BIOLOGICAL OPINION
For the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project

Service File No. 08FBTD00-2019-F-0164

U.S. Fish and Wildlife Service
Sacramento, California

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LIST OF ACRONYMS

Act	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.)
af	acre feet
AFRP	Anadromous Fish Restoration Program
AG	agricultural
AMM	Avoidance and Minimization Measure
AMP	Adaptive Management Program
BA	Biological Assessment
BCDC	Bay Conservation and Development Commission
BDFWO	San Francisco Bay-Delta Fish and Wildlife Office
BiOp	Biological Opinion
BMP	Best Management Practice
CAMT	Collaborative Adaptive Management Team
CCF	Clifton Court Forebay
CCPP	Clifton Court Pumping Plant
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHNSR	spring-run Chinook salmon
CHNWR	winter-run Chinook salmon
CNDDB	California Natural Diversity Database
CNOR	Candidate Notice of Review
COA	Coordinated Operation Agreement
Corps	U.S. Army Corps of Engineers
COS	Current Operations Scenario
CSAMP	Collaborative Science and Adaptive Management Program
CVFPB	Central Valley Flood Protection Board
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DCC	Delta Cross Channel
DHCCP	Delta Habitat and Conservation Conveyance Program
DJFMP	Delta Juvenile Fish Monitoring Program
DOI	Department of the Interior
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DSM2	Delta Simulation Model II
DSP	Delta Science Program
DWR	Department of Water Resources
E/I	[Delta] export/inflow
EC	electrical conductivity
ECOS	Environmental Conservation Online System
EDSM	Enhanced Delta Smelt Monitoring
EPA	Environmental Protection Agency
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
FAST	Fishery Agency Strategy Team

FCCL	Fish Conservation and Culture Laboratory
FMWT	Fall Midwater Trawl
ft	feet or foot
FR	Federal Register
FRP	Fish Restoration Program
H	horizontal
ha	hectares
HCP	habitat conservation plan
HOR	Head of Old River
HORB	Head of Old River Barrier
I/E	[San Joaquin River] inflow/export
IEP	Interagency Ecological Program
IICG	Interagency Implementation and Coordination Group
ITS	Incidental Take Statement
LAA	Likely to Adversely Affect
LSZ	Low-Salinity Zone
LTO	Long-Term Operation
m	meter
MAF	million acre feet
MIDS	Morrow Island Distribution System
MHHW	Mean High Water
MLLW	Mean Low Water
MI	municipal and industrial
mg/L	milligrams per liter
mm	millimeter
m^3/s	cubic meters per second
NDOI	Net Delta Outflow Index
NLAA	Not Likely to Adversely Affect
NMFS	National Marine Fisheries Service
No.	number
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NWR	National Wildlife Refuge
OMR	Old and Middle river
PA	Proposed Action
PCE	Primary Constituent Elements
PP	pumping plant
ppt	parts per thousand
PRBO	Point Reyes Bird Observatory
Reclamation	U.S. Bureau of Reclamation
RM	river mile
ROC	Reinitiation of Consultation
RPA	Reasonable and Prudent Alternative
RRDS	Roaring River Distribution System
RTO	real-time operations
SBFNC	Suisun Bay Federal Navigation Channels

SCCF	South Clifton Court Forebay
SDWSC	Stockton Deep Water Ship Channel
Secretary	Secretary of the Interior
SERP	Small Erosion Repair Program
Service	U.S. Fish and Wildlife Service
SKT	Spring Kodiak Trawl
SLC	California State Lands Commission
SMSCG	Suisun Marsh Salinity Control Gates
SMUD	Sacramento Municipal Utility District
SPL	sound pressure level
sq	square feet
SR	State Route
SRDWSC	Sacramento River Deep Water Ship Channel
SRWTP	Sacramento Regional Wastewater Treatment Plant
Strategy	Delta Smelt Resiliency Strategy
SWP	State Water Project
SWPPP	Stormwater Pollution Prevention Plan
SWRCB	California State Water Resources Control Board
TAF	thousand acre feet
TNS	[Summer] Townet Survey
U.S.	United States
U.S.C.	United States Code
USGS	United States Geological Survey
V	vertical
Western	Western Area Power Administration
WIIN Act	Water Infrastructure Improvements for the Nation Act
WREM	Water Resources Engineering Memorandum
WQCP	Water Quality Control Plan
WSE	Water Surface Elevation
WY	water year
YBWA	Yolo Bypass Wildlife Area

INTRODUCTION

On August 2, 2016, the 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) (Project). The Service accepted the reinitiation request on August 3, 2016, and the National Marine Fisheries Service (NMFS) accepted the reinitiation request on August 17, 2016.

The reasons stated in Reclamation's August 2, 2016 request for reinitiation of consultation included "new information related to multiple years of drought and recent data demonstrating low delta smelt populations, and new information available and expected to become available as a result of ongoing work through collaborative science processes." On August 3, 2016, the Service agreed with the request citing "multiple dry years and new information. We recognize that this new information is demonstrating the increasingly imperiled state of the delta smelt and its designated critical habitat, and that emerging science shows the importance of outflows to all life stages of delta smelt and to maintaining the primary constituent elements of designated critical habitat."

On January 31, 2019, Reclamation transmitted the Reinitiation of Consultation (ROC) Biological Assessment (BA) to the Service. As stated in the BA, the purpose of this action is "…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 nonoperational measures to avoid significant adverse effects."

Updates to the regulations governing interagency consultation (50 CFR part 402) will become effective on October 28, 2019 [84 FR 44976]. Because this consultation was pending and will be completed prior to that time, we are applying the previous regulations to the consultation. However, as the preamble to the final rule adopting the new regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." Thus, had this BiOp been completed under the revised regulations, it would not have altered our analysis.

CONSULTATION HISTORY

The history of section 7 consultation on long-term operations of the CVP and SWP began in the early 1990's. Biological Opinions (BiOps) were issued by the Service in February 1994, March 1995 and July 2004, a reinitiation of the 2004 BiOp in February 2005, and the most recent BiOp was from December 2008. The consultation history up until December 2008 is hereby incorporated by reference from the December 15, 2008 *Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP)* (2008 BiOp). Additionally, the Service participated in Long-term Operations Biological Opinions (LOBO) Biennial Science Reviews, Collaborative Science and Adaptive Management Program (CSAMP)/Collaboration Adaptive Management Team (CAMT), 2008 BiOp Remand, Fish Restoration Program (FRP), Fishery Agency Strategy Team (FAST), and real-time operations meetings, too numerous to include in the itemized Consultation History, since the issuance of the 2008 BiOp.

The following is the Consultation History of long-term operations of the CVP and SWP since the 2008 BiOp was issued:

February 13, 2009: Reclamation requested reinitiation of consultation on the 2008 Service BiOp to temporarily modify D-1641 based on the forecast of a critically dry water year.

February 17, 2009: The Service responded to Reclamation's request that the proposed temporary modification to D-1641 is within the range of effects analyzed in the 2008 Service BiOp.

March 3, 2009: The Westlands Water District, San Luis and Delta Mendota Water Authority, DWR, Metropolitan Water District of Southern California, Kern County Water Agency, and a number of other water agencies and other entities filed a complaint in the U.S. District Court of the Eastern District of California (District Court) seeking to have the court set aside the 2008 BiOp.

December 14, 2010: The District Court issued a decision on motions for summary judgment, finding the 2008 BiOp arbitrary and capricious and remanding it to the Service for further consideration.

May 4, 2011: The District Court issued an amended Final Judgment, ordering the Service to complete a draft revised BiOp by October 1, 2011, and a final revised BiOp by December 1, 2013.

July 22, 2011: The Service accepted Reclamation's proposed operations consistent with Component 3, Action 4 of the 2008 BiOp Reasonable and Prudent Alternative (RPA).

August 22 through September 2, 2011: Reclamation provided the Service with updated project description information.

September 29, 2011: Reclamation issued a memorandum to the Service describing planned operations for the fall of 2011. The Service issued a memorandum to Reclamation stating that projected operations for the Fall of 2011 were expected to be consistent with Component 3 of the 2008 BiOp RPA.

December 13, 2011: Reclamation transmitted a memorandum to the Service outlining a process by which they intend to develop a new project description, including actions intended to protect listed species, through a National Environmental Policy Act (NEPA) process.

December 14, 2011: The Service transmitted a first draft BiOp to Reclamation to assist in their development of a BA.

