Arnold Slough / Bradmoor Island | 2019 construction | 659 | Yes |
| Chipps Island | 2021 construction | 807 | Yes |
| Lookout Slough | 2022 construction | 3000 | No (2) |
| Lower Yolo Ranch | Planning | 1600 | Yes |
| Prospect Island | 2020 construction | 1360 | No (1) |
| Wings Landing | 2020 construction | 190 | No (2) |
| Unnamed private project | 2020 construction | 1680 | No (2) |
| TOTAL ACRES | | 12309 | |
| TOTAL ACRES UNDER proposed action | | [waiting on Reclamation] | |
| <p>Sources for this table: EcoRestore fact sheets (DWR 2019), email from Gardner Jones (DWR), emails from Catherine McCalvin (DWR).</p> <p>Notes</p> <p>(1) A biological opinion has been issued for this project.</p> <p>(2) This project is being undertaken by a private party, and lead agency is note Reclamation (DWR will assume ownership after site is constructed).</p> <p>1. (3) Project presumably re ceived a biological opinion, but primarily restored freshwater and alkali wetlands, although it did include a tidal slough. Acreage of slough not stated in documentation at http://resources.ca.gov/docs/ecorestore/projects/Lindsey_Slough.pdf</p> <p>2. (4) None of these projects have yet been certified by USFWS as counting towards the 8,000 acre requirement; acres shown are therefore approximate, representing a DWR estimate of what will be qualifying acreages.</p> <p>3. (5) A biological assessment has been submitted but a biological opinion has not yet been received.</p> <p>4. (6) Project is in construction, therefore ESA compliance is assumed, but not confirmed.</p> | | | |

5.23.3.1.1.2 Habitat Conversion

The component projects and approach used in Tidal Habitat Restoration have been described previously. Tidal Habitat Restoration at sites named in Table 5.23-2 that are part of the proposed action could affect salt marsh harvest mouse via direct effects of construction, or through conversion of habitat, as described below. Take of salt marsh harvest mouse resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled salt marsh harvest mouse habitat at these three sites are shown in Table 5.23-3. Models used to identify habitat for the salt marsh harvest mouse are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-3. Expected Impacts on modeled Salt Marsh Harvest Mouse Habitat from Tidal Habitat Restoration

| Habitat_Type | Restoration Site (acres) | | | |
|---------------------------------------------|---------------------------------|---------------|-------------|--------------|
| | Arnold Slough / Bradmoor Island | Chipps Island | Hill Slough | Total |
| Managed Wetland - Upland | 3 | 0 | 15 | 18 |
| Managed Wetland - Primary | 68 | 41 | 98 | 207 |
| Managed Wetland - Secondary | 133 | 171 | 53 | 357 |
| Tidal Brackish Emergent Wetland - Primary | 25 | 123 | 524 | 672 |
| Tidal Brackish Emergent Wetland - Secondary | 26 | 307 | 14 | 346.49 |
| Upland Secondary | 24 | 0 | 141 | 165 |
| TOTAL | 276 | 642 | 830 | 1,748 |

The effects on habitat will include the conversion of primary mid- and high-marsh habitat types to secondary low-marsh types; the conversion of secondary, low-marsh habitat to subtidal habitat; and the conversion of upland refugia habitat to tidal habitat. While it is expected that primary and secondary salt marsh harvest mouse habitat will persist after restoration of tidal action, the extent of primary habitat types (mid- and high-marsh) is expected to decrease in the near-term. In the longer-term, and with the implementation of remedial measures and adaptive management, the extent of primary habitat is expected to expand. The extent of primary habitat may not expand to pre-restoration conditions, although the habitat will be more resilient to climate change because tidal habitat has potential to accrete sediment to keep up with sea level rise whereas diked wetlands do not. Sea level rise is one of the primary threats to the Suisun Marsh salt marsh harvest mouse (USFWS 2013b). Most occupied habitat in Suisun Marsh is diked and subsided and therefore vulnerable to catastrophic loss as a result of levee failure; and levees are more likely to fail as sea levels rise (USFWS 2013b). Consistent with the Suisun Marsh Plan Biological

Opinion (USFWS 2013a), the creation of more resilient tidal wetland salt marsh harvest mouse habitat will compensate for the loss of diked wetland habitat.

5.23.3.1.1.3 Construction-Related Effects

Tidal Habitat Restoration may include excavation of levees, construction of tidal control gates, movement and staging of large construction equipment, piling and storage of soils, dredging, and filling and grading of vegetated areas. The operation of equipment for construction could result in injury or mortality of salt marsh harvest mice, if present. Only nonmechanized equipment will be used to remove vegetation in salt marsh harvest mouse habitat. Restrictions on the use of mechanized equipment, biological construction monitoring, and other measures will be implemented to ensure that salt marsh harvest mice occupying the construction area will be able to leave and escape to suitable adjacent habitat. Any vegetation removed will be done under supervision of a CDFW- and USFWS-approved biological monitor familiar with salt marsh harvest mouse. Temporary exclusion fences will be installed to ensure that mice do not reenter work areas during construction.

5.23.3.1.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the proposed action would maintain conditions similar to current, while under the WOA scenario DWR would cease operations of the Suisun Marsh Salinity Control Gates. The proposed action maintains a more constant salinity regime within the Marsh than would exist under WOA. Changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm the salt marsh harvest mouse.

In the Bay and in the lower Delta (the only portion of the Delta occupied by salt marsh harvest mouse), differences between proposed action and COS are negligible, on the order of a few percent change in flows at various times of the year. Changes at this scale are unlikely to produce any measurable change in quantity or quality of salt marsh harvest mouse habitat in the Delta, and there is no apparent mechanism by which these changes could result in harm to individual salt marsh harvest mice. Conversely, differences between the proposed action and WOA are large, with decreased flows in all months except September, and January through March flows under WOA exceeding flows in any month under PA or COS. The flow increases under WOA could result in flooding and erosion at any restoration sites or residual habitat for salt marsh harvest mice in the Bay-Delta, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.4 California Ridgway's Rail

The components of the proposed action that may affect this species are only in the Bay-Delta watershed.

5.23.4.1 *Bay-Delta Watershed*

Project components within the Bay-Delta watershed that could affect California Ridgway's rail are those occurring in Suisun Marsh. These include Suisun Marsh salinity control gates, and potentially tidal restoration. Potential effects of each of these components on California Ridgway's rail and the measures to avoid, minimize, or offset these effects are described below.

5.23.4.1.1 Suisun Marsh Salinity Control Gates

As described above for salt marsh harvest mouse, SMSCG operation is not expected to modify the vegetation communities in Suisun Marsh, therefore this project component is not expected to adversely affect California Ridgway's rail habitat to the extent that take would occur.

5.23.4.1.2 Tidal Habitat Restoration

The component projects and approach have been described previously. The sites named in Table 5.23-2 that are part of the proposed action are outside the range of California Ridgway's rail, but it is near the range boundary for the species. Delta Smelt habitat could provide habitat where the species' range could expand, which would be a beneficial effect.

5.23.4.1.3 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of Ridgway's rail habitat unsuitable, while creating new areas of suitable habitat. To the extent that the Ridgway's rail could not migrate to accommodate these habitat changes, or was adversely affected by short-term losses in suitable habitat, mortality would result. Conversely, as described above in Section 5.24.3.1.1 *Suisun Marsh Salinity Control Gates*, changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm the Ridgway's rail.

In the Bay, differences between the proposed action and COS are negligible, on the order of a few percent change in flows at various times of the year. Changes at this scale are unlikely to produce any measurable change in quantity or quality of Ridgway's rail habitat in the Bay, and there is no apparent mechanism by which these changes could result in harm to individual Ridgway's rail. Conversely, differences between WOA and the PA are large, with increased flows in all months except September, and January through March exceeding flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for Ridgway's rail in the Bay, resulting in degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5 Least Bell's Vireo

Watersheds with project components that may affect suitable least Bell's vireo habitat within the species' range include Upper Sacramento River watershed, Stanislaus River watershed, Lower San Joaquin River watershed, as well as Delta watershed with migratory stopover habitat. Applicable components are described below for each watershed.

5.23.5.1 *Upper Sacramento River Watershed*

The only Upper Sacramento River Watershed project components within the range of least Bell's vireo that may affect the species are *Colusa Basin Drain*. Effects of these components on least Bell's vireo are described below.

5.23.5.1.1 Colusa Basin Drain Food Web Routing

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass which is in a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels. Flows are proposed in July, August and/or September for approximately 4 weeks, which would coincide with June through mid-September nesting although no adverse effects to individuals or habitat are anticipated.

5.23.5.1.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of least Bell's vireo habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual least Bell's vireos. Conversely, differences between the proposed action and WOA are large, with flows in February and March in WOA exceeding flows in any month under PA or COS, and very low flows in WOA from July to September, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireos in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5.2 *Stanislaus River Watershed*

Stanislaus River Watershed project components within the small disjunct mapped range of least Bell's vireo include Spawning and Rearing Habitat Named Projects, Spawning Adaptive Management and Rearing Adaptive Management. Although no current occurrences of this species are known in the watershed the effects of these components on least Bell's vireo are described below.

5.23.5.2.1 Spawning and Rearing Habitat

Gravel will be placed in-stream, therefore will not result in loss or disturbance of least Bell's vireo habitat. Access to the enhancement site by vehicles, workers, and equipment may, however, disturb habitat or disrupt normal behavioral patterns of least Bell's vireo in the vicinity of the activity, in the absence of project component specific avoidance and minimization measures. Reclamation will implement AMM-LBV to completely avoid adverse effects on least Bell's vireo from spawning and rearing habitat restoration. Rearing habitat creation will be outside the range of least Bell's vireo.

5.23.5.2.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between proposed action and COS are negligible, on the order of a few percent increase in flow in February and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of least Bell's vireo habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual least Bell's vireos. Conversely, differences between the proposed action and WOA are large, with flows in February, March, June and July under WOA exceeding flows in any month under PA or COS, and very low flows from August to October, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireo in the Stanislaus watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.5.3 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the small disjunct mapped range of least Bell's vireo include Lower San Joaquin Spawning and Rearing Habitat. Effects of this component on least Bell's vireo are described below.

5.23.5.3.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.5.3.1.1 Habitat Loss or Conversion

Levee construction could result in removal or conversion of least Bell's vireo habitat. Based on a hypothetical footprint developed for BDCP, levee construction may result in the permanent removal of approximately 28 acres of least Bell's vireo habitat along the lower San Joaquin River. Although habitat consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River. Although much of this component would occur north of San Joaquin River portion of mapped range of least Bell's vireo, the southern extent could be as close as 5 miles from least Bell's vireo breeding occurrences from 2005-2007. Reclamation will ensure that least Bell's vireo habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

Under AMM-LBV, injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of 500-foot no-disturbance buffers around active nests.

5.23.5.3.1.2 Construction-Related Effects

Although least Bell's vireo nesting has not been observed in recent years in the disjunct San Joaquin River portion of mapped range, occurrences suggest that the reestablishment of a breeding population is a possibility in this area. If the least Bell's vireo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-LBV, injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of 500-foot no-disturbance buffers around active nests, as described in AMM-LBV.

Construction activities may create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, BOR will reduce noise in the vicinity of least Bell's vireo habitat as described in AMM-LBV. This will include surveying for least Bell's vireos within the 60 dBA noise contour around the construction footprint, and if a least Bell's vireo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area.

Night lighting may also have the potential to affect least Bell's vireos. While there is no data on effects of night lighting on this species, studies show that other bird species are attracted to artificial lights and this may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, BOR will screen all lights and direct them away from habitat as described in AMM-LBV. With this measure in effect, and given that least Bell's vireos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

5.23.5.3.1.3 Inundation

Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to inundate an estimated 148 acres of least Bell's vireo habitat. The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of floodplain restoration is not expected to adversely affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when the vireo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species.

5.23.5.3.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of least Bell's vireo habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual least Bell's vireos. Conversely, differences between proposed action and WOA are large, with flows in February and May-June under WOA that exceed flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for least Bell's vireo in the lower San Joaquin watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6 Western Yellow-Billed Cuckoo

5.23.6.1 *Upper Sacramento River Watershed*

Upper Sacramento River Watershed project components within the mapped range of western yellow-billed cuckoo include Spawning and Rearing Named Projects, Colusa Basin Drain Food Web Routing. Implementation of AMM-WYBC will result in avoidance of effects on western yellow-billed cuckoo. Effects from the remaining project components are described below.

5.23.6.1.1 Spawning and Rearing Named Projects

5.23.6.1.1.1 Permanent Habitat Loss or Conversion

Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. The majority of the proposed projects are north of Red Bluff, California, where no occurrences of this species have been reported. However, the southernmost two proposed projects (La Barranca and Woodson Bridge Bank Rearing Improvement) are south of Red Bluff and overlap with a 2013 occurrence and 1988 occurrence, respectively. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM22, up to 58 acres of western yellow-billed cuckoo habitat may be removed.

5.23.6.1.1.2 Construction-Related Effects

Although the majority of sites are far from known western yellow-billed cuckoo occurrences, the recent observation identified above suggest that western yellow-billed cuckoos may nest in the area. If the western yellow-billed cuckoo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-WYBC, injury or mortality to nesting western yellow-billed cuckoos will be avoided through preconstruction surveys and establishment of a 500-foot no-disturbance buffers around active nests, as described in AMM-WYBC. Construction activities may create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, Reclamation will reduce noise in the vicinity of western yellow-billed cuckoo habitat as described in AMM-WYBC. This will include surveying for western yellow-billed cuckoos within the 60 dBA noise contour around the construction footprint, and if a western yellow-billed cuckoo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area.

Night lighting may also have the potential to affect western yellow-billed cuckoos. While there is no data on effects of night lighting on this species, studies show that other bird species are attracted to artificial lights and this may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, Reclamation will screen all lights and direct them away from habitat as described in AMM-WYBC. With this measure in effect, and given that western yellow-billed cuckoos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

5.23.6.1.1.3 Colusa Basin Drain Food Web Routing

5.23.6.1.1.3.1 Inundation Effects

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass which includes a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels and are unlikely to reach 3 feet above the ground where effects on cuckoo are possible. Flows are proposed in July, August and/or September for approximately 4 weeks, which would coincide with June through mid-September nesting although no adverse effects to individuals or habitat are anticipated.