February 12, 2013: Reclamation requested reinitiation of consultation as a precautionary measure on the incidental take of adult delta smelt.

February 13, 2013: The Service agreed to reinitiate the consultation with Reclamation.

February 22, 2013: The Service issued a memorandum to Reclamation correcting the incidental take statement for adult and larval/juvenile delta smelt.

April 19, 2013: Reclamation withdrew their request for reinitiation to address possible exceedance of the incidental take limit for adult delta smelt for that water year.

January 31, 2014: Reclamation requested concurrence that February 2014 drought response actions would not result in additional adverse effects to delta smelt or its critical habitat. The Service concurred with Reclamation's determination.

February 20, 2014: Reclamation requested concurrence that implementation of the proposed Old and Middle River Index Demonstration Project would result is no additional adverse effects to delta smelt or its critical habitat.

February 25, 2014: The Service acknowledged Reclamation's "no effect" determination on the proposed Old and Middle River Index Demonstration Project.

February 27, 2014: Reclamation requested concurrence that March 2014 drought response actions would not result in additional adverse effects to delta smelt or its critical habitat.

February 28, 2014: The Service concurred with Reclamation's February 27 determination.

March 13, 2014: The Ninth Circuit Court of Appeals reversed the District Court's decision and upheld the 2008 BiOp on ESA grounds, finding that it was not arbitrary and capricious.

April 8, 2014: Reclamation reinitiated consultation to address drought response actions for the remainder of that water year. The Service concurred that April and May 2014 actions would not result in additional adverse effects beyond those previously analyzed in the 2008 BiOp but requested additional information for the June through November 2014 actions.

May 1, 2014: Reclamation requested reinitiation of consultation to address drought response actions for June through November 2014. The Service concurred that the proposed changes would have no additional adverse effects on delta smelt or its critical habitat.

September 26, 2014: Reclamation requested reinitiation of consultation to address modified drought response actions for the beginning of Water Year 2015.

October 1, 2014: The Service concurred with Reclamation's September 26 determination that the proposed modified drought response actions would have no additional adverse effects on delta smelt or its critical habitat.

January 9, 2015: Reclamation requested reinitiation of consultation on the incidental take of adult delta smelt because the concern level was nearly reached. The Service completed reinitiation approving an interim methodology for calculating incidental take until it could be replaced with a proportional entrainment method.

January 27, 2015: Reclamation submitted additional information to their January 9, 2015 request seeking concurrence that drought response actions would result in no additional adverse effects on delta smelt or its critical habitat for the months of February and March 2015.

January 30, 2015: The Service accepted Reclamation's January 27 determination.

February 9, 2015: Reclamation requested reinitiation of consultation in response to a second consecutive year of dry or critically dry conditions.

February 10, 2015: The Service responded to Reclamation's February 9 reinitiation request. The Service concurred that Reclamation's drought response actions were not likely to result in additional adverse effects beyond what was analyzed in the 2008 BiOp.

March 24, 2015: Reclamation requested concurrence that the drought response modifications would result in no additional adverse effects on delta smelt or its critical habitat for April to September 2015.

March 27, 2015: The Service accepted Reclamation's March 24 determination.

May 22, 2015: Reclamation requested concurrence that the revised drought response modifications superseding and extending the March 24, 2015 request to November 2015 are consistent with the range of effects analyzed in the 2008 BiOp.

June 25, 2015: Reclamation submitted revised drought response modifications and requested concurrence that the modifications are consistent with the range of effects analyzed in the 2008 BiOp.

June 26, 2015: The Service accepted Reclamation's May 22 and June 25 determinations.

February 10, 2016: The U.S. Army Corps of Engineers (Corps) requested formal consultation on the Tule Red Tidal Restoration Project, a project proposed to partially fulfill RPA Component 4 of the 2008 BiOp.

February 22, 2016: The Corps requested formal consultation on the Yolo Flyway Farms Restoration Project, a project proposed to partially fulfill RPA Component 4 of the 2008 BiOp.

August 1, 2016: The Service issued a BiOp on the Tule Red Tidal Restoration Project to the Corps. When constructed the project would partially fulfill RPA Component 4 of the 2008 BiOp.

August 2, 2016: Reclamation requested reinitiation of consultation on long-term operations of the CVP and SWP.

August 3, 2016: The Service responded to Reclamation's August 2, 2016 request agreeing that reinitiation of consultation was warranted.

November 21, 2016: The Corps requested formal consultation on the Decker Island Tidal Habitat Restoration Project, a project proposed to partially fulfill RPA Component 4 of the 2008 BiOp.

December 16, 2016: The Water Infrastructure Improvements for the Nation Act (WIIN Act) was signed into law, including Section 4004(a) which provided that agencies cooperate with State and local agencies in reconsultation on coordinated operations of the CVP and the SWP.

December 19, 2016: Reclamation provided the Service a draft Annotated outline of a draft Biological Assessment for ROC on LTO.

December 30, 2016: The Service, NMFS, Reclamation, California Department of Fish and Wildlife (CDFW), and DWR entered into a Memorandum of Understanding. The purposes of this Memorandum were to describe the expected tasks, processes (including schedule development), and participants for the ROC on Long-Term Operation (LTO).

February 14, 2017: Reclamation convened a meeting with stakeholders and agencies to discuss the objectives, scope, and process for the ROC on LTO.

July 17, 2017: By this date, several water agencies requested and were granted Designated Non-Federal Representative status for the ROC on LTO consultation and to review and comment on the draft biological opinions and peer review process.

February 2017 through August 2018: Reclamation, the Service, NMFS, DWR, and CDFW held a series of agency meetings to discuss multiple topics related to the ROC on LTO. Topics included, but are not limited to, relationship to other consultations, scope, baseline, Proposed Action, technical teams, effects analyses, and the NEPA and California Environmental Quality Act processes. During this time, multiple geographic and topic-specific technical teams were also meeting to discuss ideas for proposed operations of the CVP and SWP and conservation measures.

March 8, 2017: The Service received a request from Reclamation for concurrence that the extension of the Corps permit for years 2017, 2018, 2019, and 2020, increasing the maximum diversion rate into Clifton Court Forebay (CCF) during the months of July, August, and September does not require a separate section 7 consultation.

March 16, 2017: Reclamation requested reinitiation as a precautionary measure to address increasing the incidental take threshold of adult delta smelt for 2017.

March 17, 2017: The Service acknowledged Reclamation's request and agreed to further analyze potential effects.

April 10, 2017: The Service issued a memorandum to Reclamation authorizing additional incidental take of adult delta smelt for the remainder of that water year.

June 7, 2017: The Service responded to Reclamation's March 8, 2017 request that the extension of the Corps permit does not require a separate consultation or reinitiation of the 2008 BiOp.

August 24, 2017: The Service issued a BiOp on the Yolo Flyway Farms Restoration Project to the Corps. When constructed the project would partially fulfill RPA Component 4 of the 2008 BiOp.

September 7, 2017: Reclamation requested reinitiation to address implementation of a one-month modification to Component 3, Action 4 of the 2008 BiOp.

September 26, 2017: The Service issued a memorandum to Reclamation concerning effects resulting from a proposed one-month modification to the Component 3, Action 4 of the RPA of the 2008 BiOp.

November 29, 2017: The Corps requested formal consultation on the Prospect Island Tidal Restoration Project, a project proposed to partially fulfill RPA Component 4 of the 2008 BiOp.

December 12, 2017: Reclamation, the Service, and NMFS met with representatives of the Yurok and Hoopa tribes to discuss issues and considerations for the ROC on LTO.

December 27, 2017: The Service received a request from Reclamation to modify the CCF Aquatic Weed Program under the 2008 BiOp.

January 19, 2018: Reclamation convened a Delta Technical Brainstorming Workshop for multiple stakeholders and agencies.

February 14, 2018: The Service issued a BiOp on the Decker Island Tidal Habitat Restoration Project to the Corps. When constructed the project would partially fulfill RPA Component 4 of the 2008 BiOp.

March 2, 2018: Reclamation convened a Track 1 discussion for multiple stakeholders and agencies.

March 5, 2018: The Service acknowledged Reclamation's request to modify the CCF Aquatic Weed Program and determined it did not result in effects not previously analyzed in the 2008 BiOp. The Service also acknowledged Reclamation's expectation that the modifications would be incorporated in the ROC.