5.23.6.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February and March under WOA exceeding flows in any month under PA or COS, and very low flows from July to September in WOA, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoos in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.3 American River Watershed

Project components in the American River Watershed that may affect western yellow-billed cuckoo include Spawning and Rearing Named Projects and Rearing Adaptive Management. Nimbus Hatchery Physical and Operational Improvements will avoid disturbance of western yellow-billed cuckoo habitat as described in AMM-WYBCC.

5.23.6.3.1 Spawning and Rearing Habitat

5.23.6.3.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of western yellow-billed cuckoo habitat, consistent with AMM-WYBC. Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-WBYC, up to four acres of riparian habitat may be removed.

5.23.6.3.1.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the American River watershed, differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in December, February and March, a few percent increase in July and September. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the

American River watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February, March, and April under WOA exceeding flows in any month under PA or COS, and very low flows from July to October under WOA, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoos in the American River watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.4 Stanislaus River Watershed

5.23.6.4.1 Spawning and Rearing Habitat Named Projects

Creation of spawning habitat will avoid disturbance of western yellow-billed cuckoo habitat, consistent with AMM-WYBC. Creation of side channels will require removal of riparian habitat within the range of western yellow-billed cuckoo. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-WYBC, up to 43 acres of riparian habitat may be removed.

5.23.6.4.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Stanislaus watershed, differences between proposed action and COS are negligible, on the order of a few percent decrease in flow in February and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of western yellow-billed cuckoo habitat in the Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February, March, June and July under WOA exceeding flows in any month under PA or COS, and very low flows from August to October in WOA, potentially causing drought stress in riparian or wetland vegetation. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoo in the Stanislaus watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.6.5 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the range of western yellow-billed cuckoo include Lower San Joaquin Spawning and Rearing Habitat. Effects of this component on western yellow-billed cuckoo are described below.

5.23.6.5.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.6.5.1.1 Habitat Loss or Conversion

Levee construction associated with floodplain restoration will result in the permanent removal of up to an estimated 11 acres of western yellow-billed cuckoo habitat. This habitat is of moderate value: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing conservation lands. Because the estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, actual habitat loss is expected to be lower because sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

5.23.6.5.1.1.1 Construction-Related Effects

If the western yellow-billed cuckoo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM-WYBC, injury or mortality to nesting western yellow-billed cuckoos will be avoided.

5.23.6.5.1.2 Inundation

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 70 acres of habitat for the western yellow-billed cuckoo. The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the yellow-billed cuckoo because flooding is unlikely to occur during the breeding season when the cuckoo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species.

5.23.6.5.2 Proposed Flow Changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the lower San Joaquin watershed, differences between the proposed action and COS are almost nonexistent and have no potential to produce any change in quantity or quality of western yellow-billed cuckoo habitat in the lower San Joaquin watershed. There is also no risk that these changes could result in harm to individual western yellow-billed cuckoos. Conversely, differences between the proposed action and WOA are large, with flows in February and May-June under WOA that exceed flows in any month under PA or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for western yellow-billed cuckoo in the lower San Joaquin watershed, resulting in degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has lower flows in the spring and maintains current general flow regimes.

5.23.7 Giant Garter Snake

Based on the 2017 Recovery Plan (USFWS 2017) the current range of the giant garter snake encompasses nine separate populations associated with distinct watershed basins. Known giant garter snake populations and corresponding recovery units that overlap with proposed action components include the Butte Basin,

Sutter Basin, Colusa Basin, Yolo Basin, and Delta Basin populations. Components of the proposed action that may affect this species are in the Upper Sacramento River watershed and the Bay-Delta watershed only.

5.23.7.1 *Upper Sacramento River Watershed*

Upper Sacramento River Watershed project components within the range of giant garter snake include Spawning and Rearing Named Projects, Colusa Basin Drain Food Web Routing. Projects within Sacramento River and on its banks, however, are not expected to affect giant garter snake habitat. This species does not typically occupy large rivers. Therefore, project components described below do not include Spawning and Rearing Named Projects or Sacramento Weir, as these components occur along the Sacramento River.

Effects from each of these components are described below.

5.23.7.1.1 Colusa Basin Drain Food Web Routing

5.23.7.1.1.1 Permanent Habitat Loss or Conversion

The diversion of approximately 24,000 AF of agricultural water over a 4-week period (during July, August, and/or September) from Colusa Basin into Yolo Bypass rather than outfalling into the Sacramento River would not result in adverse effects on giant garter snake because the Sacramento River does not support suitable aquatic habitat for this species. Increasing flows into the Yolo Bypass during late summer would be expected to increase surface water and improve habitat conditions for giant garter snake in the Yolo Bypass. Therefore, Food Web Routing would have a beneficial effect on giant garter snake.

5.23.7.1.2 Proposed flow changes

See the discussion of flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the upper Sacramento watershed, differences between the proposed action and COS are negligible, on the order of a few percent increase in flow in November and a few percent decrease in May and June. These changes are unlikely to produce any measurable change in quantity or quality of giant garter snake habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual giant garter snakes. Conversely, differences between WOA and the PA are large, with flows in February and March exceeding flows in any month under PA or COS, and very low flows from July to September, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for giant garter snakes in the upper Sacramento watershed, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action does not have these impacts, as it has higher flows in the fall and maintains current vegetation. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.7.2 *Bay-Delta Watershed*

5.23.7.2.1 Delta Cross Channel Improvements

Delta Cross Channel Improvements involves modernizing Delta Cross Channel gates. Potentially suitable giant garter snake habitat is present in the vicinity of these gates. Assuming disturbance will occur within a 25-foot radius around the existing gates, Delta Cross Channel Improvements could result in loss of up to 0.2 acre of upland and .4 acre of aquatic habitat for giant garter snake.

5.23.7.2.2 Tidal Habitat Restoration

5.23.7.2.2.1 Habitat Conversion

The component projects and approach were described previously. Habitat Restoration at two of the sites named in Table 5-.23-2 that are part of the proposed action could affect giant garter snake via direct effects of construction, or through conversion of habitat, as described below. Take of giant garter snake resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled giant garter snake habitat at these three sites are shown in Table 5-5.23-4. Models used to identify habitat for the giant garter snake are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-4. Expected Impacts on Modeled Giant Garter Snake Habitat from Tidal Habitat Restoration

| Habitat_Type | Restoration Site (acres) | | |
|------------------|--------------------------|------------------|-------|
| | Dutch Slough | Lower Yolo Ranch | Total |
| Aquatic-Nontidal | 37 | 8 | 45 |
| Aquatic-Tidal | 17 | 45 | 62 |
| Upland | 279 | 368 | 647 |
| TOTAL | 333 | 421 | 754 |

Tidal Habitat Restoration at each site would be achieved by conversion of currently leveed, cultivated land through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Where appropriate, portions of restoration sites will be raised to elevations that will support tidal marsh vegetation following levee breaching. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing clean dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will create a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to establish and maintain itself naturally at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces.

Permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches are modified and flooded as part of the tidal habitat restoration process, or as part of the channel margin restoration process in projects that entail levee setback. The conversion of rice to tidal habitat would be a

permanent loss, however, rice is not common in the areas where tidal restoration and channel margin restoration would likely be sited. Other aquatic features that have potential to occur on restoration sites include natural channels and topographic depressions. Tidal aquatic edge habitat where open water meets the levee edge will also be permanently lost in those reaches where the levee is breached. Temporary effects on aquatic edge habitat are also likely to occur during the time of construction, though these effects would not be expected to last more than 2 years. Permanent effects on upland habitat will primarily occur where upland habitat is removed to create tidal connectivity.

5.23.7.2.2.2 Construction Related Effects

The operation of equipment for land clearing and restoration could result in injury or mortality of giant garter snakes. This risk is highest from late fall through early spring, when the snakes are dormant. Increased vehicular traffic associated with construction activities could contribute to a higher incidence of road kill. However, construction monitoring and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in AMM-GSS. Noise and visual disturbance outside the project footprint but within 200 feet of construction activities could temporarily affect the use adjacent habitat. These effects will be minimized by siting construction 200 feet away from the banks of giant garter snake aquatic habitat, where feasible, as described in AMM-GSS.

5.23.7.2.3 Proposed Flow Changes

See Section 5.24.1.1.3.1 *General Discussion of Flow Change Effects* for a statement of the methods and approach used to assess proposed flow change effects on covered species. In the Bay-Delta watershed, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of giant garter snake habitat unsuitable, while creating new areas of suitable habitat. To the extent that the giant garter snake could not migrate to accommodate these habitat changes, or was adversely affected by short-term losses in suitable habitat, mortality would result, possibly with long-term effects on genetic diversity and population structure. Conversely, as described previously, changes under the proposed action scenario would be negligible relative to COS, with little potential for the proposed action to modify habitat or otherwise harm the giant garter snake.

In the Delta, differences between COS and the proposed action are negligible, on the order of a few percent change in flows at various times of the year. Changes at this scale are unlikely to produce any measurable change in quantity or quality of giant garter snake habitat in the Delta, and there is no apparent mechanism by which these changes could result in harm to individual giant garter snake. Conversely, differences between WOA and the PA are large, with increased flows in all months except September, and January through March exceeding flows in any month under the proposed action or COS. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for giant garter snakes in the Delta, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.8 Valley Elderberry Longhorn Beetle

5.23.8.1 *Upper Sacramento River Watershed*

All Upper Sacramento River watershed project components that result in habitat disturbance are within the range of valley elderberry longhorn beetle. Effects of the remaining components are described for each relevant component below.

5.23.8.1.1 Colusa Basin Drain Food Web Routing

High water levels (flows of 200 to 500 cubic cfs) are proposed to pass through the Yolo Bypass which is in a disjunct portion of the current range for this species. The proposed flows will not exceed local flooding levels. Flows are proposed in July, August and/or September for approximately 4 weeks, which would potentially adversely affect valley elderberry shrubs, although the extent to which these effects might occur is uncertain.

5.23.8.1.1.1 Spawning and Rearing Habitat Restoration

5.23.8.1.1.1.1 Permanent Habitat Loss or Conversion

During placement of gravel and other measures to enhance spawning habitat, Reclamation will avoid disturbance of elderberry shrubs consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle, and although Reclamation will minimize disturbance associated with this activity, they may remove up to an estimated 58 acres of riparian habitat that could include elderberry shrubs supporting valley elderberry longhorn beetle. Assuming an estimated average of 0.9 shrubs per acre (from BDCP, Appendix 6B), rearing habitat restoration could result in removal of up to 52 elderberry shrubs. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017).

5.23.8.1.1.1.2 Construction-Related Effects

Habitat restoration may include use of heavy equipment for ground clearing, grading, excavation, and placement of gravel or habitat structures. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described AMM-VELB.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th to June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in AMM-VELB.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). However, one study indicated that dust deposition was not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), although dust was weakly correlated with elderberry stress symptoms (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas that will occur within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles may result in deposition of particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. The results of a study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Eisenbeis 2006). No restoration activity will occur during nighttime hours in the vicinity of habitat for federally listed species.

5.23.8.2 Proposed flow changes

See the previous discussion regarding flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. Differences between the proposed action and COS are negligible, on the order of a few percent decrease in flow in November and a few percent increase in May and June. These changes are unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the upper Sacramento watershed, and there is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles. Conversely, differences between WOA and the PA are large, with flows in spring exceeding flows under PA or COS, and very low flows in the summer, which could very likely cause drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability. The flow increases could result in flooding and erosion at any restoration sites or residual habitat for valley elderberry longhorn beetles, resulting in a substantial degradation in quality and possible loss of existing habitat, with potential for mortality of individual animals in response to flooding or loss of foraging resources. The proposed action would provide benefits as compared to the Without Action by increasing fall flows, avoiding drought stress in riparian or wetland vegetation that depended upon flow to maintain soil water availability, and by keeping more constant spring flows, avoiding erosion at restoration sites.

5.23.8.3 American River Watershed

All American River watershed project components that result in habitat disturbance are within the range of valley elderberry longhorn beetle. Effects from other components are described below.

5.23.8.3.1 Spawning and Rearing Habitat Restoration

5.23.8.3.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-VELB, up to four acres of riparian habitat may be removed (approximately 3 to 4 elderberry shrubs). Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017), or through mitigation.

5.23.8.3.1.2 Construction-Related Effects

Construction-related effects associated with Spawning and Rearing Named Projects in the American River Watershed are as described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

5.23.8.4 Stanislaus River Watershed

5.23.8.4.1 Spawning and Rearing Habitat Named Projects

5.23.8.4.1.1 Permanent Habitat Loss or Conversion

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB. Creation of side channels will require removal of riparian habitat within the range of valley elderberry longhorn beetle. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM-VELB, up to 43 acres of riparian habitat may be removed. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation, consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017), or through mitigation.

5.23.8.4.1.2 Construction-Related Effects

Construction-related effects associated with Spawning and Rearing Named Projects in the Stanislaus River Watershed are as described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

5.23.8.5 Lower San Joaquin River Watershed

Lower San Joaquin River Watershed project components within the range of valley elderberry longhorn beetle include Lower San Joaquin Spawning and Rearing Habitat Restoration. Effects of this component on valley elderberry longhorn beetle are described below.

5.23.8.5.1 Lower San Joaquin Spawning and Rearing Habitat

5.23.8.5.1.1 Habitat Loss or Conversion

Levee construction associated with floodplain restoration will result in the permanent removal of up to an estimated 52 acres of valley elderberry longhorn beetle habitat (an estimated 47 shrubs). Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017).

5.23.8.5.1.2 Construction-Related Effects

Construction-related effects associated with *Lower San Joaquin Spawning Adaptive Management* are as described above for *Spawning and Rearing Named Projects* in the Upper Sacramento River Watershed.

5.23.8.5.1.3 Inundation

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 226 acres of riparian habitat for the valley elderberry longhorn beetle. The area to be inundated will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10

years or more). While elderberry shrubs are not expected to be sustained in the lower elevation areas that frequently flood, the higher floodplain is expected to remain as high-value habitat for the species.

5.23.8.6 Bay-Delta Watershed

5.23.8.6.1 Tidal Habitat Restoration

5.23.8.6.1.1 Habitat Conversion

The component projects and approach used in Tidal Habitat Restoration have been described previously. Tidal Habitat Restoration at four of the sites named in Table 5.23-2 that are part of the proposed action could affect Valley elderberry longhorn beetle via direct effects of construction, or through conversion of habitat, as described below. Take of Valley elderberry longhorn beetle resulting from restoration at these sites will not be authorized through the biological opinion for this project, and will require separate consultation. Acreages of impact to modeled Valley elderberry longhorn beetle habitat at these three sites are shown in Table 5.23-5. Models used to identify habitat for the valley elderberry longhorn beetle are described in the Draft BDCP (DWR and Reclamation 2013, Appendix 2.A).