May 7, 2018: The Service issued a BiOp on the Prospect Island Tidal Restoration Project to the Corps. When constructed the project would partially fulfill RPA Component 4 of the 2008 BiOp.

June 14, 2018: Reclamation requested reinitiation to address a proposed operation of the Suisun Marsh Salinity Control Gates in August 2018.

June 29, 2018: The Service determined that the August 2018 proposed operation of the Suisun Marsh Salinity Control Gates would not likely result in additional adverse effects to delta smelt or its critical habitat.

October 19, 2018: The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West directed the Secretaries of Interior and Commerce to streamline regulatory processes involving western water infrastructure.

November 19, 2018: The Department of the Interior and the Department of Commerce issued a reply pursuant to the October 19, 2018, Presidential Memorandum outlining the plans and deadlines for meeting several project-specific ESA and NEPA compliance requirements, including for the CVP.

November 2018 through January 2019: The Service participated in multi-agency meetings to discuss development of the BA.

January 28, 2019: The Service received the Corps request for formal consultation on the Winter Island Tidal Habitat Restoration Project, a project proposed to partially fulfill RPA Component 4 of the 2008 BiOp.

January 30, 2019: The Service issued a memorandum revising the incidental take statement for the 2008 BiOp.

January 31, 2019: Reclamation transmitted the BA for ROC on LTO.

February through October 2019: Per the WIIN Act, various meetings were held to discuss the Proposed Action and effects analyses between Reclamation, the Service, NMFS, CDFW, DWR, and stakeholders.

April 1, 2019: Reclamation transmitted revisions to Chapter 4 of the BA to the Service, NMFS, and stakeholders, which reflected changes to the Proposed Action.

April 12, 2019: The Service transmitted draft sections of the delta smelt and critical habitat analysis to the independent peer review panel, Reclamation, and DWR for review and comment. Reclamation transmitted the documents to stakeholders.

April 26, 2019 and May 3, 2019: Reclamation transmitted to the Service comments including comments from water users on the April 12, 2019 draft sections of the delta smelt and critical habitat analysis.

April 27 through 29, 2019: The Service received reports from the independent peer review reports on the draft sections of the delta smelt and critical habitat analysis.

April 30, 2019: Reclamation transmitted revisions to Chapter 4 of the BA to the Service and NMFS, which reflected changes to the Proposed Action.

June 6, 2019: The Service transmitted to Reclamation and DWR the draft sections of the analysis for delta smelt, delta smelt critical habitat, California clapper rail, California least tern, giant garter snake, least Bell's vireo, salt marsh harvest mouse, soft bird's-beak, soft bird's-beak critical habitat, Suisun thistle critical habitat, valley elderberry longhorn beetle, riparian brush rabbit, riparian woodrat. Reclamation transmitted the documents to stakeholders.

June 12, 2019: The Service received information to be considered in the development of the BiOp from a non-governmental organization.

June 14, 2019: Reclamation and DWR transmitted to the Service comments including comments from water users on the June 6, 2019 draft sections.

June 15, 2019: Reclamation transmitted revisions to Chapter 4 of the BA to the Service and NMFS, which reflected changes to the Proposed Action.

June 20, 2019: The Service met with Reclamation to discuss the draft Incidental Take Statement of this BiOp.

June 20 and 24, 2019: The Service received comments from DWR on the BiOp.

June 21, 2019: The Service transmitted the draft Incidental Take Statement to Reclamation.

July 9 through October 10, 2019: The Service participated in multi-agency meetings to discuss refinements to the Proposed Action and the Service's and NMFS' BiOps.

July 30, 2019: The Service transmitted the partial draft BiOp to an independent peer review panel, along with supplemental materials such as the revised Proposed Action and questions for which we were seeking input on our draft analysis. Reclamation shared these documents with stakeholders.

August 7, 2019: A conference call was held between the Service, other agency representatives, and the independent peer review panel to discuss their initial questions and comments.

August 9, 2019: Reclamation and the Service received comments from water users on the partial draft BiOp.

August 12, 2019: The Service received comments from the independent peer review panel on the partial draft BiOp.

September 18, 2019: The Service issued a memorandum to Reclamation concerning effects resulting from a proposed modification for part of September and all of October 2019 to the Component 3, Action 4 of the RPA of the 2008 BiOp. In a letter dated October 1, 2019, Reclamation stated that it would not implement the proposed modification.

October 3, 2019: Reclamation transmitted revisions to Chapter 4 of the BA to the Service and NMFS, which reflected changes to the Proposed Action.

October 17, 2019: Reclamation transmitted the Final BA to the Service and NMFS.

Peer Review

The Service obtained two separate peer reviews of its draft BiOp. The Service transmitted draft sections of the delta smelt and critical habitat analyses to independent peer review panels on April 12, 2019 through a contract with Anchor QEA, and on July 30, 2019 through a contract with Atkins. For the April review, three reviewers, Dr. Ron Kneib (Professor Emeritus, University of Georgia Marine Institute), Dr. Ernst Peebles (Professor, University of South Florida College of Marine Science), and Dr. Joe Merz (President, Principal Scientist, Cramer Fish Sciences), were selected from a pool of 33 potential reviewers, based on availability, knowledge, and experience. The reviews of these three experts were provided to the Service on April 29, 2019. The same three reviewers and a fourth reviewer (Dr. Mike Chotkowski, Science Coordinator, USGS) reviewed a second draft of the delta smelt portions of the BiOp in early August 2019 and the Service received these four expert reviews on August 12, 2019. In both April and August, the reviewers received relevant background information and supplemental materials to consider in their reviews. The Service was available during both reviews to respond to questions or address clarification needs during the reviews. This BiOp, and its supporting administrative record, considered all of the substantive recommendations from both peer reviews, as appropriate.

SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

The Service concurs with Reclamation's determination that the Proposed Action (PA) may affect but is not likely to adversely affect (NLAA) the California red-legged frog, California tiger salamander and its critical habitat, vernal pool fairy shrimp, and vernal pool tadpole shrimp. The PA occurs within the current and historic range of the California red-legged frog, California tiger salamander, vernal pool fairy shrimp, and vernal pool tadpole shrimp; however, the major components of the PA occur within riparian habitat along major rivers that are unlikely to support these species. For restoration projects associated with the PA that have known occurrences of the California red-legged frog, California tiger salamander, vernal pool fairy shrimp, and vernal pool tadpole shrimp, Reclamation has proposed to avoid suitable habitat that support these species with a minimum 250-foot non-disturbance buffer. Reclamation will also either conduct protocol-level surveys to assess whether habitat is occupied or will assume presence of the species. Reclamation will avoid affecting any of the primary constituent elements of critical habitat for the California tiger salamander within any designated critical habitat units located in the Action Area.

1.0 CONSULTATION APPROACH

The purpose of this section 7 consultation is to evaluate the effects of the PA on listed species and designated critical habitat. After reviewing the PA with site specific and programmatic actions as proposed by Reclamation, the Service has determined that the PA presents a mixed programmatic action, as defined in 50 CFR 402.02. The Service's consultation includes a mix of standard consultation (which includes an Incidental Take Statement [ITS]) and programmatic consultation (for which an ITS is not required at the programmatic stage). An analysis and conclusion of whether or not the PA is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of their critical habitat is included in this BiOp. It is recognized that subsequent site-specific actions authorized, funded, or carried out under the programmatic actions addressed in this BiOp will be subject to subsequent section 7 consultation and ITSs, as appropriate. Changes to the site-specific actions in the standard consultation of this BiOp may require reinitiation of consultation.

Some of the project elements are described at a site-specific level with no future Federal action required. For other project elements, the PA describes activities in on-going programs, some of which can tier to or append to existing programmatic consultations, and other activities which will require subsequent consultations prior to implementation. This BiOp uses a framework programmatic approach to discuss the process for future project-specific consultations. The remainder of the project elements not addressed programmatically are addressed as a standard, project-level consultation because they are not subject to future Federal approvals. For framework programmatic actions, an ITS is not required at the program (framework) level for those actions falling within the definition of framework programmatic action (50 CFR 402.02). Therefore, this BiOp contains an ITS for those standard, site-specific consultation elements for which incidental take is reasonably certain to occur for an individual species.

Programmatic portions of the PA will require separate section 7 consultations as part of the subsequent approval. These portions of the PA are not authorized to commence until these separate consultations are completed.