Table 5.23-5. Expected Impacts on Modeled Valley Elderberry Longhorn Beetle Habitat from Tidal Habitat Restoration

| Habitat Type | Restoration Site | | | | |
|----------------------------|------------------|-------------|------------------|---------------|-------|
| | Dutch Slough | Hill Slough | Lower Yolo Ranch | Winter Island | Total |
| Habitat (acres) | 29 | 0 | 56 | 3 | 88 |
| Estimated number of shrubs | 26 | 0 | 50 | 3 | 79 |

Levee breaches performed during tidal wetland restoration will require removal of riparian and contiguous grassland habitat within the range of valley elderberry longhorn beetle. The number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in AMM-VELB. Reclamation will offset adverse effects on elderberry shrubs through transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (USFWS 2017c).

5.23.8.6.1.2 Construction Related Effects

Tidal Habitat Restoration may include use of heavy equipment for ground clearing, grading, excavation, and placement of large wood. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in AMM-VELB.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th and June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in AMM-VELB.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). Dust deposition is not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), but it is weakly correlated with signs of stress in elderberry plants (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles might deposit particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. A study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Eisenbeis 2006). No restoration activity will occur during nighttime hours in the vicinity of habitat for federally listed species.

5.23.9 Soft Bird's-Beak and Suisun Thistle

5.23.9.1 *Bay-Delta*

5.23.9.1.1 Bay-Delta Watershed

Project components that could affect these species include Suisun Marsh salinity control gates and Chipps Island restoration. Potential effects of each of these components on soft bird's-beak and Suisun thistle and the measures to avoid, minimize, or offset these effects are described below.

5.23.9.1.2 Suisun Marsh Salinity Control Gates

Under the proposed action the Suisun Marsh Salinity Control Gates (SMSCG) will be operated between June and September for no more than 60 days in above-normal and below-normal Sacramento Valley Index year types. The gates would be operated to minimize seawater intrusion into Montezuma Slough and decrease salinities overall to expand the extent of suitable habitat for Delta smelt. Other than this proposed change in SMSCG operations, gate operations would be unchanged from current conditions and salinities will not be substantially changed.

UnTRIM modeling of the proposed operation of the SMSCG found salinity decreases up to 2 PSU in Montezuma Slough in August and September in dry and below-normal water years (GEI 2018). Because of the limited temporal scale of the proposed action (60 days), the limited temporal overlap between the proposed action and the typical flooding regime for diked wetlands, the variability of existing salinities as well as the variability created between years when the proposed action is implemented and years when it is not; the salinity variability in the winter and spring (when there are no effects from the proposed action but when diked wetland flooding occurs), and the requirements to maintain adherence with RWQCB water quality requirements, the effects from SMSCG operations would reduce salinities by no more than 2% in above-normal and below normal water years. Because salinity levels of the habitat in which soft bird's-beak or Suisun thistle would not be substantially altered, the proposed operation of the SMSCG would not be likely to affect either species.

5.23.9.1.3 Tidal Habitat Restoration

The proposed action will convert the 450-acres of nontidal wetlands in the northern property to tidal action and may implement enhancement actions on the 250-acre southeastern parcel that is currently exposed to muted tidal action. Chipps Island occurs within the range of soft bird's-beak. However, neither soft bird's-beak nor Suisun thistle occur on Chipps Island. Therefore, habitat restoration at Chipps Island would not affect either soft bird's-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird's-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.4 Bradmoor Island Habitat Restoration

The proposed action will restore tidal inundation to approximately 500 acres of managed wetlands and enhance and protect another 115 acres of existing tidal habitat. Bradmoor Island occurs within the range of soft bird's-beak. However, neither soft bird's-beak nor Suisun thistle occur on Bradmoor Island. Therefore, habitat restoration at Bradmoor Island would not affect either soft bird's-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird's-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.5 Dutch Slough Habitat Restoration

The proposed action will restore 1,187 acres of Delta habitats on three leveed parcels adjacent to Dutch Slough. This area is outside of the ranges for Soft bird's-beak and Suisun thistle, and the proposed action would not affect either soft bird's-beak or Suisun thistle.

5.23.9.1.6 Hill Slough Habitat Restoration

The proposed action will restore tidal marsh on 750 acres of managed wetlands and enhance 200 acres of upland managed wildlife habitat. This area is within the range of both Soft bird's-beak and Suisun thistle, although neither species is known to occur within the action area. The proposed action is not likely to directly affect either species. However, restoration of tidal habitat at this site potentially could provide habitat into which soft bird's-beak or Suisun thistle could spread or where the species could be introduced, which would be a beneficial effect.

5.23.9.1.7 Lower Yolo Ranch Habitat Restoration

The proposed action will restore about 1,670 acres of tidal wetlands on a site which has historically been used for cattle grazing. This area is outside of the ranges for Soft bird's-beak and Suisun thistle, and the proposed action would not affect either soft bird's-beak or Suisun thistle.

5.23.9.1.8 Winter Island Habitat Restoration

The proposed action will restore tidal action on 589 acres of habitat on Winter Island. Winter Island occurs within the range of soft bird's-beak. However, neither soft bird's-beak nor Suisun thistle occur on Winter Island. Therefore, habitat restoration at Winter Island would not affect either soft bird's-beak or Suisun thistle. Restoration of tidal habitat at this site potentially could provide habitat where soft bird's-beak or Suisun thistle could be introduced, which would be a beneficial effect.

5.23.9.1.9 Proposed Flow Changes

See the previous discussion regarding flow change effects for a statement of the methods and approach used to assess proposed flow change effects on covered species. In Suisun Marsh, the methodology must be altered somewhat to reflect the complex effects of flow manipulation in the Delta and Suisun Marsh. In Suisun Marsh, the WOA scenario would cease operations of the Suisun Marsh Salinity Control Gates. This would lead to a more varied salinity regime within the Marsh, resulting in changes in marsh vegetation that would persist until the vegetation adapted to the new salinity and flow regime. This would likely render some areas of soft bird's-beak nor Suisun thistle habitat unsuitable, potentially extirpating occurrences of these plants, while also creating new areas of suitable habitat. To the extent that soft bird's-beak or Suisun thistle could not disperse to accommodate these habitat changes, or were adversely affected by short-term losses in suitable habitat, mortality would result, possibly with long-term effects on genetic diversity and population structure. Conversely, as described above in Section 5.24.3.1.1 *Suisun Marsh Salinity Control Gates*, changes under the PA scenario would be negligible relative to COS, with little potential for the PA to modify habitat or otherwise harm soft bird's-beak or Suisun thistle.

5.23.10 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Project components with the potential to affect vernal pool fairy shrimp and vernal pool tadpole shrimp are associated with *Tidal Habitat Restoration*. Reclamation will, however, avoid disturbance of vernal pools that are occupied or assumed to be occupied, including a 250 foot buffer of upland around the pools, for the restoration projects.

5.23.11 California Tiger Salamander

Project components with the potential to affect California tiger salamander are associated with Tidal Habitat Restoration and Conservation Fish Hatchery. Reclamation will, however, avoid disturbance of potentially occupied California tiger salamander habitat for these restoration.

5.23.12 California Least Tern

Project components with the potential to affect California least tern are associated with Tidal Habitat Restoration. Although most of the project components could affect aquatic areas that provide California least tern foraging habitat, these activities are not expected to adversely affect the species, since foraging habitat is readily available and the restoration and enhancement projects are expected to increase food supply. Proposed flow changes under the proposed action likewise have little potential to alter extent or quality of habitat available to the California least tern. Reclamation will avoid disturbance of any California least tern nesting colony sites. The proposed action is therefore expected to have a net beneficial effect on the species.

5.23.13 California Red-Legged Frog

Project components with potential to affect California red-legged frog are associated with *Spawning and Rearing Named Projects* in the Upper Sacramento River Watershed. Although these components occur within the historic range of the species, there are no known populations within these areas and Reclamation has conducted surveys for California red-legged frog to support past spawning and rearing projects along the Sacramento River, south of Shasta Dam, and have not observed the species. Therefore, the likelihood of species occupancy of habitats along the Sacramento River downstream of Shasta Dam is discountable.

5.24 Effects on Terrestrial Species Critical Habitat

Federally listed species with critical habitat in the Action Area include western yellow-billed cuckoo, California red-legged frog, California tiger salamander, valley elderberry longhorn beetle, vernal pool fairy shrimp, vernal pool tadpole, soft bird's-beak, and Suisun thistle. Effects on critical habitat will be avoided for all these species except western yellow-billed cuckoo. Effects are described below.

5.24.1 Western Yellow-Billed Cuckoo Proposed Critical Habitat

Western yellow-billed cuckoo proposed critical habitat is present in Tisdale Bypass and Sutter Bypass. However, Reclamation's proposed action does not modify flows in the Tisdale or Sutter Bypasses. Changes in frequency of inundation in the Sacramento River would be minor, and within the current minimum and maximum flows. The proposed action could provide for some different riparian species that require year-round flows, as compared to WOA, where low flows in the fall would stress invasive plants and encourage drought tolerant native species to persist.

The average monthly flows under adjusted CP4A were similar (5% or less difference) to the proposed action in June-August. The average flows generally increase in September (by 44%) and November (by 30%) and decrease in December-May (by at most 19%) with a raised Shasta Dam (adjusted CP4A) compared to the proposed action model results. The operation of a Shasta Dam raise is not anticipated to change the minimum or maximum flows in the Sacramento River.

5.24.2 Valley Elderberry Longhorn Beetle

Critical habitat for valley elderberry longhorn beetle is present along the American River. However, Reclamation will avoid valley elderberry longhorn critical habitat. Therefore, there is no effect to valley elderberry longhorn beetle critical habitat.

5.24.3 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Critical habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp is present in areas that Reclamation could potentially use for Tidal Habitat Restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for these species in the critical habitat units. Therefore, the proposed action has no effect on critical habitat for these species.

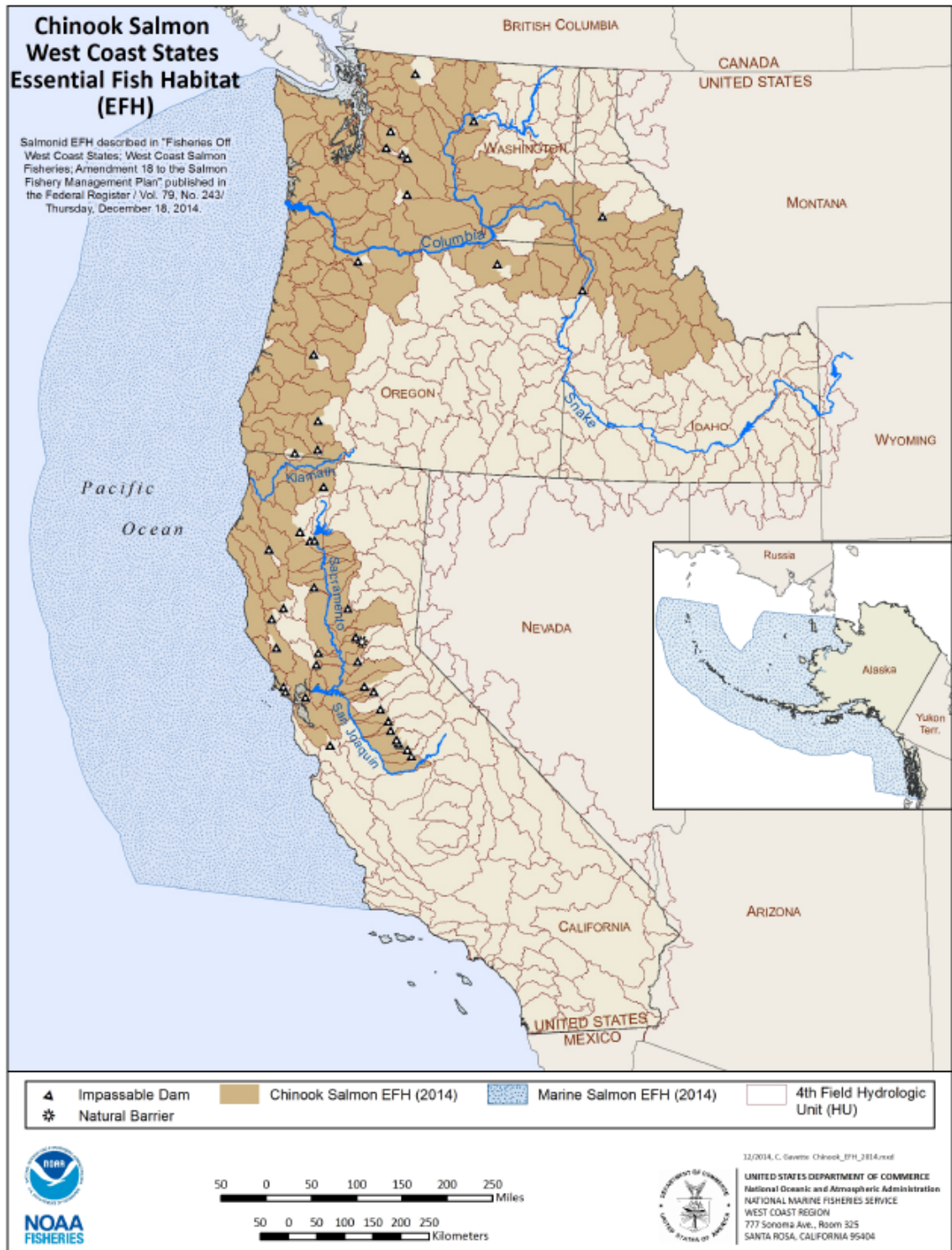
5.24.4 California Tiger Salamander

Critical habitat for California tiger salamander is present in areas that Reclamation could potentially use for Tidal Habitat Restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for this species in the critical habitat units.