For components of the PA that are defined as programmatic, this BiOp provides a framework for future, site-specific actions that are subject to section 7 consultations and ITSs. Subsequent consultations associated with these programmatic actions will develop the necessary site-specific information to inform an assessment of where, when, and how listed species are likely to be affected. Many of these programmatic components are part of larger programs that have existing programmatic consultations or previously analyzed activities within these programs that have stand-alone consultations. Future components of the PA, such as tidal marsh restoration, will be developed and implemented in a manner that is consistent with on-going planning efforts and the framework established within the existing programmatic consultations and stand-alone consultations. Measures will be included to minimize adverse effects to listed species consistent with or better than existing consultations within the programs. For example, future tidal marsh restoration projects intended to enhance food web for delta smelt to minimize the effects of the CVP and SWP will be developed within the existing FRP/FAST process. A restoration project within the Suisun Marsh will be appended to the Suisun Marsh Plan Programmatic Biological Opinion and will adhere to the process and conservation measures of that consultation. An Anadromous Fish Restoration Program (AFRP) project will continue to utilize the existing planning and consultation process. Species under the Service's jurisdiction that may be affected by programmatic components of the PA that will be addressed through existing programmatic consultations or subsequent consultation consistent with the framework in this BiOp are listed below in Table 1-1.

Table 1-1: Consultation Approach for Programmatic Components of the Proposed Action

Component	Existing Programmatic	Subsequent Consultation to this BiOp
Upper Sacramento Spawning and Rearing Habitat Restoration	Upper Sacramento River AFHRP Programmatic	Not necessary if utilizing the existing programmatic
Yellow-billed Cuckoo Surveys	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this activity
American River Spawning and Rearing Habitat Restoration	American River AFHRP Programmatic	Not necessary if utilizing the existing programmatic
Small Screen Program	Installation of Small Fish Screens Programmatic Biological Opinion	Not necessary if utilizing the existing programmatic
Stanislaus River Spawning and Rearing Habitat Restoration	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this activity

Lower San Joaquin River Habitat Restoration	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this activity
Sacramento Deepwater Ship Channel Food Study	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this study
North Delta Food Subsidies/Colusa Basin Drain Study	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this study
Suisun Marsh Roaring River Distribution System Food Subsidies Study	None	Reclamation will complete subsequent consultation when more details are developed for implementation of this study
Tidal Habitat Restoration (Complete 8,000 acres from 2008 BiOp)	Suisun Marsh Plan Programmatic Biological Opinion	For areas outside Suisun Marsh Plan Programmatic Action Area, Reclamation will ensure that subsequent consultation will occur when more details are developed through the existing FRP/FAST process
Predator Hot Spot Removal in the Bay-Delta	None	Reclamation will complete subsequent consultation when more details are developed for this activity
Delta Fish Species Conservation Hatchery	None	Subsequent consultation will be completed when more details are developed for this activity

2.0 DESCRIPTION OF THE PROPOSED ACTION

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. Operations are in accordance with the Coordinated Operations Agreement, as amended (COA), between Reclamation and DWR. Chapter 4 of the BA describes in more detail how these two agencies work together to carry out storage, diversion, and conveyance of water through the CVP and SWP. Reclamation has proposed the term of this consultation to be through the year 2030. This BiOp evaluates Reclamation's final PA transmitted to the Service on October 4, 2019. The Service recognizes that Reclamation is continuing to evaluate the PA and other alternatives pursuant to the National Environmental Policy Act (NEPA). If the PA is modified through the NEPA process, the Service expects that Reclamation will reinitiate consultation on the modified proposed action as appropriate.

Table 4-6 of the BA includes all components of the PA that may affect listed species and critical habitat under the jurisdiction of both the Service and NMFS. Table 2-1 below is a summary of this table from the BA but removes components that only affect NMFS species and/or critical habitat and are therefore not relevant to this BiOp. Table 2-1 includes only those components of the PA which affect or are proposed to minimize the effect to Service listed species and critical habitat. Therefore, the effects analysis of this biological opinion only addresses effects of the PA components in Table 2-1.

There are several components of the PA that have already been addressed in previous consultations. There are also components of the PA that Reclamation is not authorizing, funding, or carrying out as part of this consultation. These were included in the PA because they are factors in long-term operations of the CVP and SWP. These components are listed in Section 4.10 of the BA but are not included in Table 2-1 below. Components of the PA that have already been analyzed in previous consultations are included in the Environmental Baseline as Federal actions that have already undergone consultation that contribute to the current condition of the species and critical habitat in the Action Area pursuant to the section 7 of the ESA. Those components will be addressed in the jeopardy and adverse modification analyses in this biological opinion pursuant to the *Analytical Framework for the Jeopardy Determination* and the *Analytical Framework for the Adverse Modification Determination*.

The PA includes avoidance and minimization measures (Appendix E of the BA) that will be implemented as necessary and appropriate for components of the PA. For the components addressed programmatically, a determination of which measures will be implemented will be made during the subsequent consultations. The Implementation Approach for each of the PA components are included in Table 2-1 below and described in Section 4.12 of the BA. All of these sections are hereby incorporated by reference from the BA into this BiOp.

The three proposed implementation approaches are generally described as follows (further details are provided in the BA):

- “Core” – the action is part of the Core Water Operations of the CVP and SWP.
- “Scheduling” – agencies and water users provide recommendations to Reclamation on scheduling and shaping specific flow actions.
- “Collaborative Planning” – agencies and water users work collaboratively to define, plan, and implement an action.

Table 2-1: Components of the Proposed Action

Project Component	Standard or Programmatic Consultation	Implementation Approach	Species that may be affected (NLAA and Likely to Adversely Affect [LAA])
CVP/SWP-Wide			
Divert and store water consistent with obligations under water rights and decisions by the State Water Resources Control Board	Standard	Core	Delta smelt, western yellow-billed cuckoo, valley elderberry longhorn beetle
Related Action			
Shasta Critical Determinations and Allocations to Water Service and Water Repayment Contractors and Agreements with Settlement and Exchange Contractors (see section 4.4 of the ROC BA for additional details of the PA as it relates to the Sacramento River Settlement Contracts)			
Upper Sacramento			
Seasonal Operations Reclamation proposes to operate Shasta according to general seasonal objectives (see BA for details). Winter operations will focus on flood control and maintaining minimum flows while building storage. Operations in the spring are focused on meeting instream demands along with Delta requirements such as outflow. During the summer, operational considerations include flows required for Delta outflows, instream demands, temperature control, and exports. Fall operations are dominated by temperature control and provision of fish spawning habitat.	Standard	Core	Western yellow-billed cuckoo, valley elderberry longhorn beetle
Spring Pulse Flows Reclamation would release spring pulse flows when the projected total May 1 Shasta Reservoir storage indicates a likelihood of sufficient cold water to support summer cold water pool management. Total storage provides a surrogate for the likely cold water pool and would inform the decision in addition	Standard	Scheduling	Western yellow-billed cuckoo, valley elderberry longhorn beetle

to monthly winter reservoir temperature measurements and climate forecasts. Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March, and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. Reclamation anticipates that a projected May 1 storage greater than 4 MAF provides sufficient cold water pool management for Tier 1 and may release the spring pulse if it does not impact the ability to meet project objectives. Reclamation could also determine, in coordination with the Upper Sacramento scheduling team, that while the reservoir is less than 4 MAF, there is sufficient water to do a pulse of up to 150 TAF. The Upper Sacramento scheduling team could also determine that the benefits of a spring pulse flow do not outweigh the potential negative impacts on the system, in which case Reclamation would not release one. Reclamation would also not make a spring pulse release if the release would cause Reclamation to drop into a Tier 4 Shasta summer cold water pool management (i.e., the additional flow releases would decrease cold water pool such that summer Shasta temperature management drops in Tier 4), would interfere with meeting performance objectives, or would interfere with the ability to meet other anticipated demands on the reservoir. The Upper Sacramento Scheduling Team would determine the timing, duration, and frequency of the spring pulse within the 150 TAF volume. Wet hydrology downstream of Keswick Dam may meet the need for pulse flows without increased releases.			
Operation of a Shasta Dam Raise There is a separate process and environmental impact statement for the Shasta Dam Raise, for which a Record of Decision and Biological Opinions have not been completed. Reclamation would not change operations described in the PA until the Shasta Dam Raise ROD and separate ESA consultations are completed. In the interim, Reclamation would operate the enlarged reservoir consistent with the operations and requirements of the PA.	Standard	Core	Western yellow-billed cuckoo, valley elderberry longhorn beetle