5.25 Essential Fish Habitat

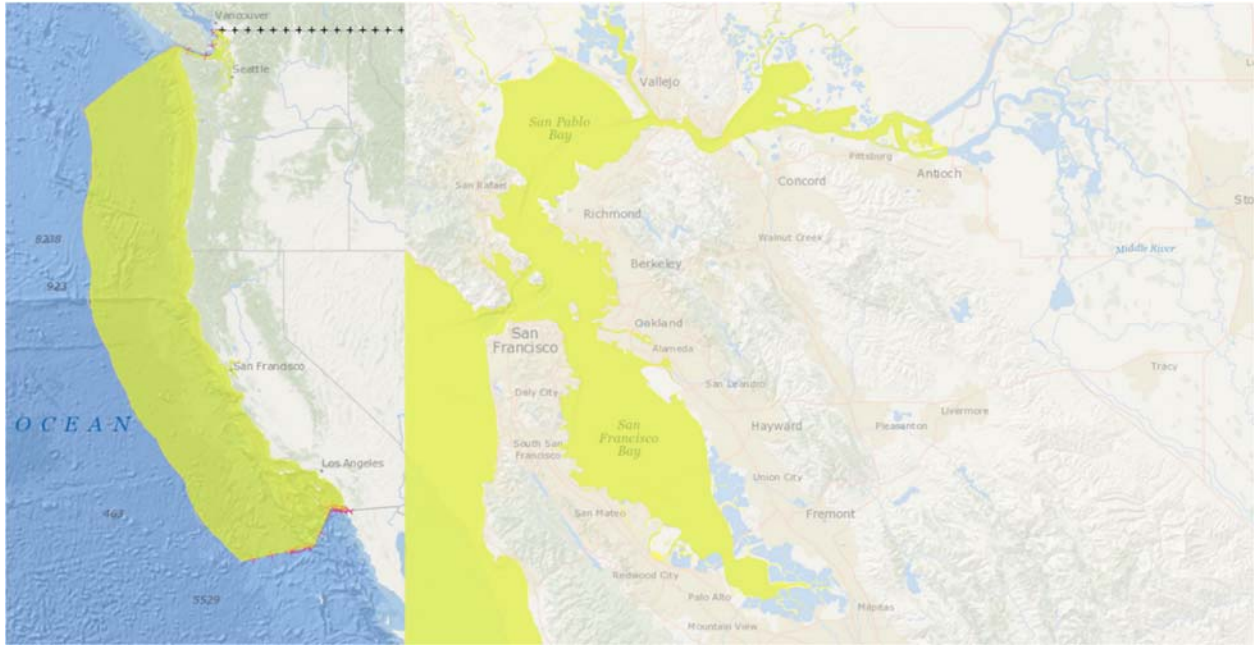
The action area encompasses designated EFH for Pacific Coast Salmon (Figure 5.25-1), Coastal Pelagic Species (Figure 5.25-2), and Pacific Coast Groundfish (Figures 5.25-3 and 5.25-4). There is a number of species included in these groups that could be present in the action area (Table 5.25-1). The analyses below generally focus on species that are likely to be abundant (relative to other species within each group) in the main portion of the action area that could be affected by the proposed action, i.e., Pacific Coast Salmon: Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run and Fall-run/Late Fall-run Chinook Salmon, Upper Klamath-Trinity Rivers Fall-run and Spring-run Chinook Salmon, Southern Oregon-Northern California Coastal Chinook Salmon, and Southern Oregon-Northern

California Coast Coho Salmon; Coastal Pelagic Species: Northern Anchovy; and Pacific Coast Groundfish: Starry Flounder.



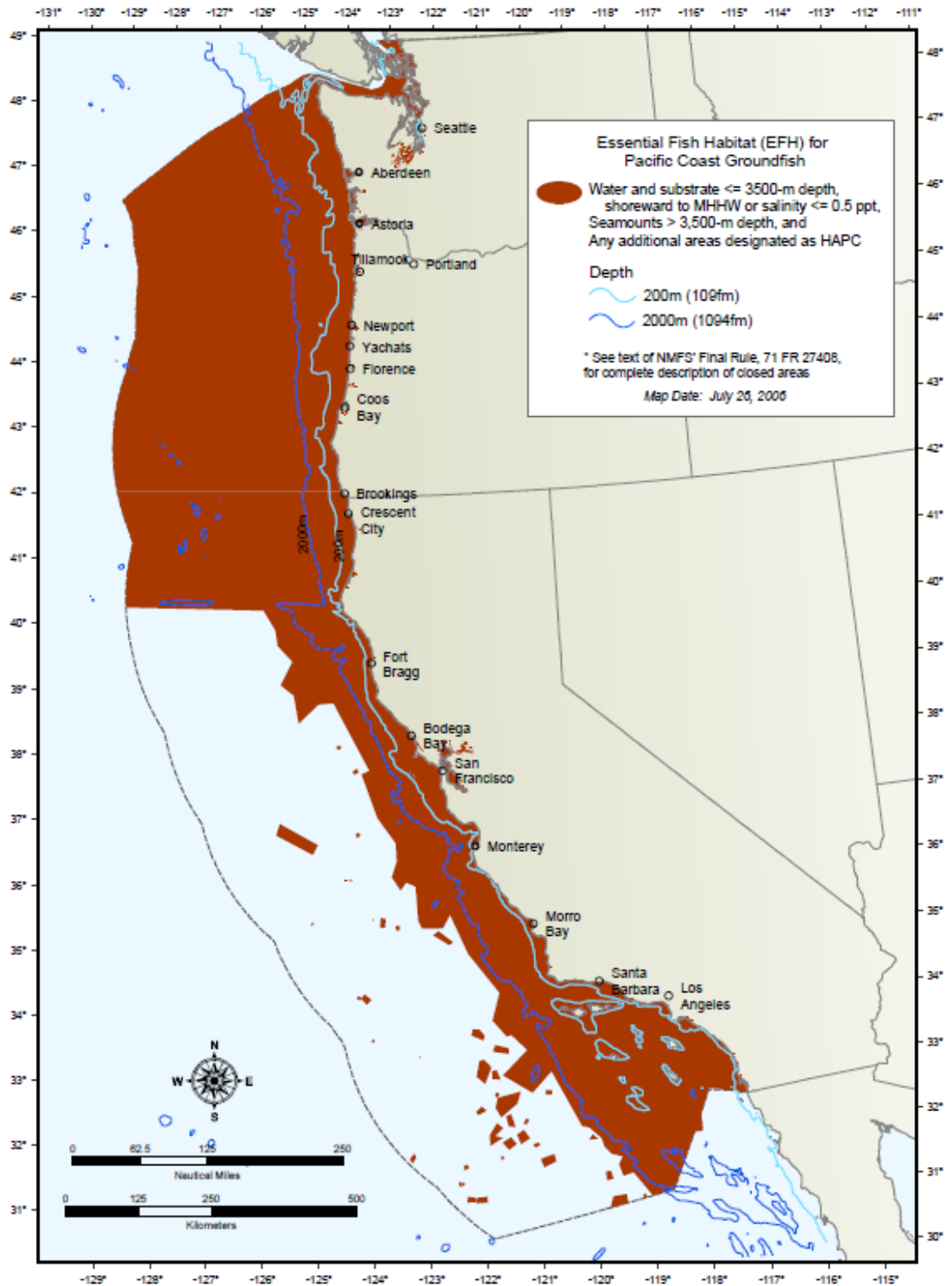
Source: https://www.westcoast.fisheries.noaa.gov/publications/habitat/essential_fish_habitat/west_coast_salmon_ehf_2014_1.pdf. Accessed: December 20, 2018.

Figure 5.25-1. Essential Fish Habitat for Pacific Coast Salmon



Source: <https://www.habitat.noaa.gov/protection/efh/efhmapper/> Accessed: December 20, 2018. Note: Left map shows full extent of Coastal Pelagic Species EFH; right map includes main portion of EFH in the San Francisco Bay-Delta (there is no EFH in the Lower Klamath River, so that area is not included).

Figure 5.25-2. Essential Fish Habitat for Coastal Pelagic Species in the Vicinity of the Action Area



Source: https://www.westcoast.fisheries.noaa.gov/publications/gis_maps/maps/groundfish/map-gfish-efh.pdf Accessed: December 19, 2018.

Figure 5.25-3. Essential Fish Habitat for Pacific Coast Groundfish

Table 5.25-1. Essential Fish Habitat Species Potentially Present in the Action Area, with Focal Species in Bold

| Common Name | Scientific Name | Comment |
|------------------------------|-----------------------------------|--------------------------------------------|
| Coastal Pelagic Species | | |
| Jack Mackerel | <i>Trachurus symmetricus</i> | Present; eggs & larvae |
| Northern Anchovy | <i>Engraulis mordax</i> | Abundant; eggs, larvae, juveniles & adults |
| Pacific Sardine | <i>Sardinops sagax</i> | Rare; juveniles & adults |
| Pacific Coast Groundfish FMP | | |
| Big Skate | <i>Raja binoculata</i> | Present; juveniles & adults |
| Bocaccio | <i>Sebastes paucispinis</i> | Rare; juveniles |
| Brown Rockfish | <i>Sebastes auriculatus</i> | Abundant; juveniles & adults |
| Cabezon | <i>Scorpaenichthys</i> spp. | Rare; juveniles & adults |
| Curlfin Sole | <i>Pleuronichthys decurrens</i> | Present; juveniles |
| English Sole | <i>Pleuronectes vetulus</i> | Abundant; juveniles & adults |
| Kelp Greenling | <i>Hexagrammos</i> spp. | Present; juveniles & adults |
| Leopard Shark | <i>Triakis semifasciata</i> | Present; juveniles & adults |
| Lingcod | <i>Ophiodon elongatus</i> | Present; juveniles & adults |
| Pacific Sanddab | <i>Citharichthys sordidus</i> | Present; eggs, larvae, juveniles & adults |
| Pacific Whiting (Hake) | <i>Merluccius productus</i> | Present; eggs & larvae |
| Sand Sole | <i>Psettichthys melanostictus</i> | Present; larvae, juveniles & adults |
| Soupfin Shark | <i>Galeorhinus zyopterus</i> | Present; juveniles & adults |
| Spiny Dogfish | <i>Squalus acanthias</i> | Present; juveniles & adults |
| Starry Flounder | <i>Platichthys stellatus</i> | Abundant; eggs, larvae, juveniles & adults |

| Common Name | Scientific Name | Comment |
|-------------------------------------------|---------------------------------|--------------------------------------------|
| Pacific Coast Salmon FMP | | |
| Chinook Salmon | <i>Oncorhynchus tshawytscha</i> | Abundant; eggs, larvae, juveniles & adults |
| Coho Salmon | <i>Oncorhynchus kisutch</i> | Present; eggs, larvae, juveniles & adults |
| Source: Adapted from NMFS (2017, p.1211). | | |

5.25.1 Pacific Coast Salmon

Pacific Coast Salmon EFH includes the entire action area (Figure 5.25-1).

5.25.1.1 Effects of Operation

Operations of the proposed action have the potential to positively and negatively affect Pacific Coast Salmon EFH. Detailed analyses for *Flow-Dependent Actions* were previously described for Central Valley Chinook Salmon stocks, i.e., Winter-run, Spring-run, and Fall-run/Late Fall-run. Potential positive effects of the proposed action relative to the without action generally would occur as a result of reservoir storage allowing summer/fall releases to maintain favorable temperature conditions for early life stages, as exemplified for Winter-run Chinook Salmon in the Sacramento River below Keswick Dam (see Section 5.2.1.2.1 *Flow-Dependent Actions*). Potential negative effects of the Core Water Operation generally could occur during winter and spring, particularly the latter, which coincides with the main period of juvenile downstream migration and is when flow is often appreciably lower under the proposed action compared to the without action. These factors could affect juvenile salmon travel time and survival, for example.

Non-flow-dependent actions' operational effects generally would be expected to have positive effects on Chinook Salmon stocks from the Central Valley, although some negative effects are also possible, as discussed in species sections above.

5.25.1.2 Effects of Conservation Measures

As discussed in species sections above, the various proposed construction activities potentially could result in direct or indirect alteration in the quantity and quality of Pacific Coast Salmon EFH, but generally would provide beneficial long-term effects. Effects include temporary loss of aquatic and riparian habitat leading to increased predation 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 (e.g., reduction in benthic macroinvertebrate production and availability), 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. These potential effects would be minimized through restriction of in-water work to windows limiting exposure by reducing potential for spatiotemporal overlap, and implementation of other AMMs to minimize the potential for effects when species do overlap with in-water work. In the long-term, the

conservation measures proposed in this document should improve the extent and quality of EFH by increasing spawning and rearing habitat in the Sacramento, American, and Stanislaus Rivers.

5.25.1.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Pacific Coast Salmon EFH from maintenance activities.

5.25.1.4 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Pacific Coast Salmon EFH, given the limited spatial extent of habitat that would be affected by activities such as trawling, seining, or operating video weirs, for example. Monitoring activities are summarized in Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation*.

5.25.2 Coastal Pelagic Species

Coastal Pelagic Species EFH in the action area includes the action area upstream to the western Delta (lower Sacramento and San Joaquin Rivers), but not the Lower Klamath River (Figure 5.25-2).

5.25.2.1 Effects of Operation

Coastal Pelagic Species EFH could be subject to operational effects of the proposed action's Core Water Operation as it pertains to Delta outflow and its effect on the salinity field. However, the effects on salinity would be small relative to the salinity tolerance of Coastal Pelagic Species EFH such as Northern Anchovy (Baxter et al. 1999). Kimmerer et al. (2009) showed for Northern Anchovy that neither indices of habitat extent nor indices of abundance were related to X2, an index of Delta outflow and its effects. There is a large amount of Coastal Pelagic Species EFH relative to the action area (Figure 5.25-3).

5.25.2.2 Effects of Conservation Measures

Construction of proposed action components generally would be upstream of Coastal Pelagic Species EFH. Depending on the location of tidal marsh habitat restoration, there may be some construction effects from this component of the proposed action, for example if restoration sites border Suisun Bay or are on the lower Sacramento and San Joaquin Rivers. Depending on the specifics of the work, and as previously described for Pacific Coast Salmon, effects to Coastal Pelagic Species EFH could include factors such as temporary loss of aquatic habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils; 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. Implementation of AMMs (see Appendix E, *Avoidance and Minimization Measures*) would avoid and minimize potential effects to Coastal Pelagic Species EFH.

5.25.2.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities*

would be anticipated to minimize potential negative effects to Coastal Pelagic Species EFH from maintenance activities.

5.25.2.3.1 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Coastal Pelagic Species EFH, given the limited spatial extent of habitat that would be affected by sampling in the Bay-Delta (in particular the Fall Midwater Trawl, 20-mm Survey, Spring Kodiak Trawl, Bay Study, Smelt Larva Survey, Summer Townet Survey, Chipps Island Trawl, Enhanced Delta Smelt Monitoring, and Environmental Monitoring Program; see Appendix E relative to the overall extent of EFH.

5.25.3 Pacific Coast Groundfish

Pacific Coast Groundfish EFH in the action area includes San Francisco Bay and Suisun Bay, but not the legal Delta (Figure 5.25-3).

5.25.3.1 *Effects of Operation*

As with Coastal Pelagic Species EFH, the proposed action's Core Water Operation could affect the Pacific Coast Groundfish EFH as it pertains to Delta outflow and its effect on the salinity field. However, the effects on salinity would be small relative to the salinity tolerance of Pacific Coast Groundfish EFH such as Starry Flounder (Baxter et al. 1999), and indices of habitat availability of Starry Flounder are not related to Delta outflow (expressed as X2; Kimmerer et al. 2009). Kimmerer et al. (2009) found a significant negative relationship between annual mean March–June X2 (an index of Delta outflow) and annual mean Starry Flounder bay otter trawl abundance indices, which they suggested could be related to an increase in residual circulation in the San Francisco Estuary with increasing Delta outflow; if such an increase translates to more rapid or more complete entrainment of Starry Flounder early life stages into the estuary, or more rapid transport to their rearing grounds, then presumably survival from hatching to settlement would be higher under high-flow conditions (Kimmerer et al. 2009: 385). Relative to the without action WOA scenario, the proposed action scenario has lower March–June Delta outflow and therefore higher X2 (Figure 5.25-4), potentially resulting in a negative effect to Pacific Coast Groundfish EFH as reflected by Starry Flounder abundance. There is appreciable uncertainty in this predictive relationship, however (ICF International 2016: p.5.E-34).

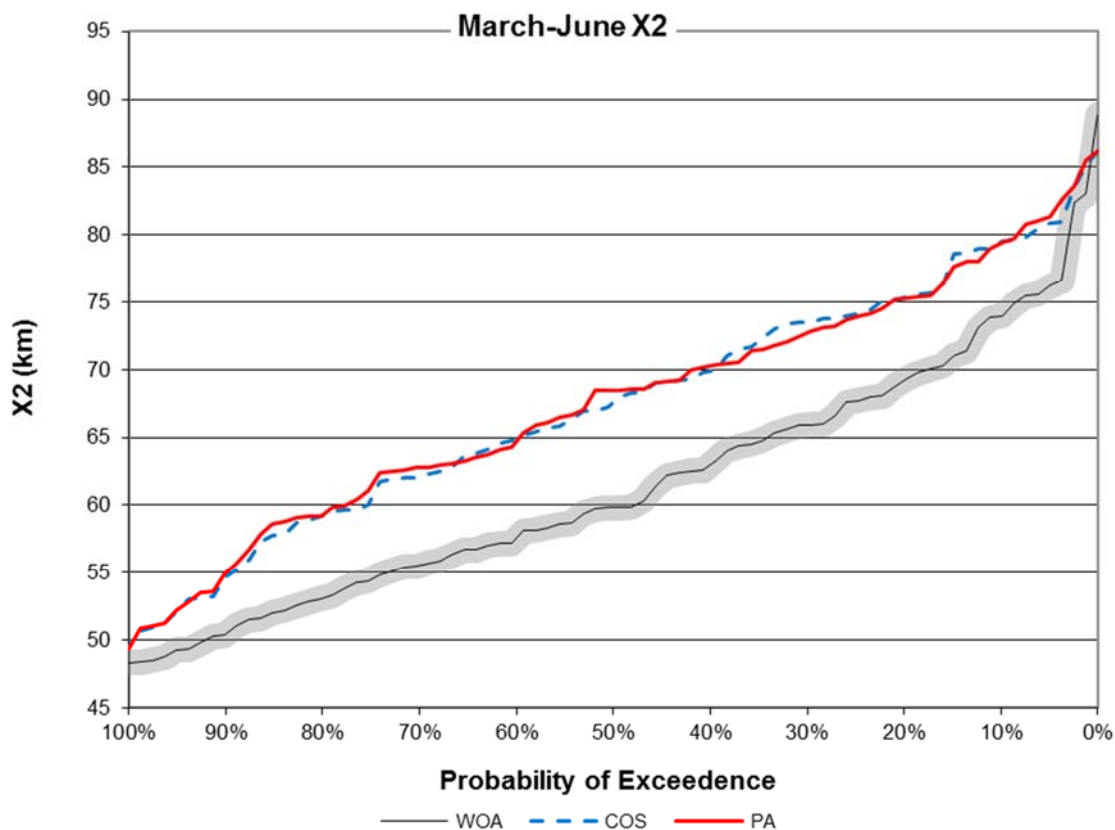


Figure 5.25-4. Mean Modeled X2, March–June

5.25.3.2 Effects of Conservation Measures

Construction of proposed action components generally would be upstream of Pacific Coast Groundfish EFH. As described for Coastal Pelagic Species EFH, there may be some construction effects from the tidal marsh habitat restoration component of the proposed action, for example if restoration sites border Suisun Bay. Depending on the specifics of the work, and as previously described for Pacific Coast Salmon, effects to Pacific Coast Groundfish EFH could include potential negative effects such as temporary loss of aquatic habitat leading to increased predation and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity; 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. Implementation of AMMs (see Appendix E, *Avoidance and Minimization Measures*) would avoid and minimize potential effects to Pacific Coast Groundfish EFH.

5.25.3.3 Effects of Maintenance

Implementation of the species avoidance and take minimization steps described in Appendix C, *ROC Real Time Water Operations Charter* in section *Routine Operations and Maintenance on CVP Activities* would be anticipated to minimize potential negative effects to Pacific Coast Groundfish EFH from maintenance activities.

5.25.3.4 Effects of Monitoring Activities

It is anticipated that there would be minimal negative effects of monitoring activities on Pacific Coast Groundfish EFH, given the limited spatial extent of habitat that would be affected by sampling in the Bay-Delta (in particular the Fall Midwater Trawl, 20-mm Survey, Spring Kodiak Trawl, Bay Study, Smelt Larva Survey, Summer Towntnet Survey, Chipps Island Trawl, Enhanced Delta Smelt Monitoring, and Environmental Monitoring Program; see Appendix C, *ROC Real Time Water Operations Charter* in section *Monitoring Program for Core CVP and SWP Operation*).

Chapter 6 Cumulative Effects

Cumulative effects, as defined by rule, are those effects of future State, tribal, local 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) that USFWS and NMFS use in conducting a jeopardy analysis. For this biological assessment, these include unscreened water diversions, state or local levee maintenance, oil and gas production and powerplants, and the point and non-point source chemical contaminant discharges related to agricultural and urban land use. These actions typically result in habitat fragmentation and degradation of habitats that incrementally reduces the carrying capacity of the rearing and migratory corridors found within the action area. Cumulative effects also include the implementation of changes in state law. Several related and reasonably foreseeable future State or private projects and actions could result in impacts on Federally-listed aquatic and terrestrial biological resources considered in this biological assessment. The projects that are most likely to affect those resources are generally described below.

6.1 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 or osmeridae (smelt) species (Mussen et al. 2013, Mussen et al. 2014). For example, as of 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). This has improved due to the Anadromous Fish Screen Program (AFSP), part of CVPIA, as well as DWR's fish screening program. 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).

6.2 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, as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters. Delta Smelt's exposure to contaminants are inherent in the Delta, ranging in the degree of effects. Sources of introduction vary from agricultural use pesticide runoff to urban wastewater treatment discharge, and other potential sources. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may disrupt various physiological mechanisms and may negatively affect reproductive success and survival rates of listed anadromous fish (Scott and Sloman 2004). However, the State of California issues Waste Discharge Requirements (WDRs) to dischargers, including irrigators, dairy operations, and cattle operations, that require implementation of Best Management Practices (BMPs) designed to be protective

of surface water quality, with benefits for listed fish species. Monitoring and reporting requirements associated with those WDRs ensure compliance with BMPs.

Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman et al. 2014). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect fish reproductive success and survival rates (Dubrovsky et al. 1998; Kuivila et al. 2004; Scholz et al. 2012). Discharges occurring outside the action area that flow into the action area also contribute to cumulative effects of contaminant exposure.

6.3 Wastewater Treatment Plants

The Sacramento Regional Wastewater Treatment Plan (SRWTP), 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 2013). By May 11, 2021, the SRWTP must meet effluent limits EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Few studies have been conducted to assess the effects of ammonia on listed fish species, although studies have been performed on surrogate non-listed fish species. 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). Additionally, a study of coho salmon and rainbow trout exposed to ammonia showed a decrease in swimming performance due to metabolic challenges and depolarization of white muscle (Wickset al. 2002).

In addition to concerns about direct toxicity of ammonia to Delta Smelt, another important potential concern is that ammonium inputs have slowed diatom growth in the Delta and Suisun Bay, thereby reducing the productivity in the Delta Smelt food web (Wilkerson et al., 2006, Gilbert et al. 2011, Dugdale et al. 2016), in combination with other factors such as invasive clams.

6.4 Increased Urbanization

With a projected growth rate of 1.2% annually through 2030, California can expect to observe future increases in urbanization and housing developments (California Department of Finance 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 will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Adverse effects on listed fish species and their critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Increased urbanization also is expected to result in increased recreational activities in the region.

6.5 Recreational Activities in the Region

Recreational boating is expected to increase in volume and frequency. 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.

6.6 Changes in Location, Volume, Timing, and Method of Delivery for Non-CVP/SWP Diversions

Changes in location, volume, timing, and method of delivery for non-CVP/SWP diversions may be implemented without Federal consultation. While not certain, 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% 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 SGMA 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.

6.7 Activities within the Nearshore Pacific Ocean

Future tribal, state, and local government actions will likely be 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 and increases and decreases in the types

of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed fish species or their habitat.

6.8 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 adversely affect habitat and interfere with natural, long term habitat-maintaining processes.

Power plant cooling system operations can also affect aquatic habitat. 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. The Pittsburg Generating Station (PGS) remains in operation and consisted of seven once-through cooling systems, two of which remain in operation. 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. On May 4, 2010, the SWRCB adopted a Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling under Resolution No. 2010-0020, which required existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (SWRCB 2010). The PGS chose to comply by retrofitting two of the existing units and retiring one unit. The retrofit and retirement of these units is underway (GenOn Delta LLC 2011). This is expected to have beneficial effects for listed species.

Chapter 7 Conclusion

The determination of effects for listed species and their designated critical habitat in this biological assessment considers direct and indirect effects of the proposed action together with the effect of other activities that are interrelated or dependent on the proposed action. This chapter presents a summary of the effects for listed species and their designated critical habitat.

This chapter also includes Reclamation’s determinations under the Magnuson–Stevens Fishery Conservation and Management Act for EFH. The effects determination for EFH concludes whether or not adverse effects would occur, and whether or not the effects would be substantial.

7.1 Analytical Approach

Population and critical habitat analyses are included in this BA to assist the fishery agencies in making the determination of whether the proposed action would reasonably 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 C.F.R. § 402.02; 16 U.S.C. § 1536(a)(2). Three possible determinations exist regarding a proposed action’s effects on listed species:

- No effect - “No effect” is the appropriate conclusion when it is determined that the proposed action will not affect a listed species or designated critical habitat.
- “May affect, but is not likely to adversely affect” is the appropriate conclusion when effects to listed species or critical habitat are expected to be discountable (extremely unlikely to occur), insignificant (never resulting in take), or completely beneficial (positive effects without adverse effects)
- May affect, likely to adversely affect is the appropriate conclusion if any adverse effect may occur to listed species or critical habitat as a direct result of the proposed action, and the effect is not discountable, insignificant, or beneficial. If incidental take is anticipated to occur as a result of the proposed action, an “is likely to adversely affect” determination is made.

7.2 Aquatic Effects Determinations

The ongoing stressors associated with existing dams and other structures are part of the environmental baseline. Reclamation and DWR do not currently have the authority to remove these structures and alter these baseline conditions. The proposed action primarily includes coordinated long-term operation of the CVP and SWP 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. The proposed action also includes habitat restoration and other actions to benefit species.

In consideration of the foregoing effects assessments, incidental take could potentially occur as a result of the proposed action. A main objective in this consultation is incidental take coverage for the coordinated long-term operation of the CVP and SWP. Incidental take is take of listed fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a Federal

agency or applicant. [50 CFR §402.02]. Take is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed species or attempt to engage in any such conduct. [ESA §3(19)] Harm means an act which actually kills or injures wildlife. Harm is further defined by USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by USFWS as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. [50 CFR §17.3]

Although the effects analysis in Chapter 5 describes effects to listed species in a holistic, species-level manner throughout the action area, Reclamation and DWR also considered whether the effects analysis indicated effects to listed species at the individual level to determine whether incidental take coverage for the proposed action is necessary. Reclamation and DWR provide this biological assessment to help the USFWS and NMFS develop their biological opinions. The determination of jeopardy or adverse modification by USFWS and NMFS is based on the effects of the action on the continued existence of the entire population of the listed species or on a listed population, and/or the effect on critical habitat. An action that does not result in jeopardy or adverse modification can nevertheless result in incidental take. Reclamation and DWR have taken a precautionary approach to describing potential incidental take in the discussion that follows.

7.2.1 Sacramento Winter-Run Chinook Salmon ESU

The overall effects of the proposed action on Winter-Run Chinook Salmon in the Sacramento River upstream of the Delta are beneficial, and the proposed action would improve flows and water temperatures for spawning, rearing, and migration of Winter-Run Chinook Salmon compared to without action conditions. The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the operation of the CVP and SWP provides the necessary cold water to ensure adequate pre-spawning, spawning, and incubation conditions for Winter-Run Chinook Salmon. These improvements in water temperature management under the proposed action, including operation of the Shasta TCD, provide for cold water to maintain egg incubation and avoid temperature dependent mortality. The impacts of increased summer and fall flows under the proposed action would be beneficial for egg and alevin survival. Under without action conditions, it is likely Winter-Run Chinook Salmon would not exist in the mainstem upper Sacramento River.

The proposed action provides substantial beneficial conditions, including water temperatures that allow Winter-Run Chinook Salmon to persist despite the existence of dams and other stressors. The benefits of the lower summer and fall water temperatures under the proposed action outweigh potential adverse effects of higher winter water temperatures because the summer and fall temperatures are often near critical temperature thresholds and, therefore, more of a limiting factor. Also, the juveniles are at their youngest and therefore most vulnerable during summer and fall. These results indicate that water temperatures under the proposed action provide benefits to rearing juvenile Winter-Run Chinook Salmon in the upper Sacramento River.