Salmonid Spawning and Rearing Habitat Restoration Reclamation proposes to create additional spawning habitat by injecting approximately 15,000 – 40,000 tons of gravel annually into Sacramento River to 2030. An additional 40-60 acres of side channel and floodplain habitat would be created by 2030. Refer to the BA for specific restoration sites.	Programmatic	Collaborative Planning	Western yellow-billed cuckoo, valley elderberry longhorn beetle
Yellow-billed Cuckoo Surveys Reclamation will coordinate with the Service to develop a baseline survey for the Western yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for the Western yellow-billed Cuckoo in the over-lapping project areas. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Western yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Western yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion. Additional details are incorporated by reference to the BA.	Programmatic	Collaborative Planning	Western yellow-billed cuckoo
American River			
Seasonal Operations Reclamation proposes to operate the American River Division according to general seasonal objectives (see BA for details). Winter operations will focus on flood control and maintaining minimum flows while building storage. Operations in the spring are focused on flood control and meeting Delta requirements. During the summer, operational considerations include summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows.	Standard	Core	Valley elderberry longhorn beetle, western yellow-billed cuckoo

Related Action			
2017 Flow Management Standard Releases and "Planning Minimum" Reclamation proposes to utilize a "planning minimum" forecast to preserve storage and build cold water pool while making adjustments to limit redd dewatering. This action includes a spring pulse flow from March 15- April 15 if no such flow event has occurred from February 1- March 1.			
Salmonid Spawning and Rearing Habitat Restoration Project activities include primarily side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions. Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the following projects: Paradise Beach, Howe Avenue to Watt Avenue rearing habitat, William Pond Outlet, Upper River Bend, Ancil Hoffman, El Manto, Sacramento Bar North, Sacramento Bar South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Upper Sailor Bar, Nimbus main channel and side channel, Discovery Park, Cordova Creek Phase II, Carmichael Creek Restoration and Sunrise Stranding Reduction. Additional sites are identified in the BA.	Programmatic	Collaborative Planning	Valley elderberry longhorn beetle, western yellow-billed cuckoo
Yellow-billed Cuckoo Surveys Reclamation will coordinate with the Service to develop a baseline survey for the Western yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for the Western yellow-billed Cuckoo in the over-lapping project areas. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Western yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Western yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after	Programmatic	Collaborative Planning	Western yellow-billed cuckoo

completion. Additional details are incorporated by reference to the BA.			
Stanislaus			
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. Seasonal operations will vary according to water year type and follow the Stepped Release Plan, described below.	Standard	Core	Western yellow-billed cuckoo, least Bell's vireo, valley elderberry longhorn beetle, riparian brush rabbit
Related action			
Stanislaus Stepped Release Plan Reclamation proposes to operate New Melones Reservoir in accordance with a Stepped Release Plan that varies by hydrologic condition/water year type. Annual release volumes range from 184.3 TAF to 476.3 TAF from critical year types up to wet year types, respectively (see BA for details). The Stanislaus Watershed Team will provide input on shaping the flows.			
Salmonid Spawning and Rearing Habitat Restoration Reclamation will continue to carry out CVPIA(b)(13) program goals of placing 4,500 tons of gravel annually in the Stanislaus River and construct 50 acres of rearing habitat by 2030.	Programmatic	Collaborative Planning	Western yellow-billed cuckoo, least Bell's vireo, valley elderberry longhorn beetle, riparian brush rabbit
Yellow-billed Cuckoo Surveys Reclamation will coordinate with the Service to develop a baseline survey for the Western yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for the Western	Programmatic	Collaborative Planning	Western yellow-billed cuckoo

yellow-billed Cuckoo in the over-lapping project areas. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Western yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Western yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after completion. Additional details are incorporated by reference to the BA.			
San Joaquin			
Lower San Joaquin River 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. 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.	Programmatic	Collaborative Planning	Riparian brush rabbit, riparian woodrat, western yellow-billed cuckoo, valley elderberry longhorn beetle
Yellow-billed Cuckoo Surveys Reclamation will coordinate with the Service to develop a baseline survey for the Western yellow-billed cuckoo. The survey for this action would focus on the critical habitat areas, associated project sites, and occupied habitat within the action area. In addition, the baseline survey would incorporate the efforts from the Yolo Restoration Project and other related projects when conducting protocol-level surveys for the Western yellow-billed Cuckoo in the over-lapping project areas. In addition, Reclamation will follow the nesting bird protocols during construction activities and consider the needs of Western yellow-billed cuckoo when designing and implementing salmonid habitat restoration projects. Results of Western yellow-billed cuckoo surveys and findings from ecological surrogate models shall be shared with the U.S. Fish and Wildlife Service Bay-Delta Fish and Wildlife Office no later than 120 days after	Programmatic	Collaborative Planning	Western yellow-billed cuckoo

completion. Additional details are incorporated by reference to the BA.			
Bay-Delta			
Seasonal Operations Reclamation proposes to operate facilities in the Delta according to general seasonal objectives (see BA for details). Winter and spring pumping operations generally maximize exports of excess, unregulated, and unstored water to help meet project demands later in the season and for Delta water quality. 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. 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.	Standard	Core	Delta smelt, delta smelt critical habitat
Minimum Export Rate 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.	Standard	Core	Delta smelt, delta smelt critical habitat
Delta Cross Channel Operations Reclamation operates the DCC gates 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)	Standard	Core	Delta smelt, delta smelt critical habitat

reduce salinity intrusion rates in the western Delta. Reclamation will operate the DCC gates to reduce juvenile salmonid entrainment risk from Oct 1 to May 20. Reclamation and DWR will form a risk assessment to determine whether or not to open the DCC. 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. 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 and Table 4-14 in the BA to determine whether to close the DCC gates and for how long. From December 1 to January 31, the DCC gates will be closed. If drought conditions are observed (i.e. fall inflow conditions are less than 90% of historic flows) Reclamation and DWR will consider opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR will coordinate with the Service, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect, or a greater range of an adverse effect, not considered under this proposed action, Reclamation will not open the DCC. During a DCC gates opening between December 1 and January 31, the CVP and SWP will divert at Health and Safety pumping levels. From February 1 to May 20, the DCC gates will be closed consistent with D-1641. From May 21 to June 15, Reclamation will close the DCC gates for 14 days during this period, consistent with D-1641.			
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 71.6°F.	Standard	Core	Delta smelt, delta smelt critical habitat

Contra Costa Water District Rock Slough Operations CCWD intakes and Los Vaqueros Reservoir operations are under biological opinions separate from ROC on LTO (see Section 4.10.5.6 of the BA). Reclamation has included all diversions at the Rock Slough Intake (350 cfs capacity for the maximum annual diversion of 195 TAF) as part of the PA. CCWD's operations in the PA are consistent with the separate biological opinions and remain unchanged from the current operations scenario.	Standard	Core	Delta smelt, delta smelt critical habitat
North Bay Aqueduct The North Bay Aqueduct (NBA) and Barker Slough Pumping Plant (BSPP) will operate under applicable regulatory requirements with a 125 TAF maximum annual diversion through the NBA. The maximum daily diversion rate for the Pumping Plant is 175 cfs. Reclamation and DWR will work with the Service to develop delta smelt minimization measures by the end of the 2019 calendar year to address the increased diversion volume. These minimization measures will aim to protect larval delta smelt from entrainment through the BSPP and will consider reduction in diversion through the NBA at the appropriate spring period and appropriate water year types by using effective detection measures or an appropriate proxy. Maintenance operations include sediment build-up removal and aquatic weed removal at the fish screens.	Standard	Core	Delta smelt, delta smelt critical habitat
Suisun Marsh Salinity Control Gates 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.	Standard	Core	Delta smelt, delta smelt critical habitat

The SMSCG are operated on an as needed basis to meet D-1641 water quality standards in Montezuma Slough. The water quality standard include the period between October through May. Operations are determined from data at D-1641 compliance stations, hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The duration of gate operation may range from no use to full use for the entire October through May period. Assuming no significant long-term changes in the operational data mentioned above, it is expected that gate operations (outside of additional actions described under Delta Smelt Summer-Fall Habitat Action) will remain at current levels (17-69 days) necessary to meet D-1641 standards. During drought conditions, gate operations are more likely to span the entire October through May period to meet D-1641 standards.			
Roaring River Distribution System 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 a maximum approach velocity of 0.2 ft/second at the intake fish screen except during mid-September – mid October, when RRDS diversion rates are controlled to maintain a maximum approach velocity of 0.7 ft/second for fall flood up operations.	Standard	Core	Delta smelt, delta smelt critical habitat
Morrow Island Distribution System 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	Standard	Core	Delta smelt, delta smelt critical habitat