The proposed action would have higher flows during summer, when flow is generally low and potentially limiting Winter-Run Chinook Salmon holding and spawning success. Additionally, the proposed action would allow for higher fall flows, leading to less dewatering, more food, rearing habitat, and cover. Spring pulse flows under the proposed action would trigger outmigrating juveniles and adults migrating upstream in late spring and provide benefits to multiple life stages.

The higher than ideal May water temperatures in the middle Sacramento River under the proposed action would be likely to negatively impact Winter-run Chinook Salmon adults migrating at that time in the middle Sacramento River, even though the proposed action would improve water temperatures over baseline conditions.

Incidental take of individual members of the species associated with the proposed action result from entrainment, impingement, and predation at the Delta pumps and other diversions, and changes in flows that may affect migratory success. Operation of the DCC gates would entrain juvenile Winter-Run Chinook Salmon into the central and south Delta. Analysis shows entrainment loss rates for Winter-Run Chinook Salmon would be low. The measures included in the proposed action provide for Delta operations to minimize salvage and other effects related to exports.

Conservation measures, such as rice decomposition smoothing, spring management of spawning locations, intakes at Wilkins Slough, Shasta Temperature Control Device Improvements, habitat restoration projects, trap and haul, predator hot spot removal, DCC improvements, Tracy and Skinner improvements, and small screen improvements would be beneficial to Winter-Run Chinook Salmon.

Winter-Run Chinook Salmon adults, eggs, and alevins would be temporarily subject to potential adverse effects from proposed spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of spawning adults and the implementation of other AMMs. These projects would be implemented for the benefit of salmonids, including Winter-Run Chinook Salmon, and these effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Spawning and rearing habitat restoration projects in Shasta and Tehama counties.
- Clifton Court aquatic mechanical weed removal and predator management.
- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the Delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the proposed action is likely to have overall beneficial effects, it is also likely to adversely affect individual salmon in the Sacramento River Winter-Run Chinook Salmon ESU.

7.2.2 Sacramento Winter-Run Chinook Salmon Critical Habitat

The proposed action would have no adverse water temperature-related effect on access to spawning areas (PBF1) in Winter-Run Chinook Salmon critical habitat. The effect of the proposed action on the availability of clean gravel for spawning substrate (PBF2) is uncertain. Natural pulse flows would be larger and less frequent under the proposed action which could result in less flushing flows. However, if flows are too large they could lead to transport of gravel without recruitment. The effects of the proposed action on PBF3 are uncertain. The proposed action is expected to substantially benefit river flows for successful spawning, incubation, and emergence; however, would reduce downstream transport and environmental cues for emigrating juveniles (PBF3). The proposed action would have benefits related to water temperatures for spawning, incubation, and development (PBF4). Riparian vegetation would establish (PBF6) less during winter under the proposed action. The proposed action would provide less favorable conditions for emigrating juveniles during winter and early spring (PBF7), because proposed action flows would be lower, but would provide more favorable conditions in the summer months because proposed action flows would be higher. The proposed action is not expected to negatively impact downstream access in critical habitat for juvenile Winter-Run Chinook Salmon emigrating down river.

Spawning and rearing habitat restoration projects in the upper Sacramento River may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to critical habitat for Winter-Run Chinook Salmon.

The proposed action would have beneficial or no adverse effect on numerous PBFs Winter-Run Chinook Salmon critical habitat relative to without action conditions. Beneficial effects include flows and water temperatures important for several PBFs. However, effects to some PBFs remain uncertain. The proposed action could reduce riparian vegetation establishment (PBF6) and provides less flows for emigrating juveniles during winter and early spring (PBF7). Overall the proposed action provides benefits to Sacramento River Winter-Run Chinook Salmon critical habitat.

7.2.3 Sacramento Winter-Run Chinook Salmon Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement include:

- Number of Winter-Run Chinook Salmon redds below the Clear Creek Confluence and proposed action measures to optimize the use of the available cold water pool under the different “Tiers” to protect the majority of redds, target critical life stages, and avoid releases for water temperatures outside of the spawning areas when cold water is limited.
- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Operation of the DCC based on near real-time monitoring of juvenile presence.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.
- Increased production in drought years at the Livingston-Stone National Fish Hatchery.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome NMFS participation, and would include progress reports in annual reporting under the ITS.

7.2.4 Chinook Salmon, Central Valley Spring-Run ESU

Overall effects of the proposed action on Central Valley Spring-Run Chinook Salmon upstream of the Delta are beneficial. The proposed action provides substantial beneficial conditions, including water temperatures that allow Spring-run Chinook Salmon to persist despite the existence of dams and other stressors. The proposed action would improve flows and water temperatures for spawning and incubation compared to without action conditions in the upper and middle Sacramento and Feather Rivers along with Clear Creek. The proposed action also provides adequate flows for rearing and migration of juveniles in the middle Sacramento and lower American rivers from the Central Valley out to the ocean. Higher flows in some years under the proposed action benefit adult Spring-Run Chinook Salmon migrating in the middle Sacramento River and holding in the upper river by enhancing water quality and upstream passage, and reducing stranding, straying, poaching, and disease risks. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP provide necessary cold water and flow to ensure adequate conditions for Spring-Run Chinook Salmon. Under without action conditions, it is likely Spring-Run Chinook Salmon would not exist in the mainstem upper Sacramento River.

The proposed action includes many beneficial aspects that are aimed at improving the status of Spring-Run Chinook Salmon. These conservation measures include habitat restoration projects, predator hot spot removal, DCC improvements, Tracy and Skinner improvements and small screen improvements. Conservation measures may expose individuals to detrimental effects; however, these actions would provide benefits to Chinook salmon and would offset the adverse effects from operations in the Delta.

Spring-Run Chinook Salmon adults, eggs, and alevins would be temporarily subject to potential adverse effects from proposed spawning and rearing habitat restoration projects in the upper Sacramento River associated with the proposed action. Construction activities could result in mortality of eggs and alevins by crushing if heavy equipment enters the stream channel or otherwise disturbs existing redds during in-water activities. Eggs and alevins could also be negatively impacted by increases in suspended sediment, turbidity, and contaminant exposure risk, leading to indirect impacts on individuals from reductions in habitat quality in the redd or direct impacts from sublethal and lethal exposures to contaminants. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of spawning adults and the implementation of other AMMs. These projects would be implemented for the benefit of salmonids, including Spring-Run Chinook Salmon, and potential adverse effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Spawning and rearing habitat restoration projects in Shasta and Tehama counties.
- Clifton Court aquatic mechanical weed removal and predator management

- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the overall effects of the proposed action are beneficial, the proposed action is likely to adversely affect individual salmon in Central Valley Spring-Run Chinook Salmon ESU.

7.2.5 Chinook Salmon, Central Valley Spring-Run ESU Critical Habitat

Critical habitat for Spring-Run Chinook Salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Spring-Run Chinook Salmon ESU, biological features of the designated critical habitat that are considered vital for Spring-Run Chinook Salmon include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Nearshore marine areas are not discussed further since the habitat is not affected by the proposed action. There are likely to be adverse effects to certain PBFs of Spring-Run Chinook Salmon designated critical habitat resulting from the proposed action. However, those effects are uncertain. These include effects to freshwater rearing habitat and estuarine habitat. However, once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the proposed action is expected to benefit spawning habitat allowing the species to persist to other life stages and habitats. The proposed action also includes additional beneficial actions that would improve habitat conditions, such as geomorphic flows and gravel augmentation. Therefore, Reclamation has determined that the proposed action would have overall long term beneficial effects on the designated critical habitat. Core and programmatic actions, such as habitat restoration and facility construction, may cause temporary localized adverse effects but are expected to result in long-term beneficial effects to PBFs for Central Valley Spring-Run Chinook Salmon critical habitat.

7.2.6 Central Valley Spring-Run Chinook Salmon Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement for Spring-Run Chinook Salmon include:

- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.
- Spring Pulse Flows for Spring-Run Chinook Salmon.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Watershed specific programs include the Clear Creek Restoration Program and San Joaquin River Restoration Program. Reclamation and DWR-led efforts welcome NMFS participation, and would include progress reports in annual reporting under the ITS.

7.2.7 Steelhead, Central Valley DPS

Overall effects of the proposed action on Central Valley Steelhead are beneficial. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP provide necessary cold water and flow to ensure adequate conditions for CV Steelhead. The proposed action will improve flows and water temperatures for spawning and incubation in the American River, upper and middle Sacramento and Feather Rivers along with Clear Creek.

The proposed action provides substantial beneficial conditions, including water temperatures that allow CV Steelhead to persist despite the existence of dams and other stressors throughout the year. Operating the temperature control devices on Shasta and Folsom dams would have beneficial effects under the proposed action. With higher reservoir storage and water temperature management actions, suitable water temperatures would be maintained through the primary CV Steelhead spawning and incubation period (January through April). Lower water temperatures under the proposed action would extend the period of suitable incubation temperatures into April. Based on the CV Steelhead spawning WUA curves for the upper Sacramento River, lower winter and spring flows under the proposed action are expected to increase spawning habitat suitability (velocity) relative to without action conditions in the mainstem Sacramento River; however, CV Steelhead do not usually spawn in the mainstem Sacramento River, but rather spawn in its tributaries.

The proposed action would result in reduced spring flows when compared to without action conditions, which are likely to affect rearing and migrating CV Steelhead and their habitat. Effects include a decrease in floodplain and side-channel habitat, reduced foraging conditions, increased competition and predation, higher water temperatures and lower DO, and reduced emigration flows. Under without action conditions, CV Steelhead completing their lifecycle in the American River, upper and middle Sacramento River, Stanislaus and Feather Rivers along with Clear Creek would not likely survive the high summer water temperatures compared to the proposed action. Several conservation measures proposed would reduce impacts of reduced spring flows on CV Steelhead juveniles. These include pulse flows from Shasta and Folsom Reservoirs, spawning and rearing habitat enhancement on the Sacramento, American, and Stanislaus rivers, cold water pool management tools and infrastructure, predator hot spot removal and the small screen program. OMR management establishes generally protective criteria to avoid entrainment.

Potential short-term adverse effects could occur from some of these beneficial conservation measures, which many are programmatic and adaptive. Adverse effects from proposed spawning and rearing habitat restoration projects resulting from construction activities could result in injuring or mortality of during in-water activities, but these effects would be temporary and minimized through AMMs.

In summary, there may be incidental take associated with the proposed action through:

- Redd dewatering and temperature dependent mortality based on in-season adjustments to operations.
- Clifton Court aquatic weed removal and predator management.

- Capture and harassment of fish at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.
- Juveniles exposed to screened CVP diversions, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including the operation of the DCC (loss in south Delta interior, loss at export facilities, and altered hydrodynamics). Loss from entrainment, impingement, and predation at the Delta pumps, could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Temporary construction activities associated with habitat restoration and facility improvements.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

The conservation measures included in the proposed action provide additional opportunities for adjustments to Delta operations to minimize salvage and other effects related to exports.

Therefore, while the overall effects of the proposed action are beneficial to the population of Central Valley Steelhead DPS, the proposed action is likely to adversely affect individuals.

7.2.8 Steelhead, Central Valley DPS Critical Habitat

Critical habitat for CV Steelhead is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Central Valley Steelhead DPS, biological features of the designated critical habitat that are considered vital for CV Steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. There are likely to be adverse impacts to certain PBFs of CV Steelhead designated critical habitat resulting from the proposed action. These include effects to freshwater migration corridors and estuarine areas. The proposed action relative to without action conditions could reduce riparian vegetation establishment and less flows for emigrating juveniles during winter and early spring.

The proposed action would have both positive and negative effects on the PBFs of freshwater migration habitat for adult and juvenile CV Steelhead. Lower flows during the winter and early spring would have negative effects on migratory habitat for juvenile Steelhead relative to without action conditions. However, higher flows and lower water temperatures under the proposed action during the late spring and summer would have beneficial effects on migratory habitat of juveniles and adults, especially in dry and critically dry years.

The proposed action includes spawning, rearing, and tidal and channel margin restoration activities that could affect estuarine and freshwater critical habitat for CV Steelhead. These construction-related effects are temporary and localized in nature, and minimized through proposed implementation of AMMs. Restoration projects under the proposed action are expected to result in long-term beneficial effects to critical habitat for CV Steelhead.

Once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the proposed action is expected to result in benefits to CV Steelhead critical habitat. Based on relationships between flow and spawning WUA for CV Steelhead in the upper Sacramento River (USFWS 2003), lower flows under the proposed action would substantially increase the number of years in which flows would be within the optimum weighted

usable area range during the primary spawning period (January through March). However, few CV Steelhead are expected to spawn in the mainstem Upper Sacramento River. The proposed action is also expected to increase the availability of freshwater rearing habitat. Benefits of higher flows under the proposed action during the summer compared to without action conditions include increased downstream extent of suitable rearing water temperatures, improved access to riparian and off-channel habitat, reduced crowding and competition, and increased prey. Therefore, Reclamation has determined that the proposed action would have overall long term beneficial effects on CV Steelhead designated critical habitat.

7.2.9 Steelhead, Central Valley DPS, Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for NMFS to consider when developing an Incidental Take Statement for Central Valley Steelhead include:

- Implementation of the 2017 Flow Management Standard and “planning minimum” on the American River.
- Operation of fish screens at Red Bluff Pumping Plant and the Rock Slough Diversion.
- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Operation of the Tracy and Skinner salvage facilities.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the SAIL monitoring program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome NMFS participation and would include progress reports in annual reporting under the ITS.

7.2.10 Coho Salmon, Southern Oregon/Northern California Coastal ESU

Overall effects of the proposed action on the Southern Oregon/Northern California Coastal ESU are beneficial. The modeling results illustrate that once the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the CVP and SWP operation provide necessary cold water and flow to ensure adequate conditions for Coho Salmon. The proposed action will improve flows and water temperatures for adult migration, holding, and spawning in the Trinity River compared to a scenario without the operation of Trinity Reservoir.

The proposed action provides beneficial conditions, including water temperatures that allow Coho Salmon to persist despite the existence of dams and other stressors. Reclamation would continue to implement the 2000 ROD flows and the Trinity River Restoration Program to reduce the effects of operation of the Trinity River Division of the CVP. The long term plan to protect salmon in the Lower Klamath River ameliorates the chances of fish die off and provides flows for Coho Salmon spawning and rearing on Grass Valley Creek under the proposed action.

Despite the beneficial components of the proposed action, the inter-basin transfer of water to the Sacramento River likely will continue to affect Coho Salmon, primarily the upper and lower Trinity River populations, through changes in habitat that affect their ability to spawn and rear in the mainstem of the Trinity River. There may be incidental take associated with the proposed action through reductions in floodplain and rearing habitat in the spring.