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. The Goodyear Slough Outfall (GYSO) connects the south end of Goodyear Slough to Suisun Bay. Prior to construction of the outfall, Goodyear Slough was a dead-end run slough. The GYSO was designed to increase circulation and reduce salinity in Goodyear Slough so as to provide higher water quality to the wetland managers who flood their ponds with Goodyear Slough water. GYSO has a series of four passive intakes that drain to Suisun bay. The outfall is equipped with slide gates on the interior of the outfall structure to allow DWR to close the system as needed for maintenance or repairs. The intakes and outfall of GYSO are unscreened but are equipped with trash racks to prevent damage. GYSO is an open system and it is possible that fish that enter the system could leave via the intake or the outfall.			
Water Transfers Water transfers would occur from July 1 through November 30 in total annual volumes up to those described in Table 4-15 of the BA, up to 600 TAF for Critical and Dry (following Critical and Dry years), and up to 360 TAF in all other years.	Standard	Core	Delta smelt, delta smelt critical habitat
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. DWR will apply herbicides after CCF water temperatures are above 25 degrees Celsius or after June 28. Mechanical harvest will occur as needed. Details provided in the BA are incorporated by reference.	Standard	Core	Delta smelt

OMR Management From the onset of OMR management to June, 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 (described below). OMR could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered as (described below) or constraints other than OMR control exports. Reclamation and DWR propose to operate to an OMR index computed using an equation. An OMR index allows for shorter-term operational planning and real-time adjustments. 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. The 3-day trigger allows for efficient power scheduling. **<u>Onset of OMR Management:</u>** 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): To minimize project influence on migration (or dispersal) of delta smelt, 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 -2,000 cfs, in response to "First Flush" conditions in the Delta. The population-scale migration of delta smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo *et al*. 2009; Sommer *et al.* 2011). Thereafter, the best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polanksy *et al*. 2018). "First Flush" conditions may be triggered between December 1 and January 31 and include: o running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and o running 3-day average of the daily turbidity at Freeport is 50 Nephelometric Turbidity Units (NTU) or greater, or	Standard	Core	Delta smelt, delta smelt critical habitat

o real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment. • This "First Flush" may only be initiated once during the December through January period and will not be required if: o spent female delta smelt are collected in monitoring surveys. • Salmonids Presence: 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 and Performance Objectives:** 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"): After the Integrated Early Winter Pulse Protection (above) or February 1, whichever comes first, and until a ripe or spent female is detected or April 1 (whichever comes first), 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. The purpose of this action is to minimize the risk to adult delta smelt in the Old and Middle River corridor, where they are subject to higher entrainment risks. This action seeks to avoid the formation of a turbidity bridge from the San Joaquin River shipping channel to the south Delta fish facilities, which historically has been associated with elevated salvage of pre-spawning adult delta smelt. If the daily average turbidity at Bacon Island cannot be maintained less than 12 NTU, Reclamation and DWR will manage exports to achieve an OMR no more negative than -			

2,000 cfs until the daily average turbidity at Bacon Island drops below 12 NTU. However, if 5 consecutive days of OMR less negative than -2,000 cfs do not reduce turbidity at Bacon Island below a daily average 12 NTU in a given month, Reclamation and DWR may determine that additional OMR restrictions to manage turbidity are infeasible, and will instead implement an OMR target that is deemed protective, based on turbidity, adult Delta smelt distribution and salvage, but not a more negative OMR than -5,000 cfs. To avoid triggering an OMR flow action during a sensor error or a localized turbidity spike that might be caused by local flows or a wind-driven event, Reclamation and DWR will consider and review data from other locations. In the event that the daily average turbidity at OBI is 12 NTU (or greater) and Reclamation and DWR determine that a Turbidity Bridge Avoidance action is not warranted based on additional data sources (isolated and/or wind-driven turbidity event at OBI), Reclamation and DWR will take no additional action and provide the supporting information to the Service within 24 hours. • Larval and Juvenile Delta Smelt: Reclamation and DWR will use results produced by USFWS approved life cycle models to manage the annual entrainment levels of larval/juvenile Delta Smelt. The Service's models will be publicly vetted and peer reviewed prior to March 15, 2020. The USFWS will coordinate with the Delta Fish Monitoring Working Group to identify a Delta smelt recruitment level that Reclamation and DWR can use in OMR management. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. In this context, recruitment is defined as the estimated number of post-larval delta smelt in June per number of spawning adults the prior February-March.			

Reclamation and DWR, in coordination with the Service will operationalize the life cycle model results through the use of real-time monitoring for the spatial distribution of Delta Smelt. On or after March 15 of each year, if QWEST is negative, and larval or juvenile delta smelt are within the entrainment zone of the pumps based on real-time sampling of spawning adults or young of year life stages, Reclamation and/or DWR will run hydrodynamic models and forecasts of entrainment, informed by the EDSM or other relevant survey data to estimate the percentage of larval and juvenile delta smelt that could be entrained. If necessary, Reclamation will manage exports to limit entrainment to be protective based on the modeled recruitment levels. Reclamation and DWR will re-run hydrodynamic models when operational changes or new sampling data indicate a potential change in entrainment risk. This process will continue until the offramp criteria have been met as described in the "End of OMR Management" below. In the event the life cycle models cannot be operationalized in a manner that can be used to inform real-time operations then Reclamation, DWR and the Service will coordinate to develop an alternative plan to provide operational actions protective of this life stage. • Cumulative Loss Threshold: ○ Reclamation and DWR propose to avoid exceeding cumulative loss thresholds over the duration of the Biological Opinions for wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April 1 through June 15th. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery			

Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria. o The cumulative loss thresholds shall be based on cumulative historical loss from 2010 through 2018. Reclamation's and DWR's performance objectives will set a trajectory such that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030. o If, at any time prior to 2024, Reclamation and DWR exceed 50% of the cumulative loss threshold, Reclamation and DWR will convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any. o In the year 2024, Reclamation and DWR will convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period. o If, during real-time operations, Reclamation and DWR exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from the Service and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with			

“Chartering of Independent Panels”* under the “Governance” section of the BA. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish. • Single-Year Loss Threshold: o In each year, Reclamation and DWR propose to avoid exceeding an annual loss threshold equal to 90% of the greatest annual loss that occurred in the historical record from 2010 through 2018 for each of wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April through June 15. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria. o During the year, if Reclamation and DWR exceed the average annual loss from 2010 through 2018, Reclamation and DWR will review recent fish distribution information and operations with the fisheries agencies at WOMT and seek technical assistance on future planned operations. Any agency may elevate from WOMT to a Directors discussion, as appropriate.			

○ During the year, if Reclamation and DWR exceed 50% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -3,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information. ○ The -3500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations. ○ During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -2,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information. ○ The -2500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations. ○ Risk assessment: Reclamation and DWR will evaluate and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring, historical trends of salmonids exiting the delta, entering the south Delta, and fish detected in salvage.			

Risks will be measured against the potential to exceed the next single-year loss threshold. Reclamation and DWR will share its technical analysis and supporting documentation with the Service and NMFS, seek their technical assistance, discuss the risk assessment and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate. o If, during real-time operations, Reclamation and DWR exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from the Service and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels"* under the "Governance" section of the BA. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish. Reclamation and DWR propose to continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protection Facility. Reclamation and DWR propose to continue the release and monitoring of yearling Coleman National Fish Hatchery late-fall run as yearling Spring-Run Chinook Salmon surrogates. **<u>Storm-Related OMR Flexibility:</u>** 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. A storm related event occurs when precipitation falls in the Central Valley and Delta watersheds and Reclamation and DWR determine that the Delta outflow index indicates a higher level of flow available for diversion. Reclamation and DWR will define storm-related events in the first year of implementation of this proposed action. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time OMR Restrictions," above. Under the following conditions, Reclamation and DWR shall not pursue storm-related OMR flexibility for capturing peak flows from storm-related events if: • Integrated Early Winter Pulse Protection (above) or Additional Real-time OMR Restrictions (above) are triggered. Under such conditions, Reclamation and DWR have already determined that more restrictive OMR is required. • An evaluation of environmental and biological conditions indicates more negative OMR would likely cause Reclamation and DWR to trigger an Additional Real-time OMR Restriction (above). • Salvage of yearling Coleman National Fish Hatchery late fall run as yearling Spring-Run Chinook Salmon surrogates exceeds 0.5% within any of the release groups. • Reclamation and DWR identify changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those anticipated to occur under OMR management. Reclamation and DWR will continue to monitor conditions and may resume management of OMR to no more negative than -5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in "Additional Real-Time OMR Restrictions", Reclamation and DWR will implement additional real-time OMR restrictions.			