Therefore, while the overall effects of the proposed action are beneficial, the proposed action is likely to adversely affect individual Southern Oregon/Northern California Coastal Coho Salmon ESU.

7.2.11 Coho Salmon, Southern Oregon/Northern California Coastal ESU Critical Habitat

Critical habitat for Coho Salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Within the range of the Southern Oregon/Northern California Coastal Coho Salmon ESU, biological features of the designated critical habitat that are considered vital for Coho Salmon include: substrate, water quality, water quantity, water temperature, water velocity, cover and shelter, food, riparian vegetation, space, and safe passage conditions.

Under the proposed action, the TRRP is expected to continue to result in increases in Coho Salmon populations, through improving fish habitat conditions, such as Coho Salmon critical habitat and associated biological features.

Although there may be adverse effects to the rearing and floodplain habitat PBFs of Coho Salmon designated critical habitat resulting from the proposed action, the ongoing TRRP, lower Klamath augmentation flows, and Grass Valley Creek flows will address these effects. Therefore, Reclamation has determined that considering the continued implementation of ongoing actions, the proposed action would have overall long term beneficial effects on the Coho Salmon designated critical habitat.

7.2.12 North American Green Sturgeon, Southern DPS

Overall, effects of the proposed action on the Southern DPS of Green Sturgeon in the Sacramento River, Bay-Delta, and Feather River are beneficial. The proposed action would also improve flows and water temperatures for spawning, rearing, and migration of Green Sturgeon. The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of CVP and SWP facilities and other stressors, the operation of the CVP and SWP generally provides better cold water and flow conditions to ensure adequate pre-spawning, spawning, and incubation survival conditions for Green Sturgeon.

Improvements in water temperature management under the proposed action, including operation of the Shasta Dam TCD, provide for cold water to maintain egg incubation and reduce temperature dependent mortality compared to without action conditions. The impacts of increased summer and fall flows under the proposed action would be beneficial for egg and larvae survival, although the proposed action reduces temperatures below the optimal growth temperature for Green Sturgeon juveniles in some months.

In the Sacramento River, spawning and rearing Green Sturgeon would benefit from the proposed action flows that are higher than without action conditions during years with dry hydrology during the months of May to October. Improved spawning and egg incubation would occur due to higher flows during June through October. The proposed action flows would increase transport of juvenile Green Sturgeon to favorable habitat, while also increasing larval rearing habitats and an increased dispersion of larvae to rearing habitats. While there are negative effects of lower flows in April during Green Sturgeon spawning and egg incubation, these reductions in flow and increases in temperature are offset by the increased flows and improved temperatures for Green Sturgeon spawning and egg incubation under the proposed action in summer and May in drier years. In addition to benefits for spawning and egg incubation, water temperatures in the summer are generally cooler under the proposed action, benefiting larvae Green Sturgeon.

In the Feather River, higher summer flows under the proposed action minimize the potential exposure to low flows for egg and larvae incubation under conditions that do not include operation of the SWP. The proposed action would also improve temperature objectives at the lower FERC boundary on the Feather River, during the months of April to July, achieving optimal range temperatures for Green Sturgeon egg and larval survival. The proposed action flows would benefit the peak period of abundance for larvae and juvenile Green Sturgeon on the Feather River. Increased flows under the proposed action during July to August are also anticipated to benefit post-spawning Green Sturgeon adults. Lower flows under the proposed action from January to June in the Feather River could negatively impact juvenile Green Sturgeon migration cues and conditions, such as foraging conditions, DO, toxicity, and habitat impacts, but these impacts are anticipated to be minimal since proposed action flows are well in excess of flows believed to be protective of Green Sturgeon juveniles.

Conservation measures, such as habitat restoration projects, predator hot spot removal, and small screen improvements would be beneficial to Green Sturgeon through increased food availability and quality and refuge habitat from predators. Some conservation measures may expose individuals to direct detrimental effects, such as adult fish rescue and juvenile trap and haul; however, these actions could provide benefits to survival and escapement and would potentially offset the adverse effects. Other conservation measures that require construction could lead to negative effects due to temporary loss of habitat leading to predation, degraded water quality, noise-related delay in migration, and direct effects from contact with construction equipment. Although these potential effects may be unavoidable, exposure to construction effects would be low based on the limited extent of proposed restoration relative to the overall distribution of Green Sturgeon adults and juveniles, and the implementation of avoidance and minimization measures.

The proposed action provides substantial beneficial conditions to the species; however, there will be incidental take of individual members of the species resulting from:

- Temperature dependent mortality based on in-season adjustments to operations.
- Entrainment, impingement, and predation at the Delta pumps and other diversions.
- Changes in flows that may affect migratory success in the Feather River.
- Juveniles exposed to CVP screened diversions on the Sacramento River to the Delta, which could result in harassment, injury or mortality.
- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from entrainment, impingement, and predation at the delta pumps could occur and migration success may be affected by changes in flows.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.

Therefore, while the proposed action is likely to have overall beneficial effects, the proposed action is likely to adversely affect individual North American Green Sturgeon southern DPS. The measures included in the proposed action provide additional opportunities for adjustments to Delta operations to minimize salvage and other effects on Green Sturgeon.

7.2.13 North American Green Sturgeon, Southern DPS Critical Habitat

Critical habitat for Green Sturgeon is defined as specific areas that contain the PBFs and physical habitat elements that are essential to the conservation of the species. Within the range of the southern DPS of North American Green Sturgeon, biological features of the designated critical habitat that are considered

vital for Green Sturgeon in estuarine habitat are: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. These biological features are also considered vital for Green Sturgeon in freshwater habitat, with the addition of substrate type or size.

In Estuarine habitats, increased flow under the proposed action, particularly during July and August of all but the wettest years, may result in greater depths, or greater diversity in habitats, which, in turn, potentially increase productivity and diversity of food resources for Green Sturgeon. Increased flows during the summer and early fall in the Sacramento River, when Green Sturgeon spawn, may adversely impact and deepen scour holes used for spawning, but would also effectively flush out contaminants.

Reduced flows under the proposed action during winter and early spring have the potential to impact immigrating adults, but the flows will be high enough to prevent passage problems in the Sacramento River. In addition, higher proposed flows during late spring, summer, and early fall have the potential to benefit spawning, eggs, and larvae life stages, such as moving larvae and juvenile Green Sturgeon quickly to rearing habitats in the middle Sacramento, although they also may result in water temperatures too cold for effective Green Sturgeon juvenile rearing.

The proposed action has the potential to reduce sediment supply and turbidity due to reduced winter-spring inflow; however, the higher spring, summer, and fall flows under the proposed action would dilute contaminants present in Green Sturgeon critical habitat. The proposed action would adversely impact Green Sturgeon substrate type and size for Green Sturgeon spawning habitat during winter and early spring months in wet years due to high flows scouring gravels suitable for spawning. However, during the late spring and summer months, when Green Sturgeon spawn, flows under the proposed action benefit the suitability of gravel substrates by removing sediments for incubating embryos. The proposed action may reduce fine sediment habitat for Green Sturgeon prey, but may also improve fine sediment conditions in spawning habitat.

Therefore, Reclamation has determined that the proposed action may adversely affect components of Green Sturgeon critical habitat while also resulting in benefits to Green Sturgeon critical habitat.

7.2.14 Delta Smelt

The modeling results illustrate that once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions that include construction of the CVP and SWP facilities and other stressors, the operation of the CVP and SWP under the proposed action results in negative effects to Delta Smelt, including adult and larval/early juvenile entrainment at the south Delta and other water diversion facilities; extent of low salinity rearing habitat through less Delta outflow or south Delta export effects in certain year types and seasons; and the diversion of water through the Rock Slough Intake. Positive effects include improved low salinity rearing habitat in drier year types and seasons (e.g. summer) and actions to address the effects of degraded habitat and invasive species on the food web. OMR management would reduce entrainment risk. The extent of the other potential adverse effects are generally uncertain.

Additional adverse effects under the proposed action would occur from proposed construction, maintenance, and monitoring activities. These effects might include potentially scoured and eroded habitat within waterways adjacent to restored areas following levee breaching; disturbance of Delta Smelt within some distance (e.g., ~100 feet, depending on tidal currents) of levee breach locations as a result of sediment plumes, noises, and vibrations; changing hydraulics because of breaching which could lead to exposure to residual (historically used) agricultural pesticides and other contaminants; and direct effects

from excavation (physical injury or death), or indirect effects through disruption of normal behavior resulting in increased predation.

Effects to Delta Smelt could include temporary or permanent loss of habitat; exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability; potential harm from accidental release of construction-related hazardous materials, chemicals, and waste; and effects from inadvertent spread of invasive or nuisance species. The magnitude of these effects is low. Construction and maintenance effects would be limited through avoidance and minimization measures, with minor effects also expected from monitoring.

The proposed action would also provide beneficial effects to Delta Smelt, primarily through operations of SMSCG for 60 days in June–September of above normal and below normal years, which would increase juvenile and subadult Delta Smelt access to relatively food-rich habitat. Several conservation measures are included to avoid and minimize or compensate for effects of the proposed action, including continuing tidal habitat restoration (8,000 acres) in the Delta; Tracy and Skinner Fish Facility improvements; and construction and operation of a Delta Fish Species Conservation Hatchery. A suite of programmatic actions to improve habitat and facilities are also part of the proposed action. Among the actions potentially benefiting Delta Smelt are reconnection of the Sacramento Deepwater Ship Channel with the Sacramento River, which together with nutrient addition could increase food availability for Delta Smelt in the north Delta; introduction of dredge material to increase turbidity; a Central Valley-wide and Delta small diversion screening program; Skinner and Tracy fish facility improvements; and provision of lower San Joaquin River spawning and rearing habitat and Putah Creek Yolo Bypass realignment restoration, which could export food from floodplains to Delta Smelt habitat.

In summary, there may be incidental take associated with the proposed action through:

- Cumulative direct and indirect loss associated with export operations including loss in south Delta interior, loss at export facilities, altered hydrodynamics, and operation of the DCC. Loss from adult and larval/early juvenile entrainment, impingement, and predation at the Delta pumps and other water diversion facilities.
- Reduction in the extent of low salinity rearing habitat through less Delta outflow or south Delta export effects
- Temporary and permanent loss of habitat
- Exposure to increased suspended sediment and turbidity leading to changes in habitat quality and foraging ability
- Potential harm from accidental release of construction-related hazardous materials, chemicals and waste
- Effects from inadvertent spread of invasive or nuisance species.
- Clifton Court aquatic mechanical weed removal and predator management.
- Diversion of water through the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF.
- Monitoring activities supporting the proposed action may result in harassment or mortality.

Therefore, while the proposed action is likely to have some beneficial effects, it is likely to adversely affect Delta Smelt.

7.2.15 Delta Smelt Incidental Take Considerations

Conservation measures and other beneficial actions provided in this biological assessment for USFWS to consider when developing an Incidental Take Statement include:

- Management of OMR reverse flows based on near real-time monitoring, fish behavioral cues, predictive tools, and salvage.
- Management of habitat acreage, creation of low salinity zone habitat in Suisun Marsh, food subsidies, and restoration.
- Operation of the Fish Conservation and Culture Lab to supplement wild populations and support development of a Delta Fish Species Conservation Hatchery.
- Operation of the Tracy and Skinner salvage facilities.

Reclamation anticipates continued collaboration in a science enterprise to implement and evolve the EDSM program as well as ongoing restoration and recovery actions developed in collaborative forums using Structured Decision Making. Reclamation and DWR-led efforts welcome USFWS participation and would include progress reports in annual reporting under the ITS.

7.2.16 Delta Smelt Critical Habitat

Within critical habitat for Delta Smelt, PBFs are considered essential to the conservation of the species. Once the effects of the ongoing operation of the CVP and SWP are isolated from baseline conditions, the proposed action would result in adverse effects to the physical habitat PBF (through reduction of spawning substrate), the water quality PBF (through reductions in food availability and turbidity), the river flow PBF (through entrainment risk), and the salinity PBF (through changes in location and reduction in extent of low salinity zone habitat) in certain years and seasons. The proposed action would result in beneficial effects to the salinity PBF (through changes in location and increase in extent of low salinity zone habitat) in certain years and seasons. Adverse effects to Delta Smelt critical habitat would also occur from construction of conservation measures and maintenance. Construction and maintenance effects would be temporary and limited through avoidance and minimization measures.

Beneficial effects to Delta Smelt critical habitat from the proposed action include reduced salinity in Suisun Marsh through operation of the SMSCG for 60 days in June through September of above normal and below normal years, increasing habitat suitability in a food-rich environment, as well as food subsidies from the Sacramento Deepwater Ship Channel, and Colusa Basin Drain. The water quality and physical habitat PCE would continue to be positively affected by the 8,000 acres of tidal habitat restoration in the Delta associated with the proposed action, which would increase food availability and extent of spawning substrate. The programmatic actions described previously could also contribute beneficial effects to the various PCEs of Delta Smelt critical habitat and reduce the extent of the adverse effects of the proposed action on Delta Smelt critical habitat.

Therefore, the proposed action results in both beneficial and adverse effects to Delta Smelt critical habitat.

7.2.17 Eulachon, Southern DPS

Under the proposed action, Trinity River at Lewiston flows would contribute less to flow entering the lower Klamath River during December–April. The timing coincides with Eulachon spawning in the Klamath River and larvae being transported to the estuary and ocean. The proposed action overall slightly

increases flows from the Trinity River in May, which is the month when the Trinity River provides the largest portion of the Klamath River flows. It is uncertain the extent to which there may be negative effects because of these differences, given the lack of quantitative relationships between biological performance and flow, but mechanisms include food transport and water temperature. Flows under the proposed action would not be appreciably lower in the lower Klamath River. Flow from the Trinity River under the proposed action during December–April generally aligns with the preferred water temperatures for spawning Eulachon. Flows and water temperature differences under the proposed action are insignificant and, therefore, are not likely to adversely affect Eulachon spawning temperatures in the lower Klamath River.

The proposed action may affect, but is not likely to adversely affect Eulachon.

7.2.18 Eulachon, Southern DPS Critical Habitat

Eulachon critical habitat PBFs include water flow, quality, and temperature conditions, and substrate supporting spawning and incubation. Under the proposed action, Trinity River flows would be less during December–April, a time when Trinity River flows form a small percentage of flow entering the lower Klamath. Flows from Trinity River would be similar under the proposed action during May, a time when Trinity River flows form a larger percentage of Klamath River flows. The proposed action does not physically obstruct migration corridors or freshwater spawning and incubation sites in the lower tidal Klamath River but could reduce water flow and quality during the main historical period of spawning migration.

The proposed action may affect, but is not likely to adversely affect Eulachon critical habitat.

7.2.19 Southern Resident Killer Whale

Effects of the proposed action to SRKW are examined within the context of changes in the availability of its preferred prey, Chinook salmon. As stated above in the effects analysis for each Chinook salmon run, the proposed action will have negative impacts to individual Chinook salmon from both the Core Water Operation and construction of conservation measures. Despite these negative effects to Chinook salmon individuals, the proposed action results in an overall beneficial effect to the different Chinook salmon populations in the Central Valley. Beneficial effects include summer/fall water temperatures favorable for rearing of early Chinook salmon life stages; provision of gravel for spawning habitat in the upper Sacramento River; restoration of rearing habitat between Keswick and Red Bluff; trap and haul for salmonid juveniles from the upper Sacramento River to downstream of the Delta in drought years; increased Winter-Run Chinook Salmon hatchery production in drought years; implementation of spawning and rearing habitat projects in the American River; continued maintenance at restoration sites in the American River; drought temperature management in the American River; 8,000 acres of habitat restoration in the Delta and Tracy; and Skinner fish facility improvements, among others. A suite of programmatic actions to improve habitat and facilities are also proposed. Among those potentially benefiting Chinook salmon are a Central Valley-wide small diversion screening program, DCC improvements, Skinner and Tracy fish facility improvements, spawning and rearing habitat restoration, and improvements to the Shasta Dam TCD.

When combined with lack of effects to hatchery production, the proposed action is not likely to reduce prey availability for SRKW. Therefore, the proposed action may affect, but is not likely to adversely affect SRKW.

7.2.20 Southern Resident Killer Whale Critical Habitat

Critical Habitat for SRKW is located outside of the action area. Therefore, the designated critical habitat will not be affected by the proposed action.

7.3 Terrestrial Effects Determinations

The procedure for analyzing effects on terrestrial species is described in Section 13. As there described, various data sources were used to identify potentially affected acreages of suitable habitat for each species; in most cases suitable habitat was identified using either a USFWS species range map or a pre-existing habitat model for the species. Table 5.23-1 identifies which components of the PA have the potential to affect each terrestrial species, in which watersheds those effects may occur, and whether each component was evaluated at the specific or programmatic level; in this context “specific” indicates that this biological assessment is intended to support a request for concurrence or incidental take authorization by USFWS, while “programmatic” indicates that this biological assessment is intended to support a jeopardy or adverse modification determination by USFWS. Table 7.3-1 summarizes the acreage of suitable habitat affected for each species, and whether the affected acreage is linked to specific or programmatic components of the PA. The effects determinations for each federally listed terrestrial species and any designated critical habitat that may be affected by the proposed action are provided below.

Table 7.3-1. Affected Areas and Mitigation

| Component | Amount Affected (Acres Unless Otherwise Specified) |
|-------------------------------------------------------------|---------------------------------------------------------------|
| American River Watershed, Western Yellow-Billed Cuckoo | 40 |
| American River Watershed, Valley Elderberry Longhorn Beetle | 40 acres or 36 shrubs |
| Bay-Delta Region, Salt Marsh Harvest Mouse | 1,748 |
| Bay-Delta Region, Valley Elderberry Longhorn Beetle | 88 acres or 79 shrubs |
| Bay-Delta Region, Giant Garter Snake | 755 |
| Feather River Watershed, Western Yellow-Billed Cuckoo | 89 |
| Feather River Watershed, Valley Elderberry Longhorn Beetle | 23 shrubs |
| San Joaquin River Watershed, Riparian brush rabbit | 345 riparian and 470 grassland |
| San Joaquin River Watershed, Riparian Woodrat | 76 plus 200 inundation consistent with AMM-RBR/RWR |

| Component | Amount Affected (Acres Unless Otherwise Specified) |
|---------------------------------------------------------------------|---------------------------------------------------------------|
| San Joaquin River Watershed, Least Bell's Vireo | 28 |
| San Joaquin River Watershed, Western Yellow-billed Cuckoo | 11 |
| San Joaquin River Watershed, Valley Elderberry Longhorn Beetle | 278 (250 shrubs) |
| Stanislaus River Watershed, Least Bell's Vireo | 30 |
| Stanislaus River Watershed, Riparian Brush Rabbit | 10 riparian |
| Stanislaus River Watershed, Riparian Brush Woodrat | 10 |
| Stanislaus River Watershed, Western Yellow-billed Cuckoo | 73 |
| Stanislaus River Watershed, Valley Elderberry Longhorn Beetle | 44 shrubs |
| Upper Sacramento River Watershed, Giant Garter Snake | 34 acres aquatic and 266 acres upland |
| Upper Sacramento River Watershed, Least Bell's Vireo | 10 |
| Upper Sacramento River Watershed, Western Yellow-billed Cuckoo | 67 |
| Upper Sacramento River Watershed, Valley Elderberry Longhorn Beetle | 60 shrubs |
| Total Across Watersheds | |
| All Watersheds, Riparian Brush Rabbit | 355 riparian and 470 grassland |
| All Watersheds, Riparian Woodrat | 86 plus 200 inundation consistent with AMM-RBR/RWR |
| All Watersheds, Salt Marsh Harvest Mouse | 1,748 |
| All Watersheds, Western Yellow-billed Cuckoo | 280 |
| All Watersheds, Least Bell's Vireo | 68 |
| All Watersheds, Giant Garter Snake | 1,055 |

| Component | Amount Affected (Acres Unless Otherwise Specified) |
|---------------------------------------------------|-------------------------------------------------------|
| All Watersheds, Valley Elderberry Longhorn Beetle | 492 shrubs |
| All other terrestrial species | 0 |

7.3.1 Riparian Brush Rabbit

The proposed action may result in loss of up to 90 acres of suitable but unoccupied riparian habitat for the species (permanent and temporary habitat loss are treated together because of the relatively long time required for riparian habitat to recover). The proposed action may also result in permanent loss of up to 25 acres and temporary loss of up to 20 acres of suitable but unoccupied adjacent grasslands. Floodplain restoration along the San Joaquin River may result in periodic flooding of up to 265 acres of suitable but unoccupied riparian and 425 acres of suitable but unoccupied adjacent grasslands for riparian brush rabbit. Reclamation will discuss appropriate mitigation ratios with USFWS. Reclamation will offset effects of periodic flooding by constructing refugia for riparian brush rabbits to use during flood events.

The proposed action may affect, is likely to adversely affect, riparian brush rabbit.

7.3.2 Riparian Woodrat

The proposed action may result in loss of up to 86 acres of suitable but unoccupied riparian habitat for the species (permanent and temporary habitat loss are treated together because of the relatively long time required for riparian habitat to recover). Floodplain restoration may result in periodic flooding of up to 200 acres of suitable but unoccupied riparian habitat for riparian woodrat. Reclamation will discuss appropriate mitigation ratios with USFWS, and will offset effects of periodic flooding by constructing refugia for riparian woodrats to use during flood events.

The proposed action may affect, is likely to adversely affect, riparian woodrat.

7.3.3 Salt Marsh Harvest Mouse

Adverse effects from Tidal Habitat Restoration would involve temporary loss of up to 1,748 acres. Over time, the restored and enhanced area is expected to be suitable for salt marsh harvest mouse and of higher long-term value for the species because it will be less vulnerable to sea level rise. Thus, the proposed action is expected to have a net beneficial effect on the species.

The proposed action may affect, is likely to adversely affect, salt marsh harvest mouse.

7.3.4 California Ridgeway's Rail

The restoration projects are outside the current range of the species. Over time, the restored and enhanced area is expected to be suitable for California Ridgeway's rail and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, and is not likely to adversely affect, California Ridgeway's rail.

7.3.5 Least Bell's Vireo

The proposed action may result in loss of up to 216 acres of suitable habitat within the species' range. Reclamation will avoid disturbance of occupied habitat and will avoid injury or mortality of least Bell's vireo. Reclamation will discuss appropriate mitigation ratios with USFWS.

The proposed action may affect, is likely to adversely affect, least Bell's vireo.

7.3.6 Western Yellow-Billed Cuckoo

The proposed action may result in loss of up to 221 acres of suitable habitat within the species' range. Reclamation will avoid disturbance of occupied habitat and will avoid injury or mortality of western yellow-billed cuckoo. Reclamation will discuss appropriate mitigation ratios with USFWS. The proposed action may affect, and is likely to adversely affect, western yellow-billed cuckoo.

7.3.7 Western Yellow-Billed Cuckoo Critical Habitat

Reclamation will avoid modification of habitat for this species within designated critical habitat units by avoiding disturbance of suitable habitat in these areas. The proposed action could provide for some different riparian species that require year-round flows, benefiting Western Yellow-Billed Cuckoo critical habitat.

The proposed action may affect, but is not likely to adversely affect western yellow-billed cuckoo critical habitat.

7.3.8 Giant Garter Snake

The proposed action may result in loss of up to 1,049 acres of giant garter snake aquatic and upland habitat. Reclamation will discuss appropriate mitigation ratios with USFWS.

The proposed action may affect, is likely to adversely affect, giant garter snake.

7.3.9 Valley Elderberry Longhorn Beetle

Adverse effects from the project components may involve removal of up to 440 elderberry shrubs. Reclamation will offset habitat loss through transplanting elderberry shrubs and planting new elderberry and associated plants consistent with USFWS guidelines.

The proposed action may affect, is likely to adversely affect, valley elderberry longhorn beetle.

7.3.10 Soft Bird's-Beak

Tidal habitat restoration will occur in areas where habitat is not currently suitable for soft bird's-beak, and no negative effects would be expected from restoration activities. Over time, the restored and enhanced area is expected to be suitable and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, but is not likely to adversely affect, soft bird's-beak.

7.3.11 Suisun Thistle

Tidal habitat restoration will occur in areas where habitat is not currently suitable for Suisun thistle, and no negative effects would be expected from restoration activities. Over time, the restored and enhanced area is expected to be suitable for the species and of higher long-term value for the species because it will be less vulnerable to sea level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, the proposed action is expected to have a wholly beneficial effect on the species.

The proposed action may affect, but is not likely to adversely affect, Suisun thistle.

7.3.12 Vernal Pool Tadpole Shrimp and Vernal Pool Fairy Shrimp

Although Tidal Habitat Restoration under the proposed action has the potential to occur where these species occur, Reclamation will avoid habitat that is occupied or assumed to be occupied by conducting surveys in potential habitat areas.

The proposed action may affect, but is not likely to adversely affect, vernal pool tadpole shrimp and vernal pool fairy shrimp.

7.3.13 California Tiger Salamander

Although Tidal Habitat Restoration under the proposed action has the potential to occur where this species occurs, Reclamation will avoid habitat that is occupied or assumed to be occupied by conducting surveys in potential habitat areas.

The proposed action may affect, but is not likely to adversely affect, California tiger salamander.

7.3.14 California Tiger Salamander Critical Habitat

Although Tidal Habitat Restoration under the proposed action has the potential to occur within a designated critical habitat unit for this species, Reclamation will avoid effects on any of the primary constituent elements of its habitat by conducting surveys in potential habitat areas.

The proposed action is not likely to adversely affect critical habitat for California tiger salamander.

7.3.15 California Least Tern

Although proposed action components occur where California least terns are potentially present, Reclamation will avoid nesting colony sites through surveys and monitoring. The restoration projects are expected to have a net benefit on the species by increasing food production.

The proposed action may affect, but is not likely to adversely affect California least tern.

7.3.16 California Red-Legged Frog

Although proposed action components occur where California red-legged frogs may have historically been present, the likelihood of occupancy of habitats along the Sacramento River downstream of Shasta

Dam is discountable as they have not been observed along the Sacramento River corridor downstream of Shasta Dam.

The proposed action may affect, but is not likely to adversely affect California red-legged frog.

7.4 Essential Fish Habitat

7.4.1 Pacific Coast Salmon

The proposed action would adversely affect Pacific Coast Salmon EFH, although the adverse effects would not be substantial. Adverse effects primarily would occur as a result of the proposed action reducing flow during winter/spring relative to without action conditions, which could affect EFH for juvenile Chinook Salmon in particular, for example by increasing travel time and predation risk. Other adverse effects could arise from construction and maintenance activities.

A number of factors would contribute to the proposed action not having a substantial effect on Pacific Coast Salmon EFH. Construction and maintenance effects under the proposed action would be limited through avoidance and minimization measure. Exposure would be limited relative to the overall extent of Pacific Coast Salmon EFH. Reservoir storage under the proposed action would allow summer/fall water temperatures to be favorable for rearing of early Chinook Salmon life stages. A number of conservation measures are included to avoid and minimize or compensate for effects of the proposed action, including provision of gravel for spawning habitat in the upper Sacramento River; restoration of rearing habitat between Keswick Dam and Red Bluff; implementation of spawning and rearing habitat projects in the lower American River; continued maintenance at restoration sites in the lower American River; drought temperature management in the lower American River; and continued implementation of 8,000 acres of habitat restoration in the Delta. A suite of programmatic actions to improve habitat are also proposed. Among those potentially benefiting Chinook Salmon are a Central Valley-wide small diversion screening program; Delta Cross Channel improvements; lower San Joaquin River spawning and rearing habitat restoration; and improvements to Shasta TCD.

7.4.2 Coastal Pelagic Species

The proposed action is not likely to adversely affect Coastal Pelagic Species EFH. Limited construction effects could occur for proposed action activities bordering EFH (e.g., Delta habitat restoration). AMMs would minimize effects. Operational effects of the proposed action on the salinity field in the Bay-Delta would be small relative to the salinity tolerance of Northern Anchovy. Overall effects to Coastal Pelagic Species EFH would be small relative to the overall extent of Coastal Pelagic Species EFH.

7.4.3 Pacific Coast Groundfish

The proposed action would adversely affect Pacific Coast Groundfish EFH, although the adverse effects would not be substantial. Limited construction effects could occur for proposed action activities bordering EFH (e.g., Delta restoration). Core Water Operation effects on the salinity field in the Bay-Delta would be small relative to the salinity tolerance of Starry Flounder, although reductions in spring Delta outflow relative to without action conditions could negatively affect abundance of Starry Flounder through effects on rearing habitat. Overall effects to Pacific Coast Groundfish EFH would be small relative to the overall extent of Pacific Coast Groundfish EFH.

Chapter 8 Literature Cited

8.1 Published References

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