End of OMR Management: OMR criteria may control operations until June 30 (for delta smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific offramps have occurred, whichever is earlier: ● Delta smelt: when the daily mean water temperature at CCF reaches 77°F for 3 consecutive days; ● Salmonids: o when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or o after daily average water temperatures at Mossdale exceed 71.6°F for 7 days during June (the 7 days do not have to be consecutive). **Real-Time Decision Making and Salvage Thresholds** When real-time monitoring demonstrates that criteria in "Additional Real-Time OMR Restrictions and Performance Objectives" are not supported, then Reclamation and DWR may confer with the Directors of NMFS, the Service, and CDFW if they desire to operate to a more negative OMR than what is specified in "Additional Real-Time OMR Restrictions". Upon mutual agreement, the Directors of NMFS and the Service may authorize Reclamation and DWR to operate to a more negative OMR than the Additional Real-Time OMR Restrictions, but no more negative than -5000 cfs. This process would be separate from the risk analysis process referenced above.			
Tracy Fish Collection Facility Reclamation proposes to continue to screen fish from Jones Pumping Plant with the TFCF. The TFCF uses behavioral louvers in the primary channel 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. Hauling trucks used to transport salvaged fish to release sites inject compressed air and/or oxygen and contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River at Emmaton and the	Standard	Core	Delta smelt

other on the San Joaquin River immediately upstream of the Antioch Bridge. Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year-round. Larval smelt sampling at the TFCF commences once a trigger is met (detection of a spent female at CVP and SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm to retain larval fish. Sampling is done four times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection. Section 4.10.5.12.1 of the BA contains additional details about louver cleaning and fish salvage and hauling procedures.			
Skinner Fish Facility DWR proposes to continue to screen fish from Banks Pumping Plant with the 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 the Skinner Fish Facility	Standard	Core	Delta smelt
Delta Cross Channel Gate Improvements Reclamation proposes to evaluate improvements to automate and streamline operation of the DCC 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.	Programmatic	Collaborative Planning	Giant garter snake

Delta Smelt Summer-Fall Habitat Action Reclamation and DWR propose to use structured decision making to implement Delta Smelt habitat actions. In the summer and fall (June through October) of Below Normal, Above Normal, and Wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following: ● Maintain low salinity habitat in Suisun Marsh and Grizzly Bay when water temperatures are suitable; ● Manage the low salinity zone to overlap with turbid water and available food supplies; and ● Establish contiguous low salinity habitat from Cache Slough Complex to the Suisun Marsh. The action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline (X2) at 80 km from the Golden Gate in Above Normal and Wet water years in September and October. Reclamation and DWR will also implement additional measures that are expected to achieve additional benefits. These measures include, but are not limited to: ● Suisun Marsh Salinity Control Gate (SMSCG) operations for up to 60 days (not necessarily consecutive) from June 1 through October 31 of Below Normal and Above Normal years. This action may also be implemented in Wet years if preliminary analysis shows expected benefits; ● Food enhancement actions, e.g., those included in the Delta Smelt Resiliency Plan to enhance food supply. These projects include the North Delta Food Subsidies/Colusa Basin Drain Study, Sacramento River Deepwater Ship Channel Food Study, and Suisun Marsh and Roaring River Distribution System Food Subsidies Study. Reclamation proposed these food enhancement actions as programmatic components of the PA; therefore, they are addressed programmatically in this consultation. Reclamation and DWR will monitor dissolved oxygen at Roaring River Distribution System drain location(s) during Delta Smelt food distribution actions to ensure compliance with Water	Standard	Collaborative Planning	Delta smelt, delta smelt critical habitat

Quality Objectives established in the San Francisco Bay Basin Plan. If the measures above (or others developed through collaborative science processes) result in benefits that are determined to provide similar or better protection than the 80 km X2 salinity management action, Reclamation and DWR will work with the Service to modify this component of the PA to implement the new actions in lieu of the salinity management action. When determining whether or not the measures above provide similar or better protection, Reclamation and DWR will consider, at minimum, the following: ○ habitat acreages in Suisun Marsh, Grizzly Bay, and other adjacent areas available to support delta smelt recruitment (e.g. 0-6 ppt at Belden's Landing, non-lethal temperatures, etc.), ○ recruitment projections based on Service-approved life cycle modeling and/or monitoring to evaluate the expected trend in delta smelt with and without the 80 km X2 salinity management action, and ○ The presence (or absence) of delta smelt in both target areas (main Delta channels and Suisun Marsh) and other areas (such as Montezuma Slough and Cache Slough), including information from monitoring, presence/absence modeling, or similar tools. These considerations (listed above) and examples of implementation of other actions will be more fully defined and developed through the structured decision making or other review process. The review will include selection of appropriate models, sampling programs, and other information to be used. The process will be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed as described below.			

Reclamation and DWR will develop a Summer-Fall Habitat Action Plan to meet the environmental and biological goals in years when Summer-Fall Habitat Actions are triggered. In Above Normal and Wet years, operating to a monthly average X2 of 80 km in September and October is the initial operation to provide a specific acreage of low salinity habitat. In every action year, Reclamation and DWR may propose, based on discussions with the Service, a suite of actions that would meet the action's environmental and biological goals. Although Reclamation and DWR agree to treat the Delta Smelt Summer-Fall Habitat Action as an in-basin use, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action will depend on the particular hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases may be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood-control limitations are expected. In these scenarios, Reclamation will make releases in a manner that minimizes redd dewatering where possible. In the event that Reclamation determines the Delta outflow augmentation necessary to meet 2 ppt isohaline at 80 km from the Golden Gate as described above cannot be met through primarily export reductions and is expected to have a high storage cost, Reclamation will still implement the rest of this action, and will meet with NMFS and the Service to discuss alternate potential approaches that improve habitat conditions. Collaborative Planning Process Reclamation shall form a Delta Coordination Group (Reclamation, DWR, the Service, NMFS, CDFW, and representatives from federal and state water contractors). The Group will utilize one of the existing structured decision-making			

models, or adopt a new model, to analyze the proposed Summer-Fall Habitat Action. Through the Delta Coordination Group, Reclamation and DWR shall develop a multi-year science and monitoring plan consistent with the structured decision-making models within 9 months of signing the National Environmental Policy Act Record of Decision (ROD). The Delta Coordination Group may use the IEP or CSAMP (or similar entity) to review project design and the science and monitoring plan. Within six months of signing the ROD, the Delta Coordination Group shall meet to select a structured decision making model; and complete model runs testing various approaches to satisfying the environmental and biological goals, utilizing the available tool box of approaches. The Delta Coordination Group shall provide the initial results of its modeling exercise in a memorandum to Reclamation, DWR, and the Service. The process for Delta Smelt Summer-Fall Habitat Action development and approval is incorporated by reference from the BA. The Delta Smelt Summer-Fall Habitat Section will be incorporated into the "Four Year Reviews" under the "Governance" section of the BA, and all reasonable and practical recommendations shall be incorporated into the Delta Smelt Summer-Fall Habitat Action. The structured decision-making model and the multi-year science and monitoring plan will be part of this Peer Review.			
Clifton Court Predator Management 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: (a) continued evaluation of predator relocation methods; (b) controlling aquatic weeds; and (c) exploration of additional predation reduction measures.	Standard	Core	Delta smelt

Sediment Supplementation Feasibility Study Reclamation proposes to develop and implement a sediment supplementation feasibility study. The goal of this study will be to determine methods to reintroduce sediment in the Delta to increase turbidity which would provide better habitat conditions for all life stages of delta smelt, including increased cover for juveniles and feeding facilitation for larval smelt. This study will include, at minimum, consideration of sediment placement upstream of the Delta during low flow periods in the spring, summer and/or fall, followed by sediment remobilization following inundation during seasonal high flows. Reclamation will coordinate with the Service and other agencies to address necessary permitting for this study. Reclamation will coordinate with the Service on the design and findings of this study, including monitoring measures to assess its effectiveness and feasibility as a long-term management program, a method to phase implementation if required for permitting and other compliance needs.	Standard	Collaborative Planning	Delta smelt, delta smelt critical habitat
Sacramento Deepwater Ship Channel Food Study Reclamation proposes to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. The ship channel has the potential to flush food production into the north Delta for delta smelt when paired with an ongoing food study. This is the topic of an in-progress study of phyto- and zooplankton production in the ship channel.	Programmatic	Collaborative Planning	Delta smelt, delta smelt critical habitat
North Delta Food Subsidies/Colusa Basin Drain Study DWR, Reclamation, and water users propose to increase food entering the north Delta by moving nutrient-rich water from the Colusa Basin into the Yolo Bypass and north Delta in July and/or September. 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.	Programmatic	Collaborative Planning	Delta smelt, delta smelt critical habitat, least Bell's vireo, valley elderberry longhorn beetle, giant garter snake

Suisun Marsh and Roaring River Distribution System Food Subsidies Study 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. Reclamation and DWR will monitor dissolved oxygen at Roaring River Distribution System drain location(s) to ensure compliance with Water Quality Objectives established in the San Francisco Bay Basin Plan when Delta Smelt food actions are being taken.	Programmatic	Collaborative Planning	Delta smelt, delta smelt critical habitat
Intertidal and Associated Subtidal Habitat Restoration (Complete 8,000 acres from 2008 Service BiOp) Reclamation and DWR propose to complete the remaining 8,000 acres of tidal habitat restoration in the Delta by 2030. Reclamation and/or DWR would monitor, operate, and maintain the restoration sites, including obtaining permanent land rights. Consistent with the current regulatory process, future separate consultations would address the effects to listed species from habitat restoration.	Programmatic	Collaborative Planning	Delta smelt, delta smelt critical habitat, salt marsh harvest mouse, California clapper rail, giant garter snake, valley elderberry longhorn beetle, soft bird's beak, soft bird's beak critical habitat, Suisun thistle, Suisun thistle critical habitat, vernal pool fairy shrimp, vernal pool tadpole shrimp, California least tern, least Bell's vireo, western yellow-billed cuckoo
Predator Hot Spot Removal 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.	Programmatic	Collaborative Planning	Delta smelt
Reintroduction Efforts for Delta Smelt Reclamation proposes to fund a two phase process that would lead to annual supplementation of the wild delta smelt	Standard	Collaborative Planning	Delta smelt

population with propagated fish within 3-5 years from issuance of the biological opinion. The first step in this process will be the development of a supplementation strategy within one year of the issuance of the BiOp that will describe the capacity needed at hatchery facilities to accommodate the delta smelt production needed to meet genetic and other hatchery considerations with a goal of increasing production to a number and the life stages necessary to effectively augment the population. The Service will be the lead on the development of this supplementation strategy. The strategy will include identification of regulatory processes to address, science studies to complete, potential facility expansion and improvements, and schedules and deliverables to support the second phases and the larger Conservation Hatchery, described below. The second step will involve using the existing UC Davis Fish Conservation and Culture Laboratory (FCCL). Reclamation and DWR are the primary funding sources for FCCL, which maintains the refugial population of delta smelt and generates additional captive-bred fish for research. The FCCL has maintained a continuous refugial population since 2008. The FCCL has closed the life cycle of delta smelt meaning that they can produce new generations of fish at their facility with or without the addition of new wild spawners, and keep enough progeny alive to repeat the process for multiple generations. Annually, the FCCL exports approximately 33,000 fish of different life stages for use in research. Additionally, approximately 32,000 adults are reared in the refuge population. To achieve these production levels, the FCCL frequently removes fish at the egg and juvenile stages. Additional funding will support expansion of facilities to maintain these fish and increase rearing capacity to provide up to approximately 125,000 adults within 3 years. By 2030, Reclamation proposes to support a larger Conservation Hatchery, described below, to take over the role of supplementing the wild population.			
Delta Fish Species Conservation Hatchery Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta Smelt, by 2030. The	Programmatic	Collaborative Planning	Delta smelt

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 habitat.			

*The PA includes the following language in section 4.12.6 *Chartering of Independent Panels*: "Reclamation and DWR agree to charter independent panels to review actions as described in certain components of the Proposed Action. Independent panels shall review actions consistent with the standards of the Delta Stewardship Council and applicable Reclamation and DWR guidance. Experts on the panel shall provide information and recommendations but shall not make consensus recommendations to Reclamation. NMFS and the Service may provide technical assistance and input in the development of the charter. Reclamation and DWR shall provide the results of the independent review to NMFS and the Service. Reclamation shall coordinate with DWR to document a response to the independent review including whether implementation of alternative strategies would require reinitiation consistent with the reinitiation triggers provided by 50 CFR 402.16. Nothing the chartering of and responding to independent panels precludes NMFS nor the Service from exercising its statutory responsibilities under the ESA."

3.0 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). The Action Area for this biological opinion is based on the descriptions of the components of the PA as described in the BA, including some for which the locations and extent of effects are not yet known. These components are addressed programmatically, and will either rely on existing consultations or will be subject to subsequent consultation. This definition of the Action Area is based on our current understanding of the extent of activities proposed by Reclamation. This encompasses areas in which effects to Service-jurisdictional species and critical habitat may occur, and excludes areas described in the BA where only effects to NMFS-jurisdictional species and critical habitat may occur.

The Action Area encompasses the following reservoirs, rivers, and the land between the levees adjacent to the rivers: (1) Sacramento River from Shasta Lake downstream to and including the Sacramento–San Joaquin Delta; (2) Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (3) Feather River from the FERC boundary downstream to its confluence with the Sacramento River; (4) American River from Folsom Reservoir downstream to its confluence with the Sacramento River; (5) Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (6) San Joaquin River from Friant Dam downstream to and including the Sacramento–San Joaquin Delta; and (7) San Francisco Bay and Suisun Marsh.

4.0 ANALYTICAL FRAMEWORK

4.1 Analytical Framework for the Jeopardy Determination

Section 7(a)(2) of the Act requires that Federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species. "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR § 402.02).

The jeopardy analysis in this BiOp considers the effects of the proposed Federal action, along with effects from baseline conditions and any cumulative effects, on the range-wide survival and recovery of the listed species. It relies on four components: (1) the *Status of the Species*, which describes the range-wide condition of the species, the factors responsible for that condition, and its survival and recovery needs, (2) the *Environmental Baseline*, which analyzes the condition of the species in the Action Area, the factors responsible for that condition, and the relationship of the Action Area to the survival and recovery of the species, (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species, and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the Action Area on the species.

The Action Area for this consultation encompasses the entire range of delta smelt. Therefore, we did not include a separate range-wide status of species section for delta smelt in this biological opinion because the *Status of the Species Within the Action Area* section for delta smelt, below, fully addresses the range-wide status.

4.2 Analytical Framework for the Adverse Modification Determination

Section 7(a)(2) of the Act requires that Federal agencies insure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. "Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species.

The destruction or adverse modification analysis in this BiOp considers the effects of the proposed Federal action, along with effects from baseline conditions and any cumulative effects, on the range-wide value of critical habitat for the conservation of the listed species. It relies on four components: (1) the *Status of Critical Habitat*, which describes the range-wide condition of the critical habitat in terms of the key components (*i.e.*, the primary constituent elements described in the delta smelt critical habitat rule) that provide for the conservation of the listed species, the factors responsible for that condition, and the intended value of the critical habitat overall for the conservation of the listed species, (2) the *Environmental Baseline*, which analyzes the condition of the critical habitat in the Action Area, the factors responsible for that condition, and the value of the critical habitat in the Action Area for the conservation of the listed species, (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated and interdependent activities on the key components of critical habitat that provide for the conservation of the listed species, and how those impacts are likely to influence the conservation value of the affected critical habitat, and (4) *Cumulative Effects*, which evaluate the effects of future non-Federal activities that are reasonably certain to occur in the Action Area on the key components of critical habitat that provide for the conservation of the listed species and how those impacts are likely to influence the conservation value of the affected critical habitat.

The Action Area for this consultation encompasses all of the designated critical habitat for delta smelt. Therefore, we did not include a separate section to address the status of the entire critical habitat designation for delta smelt in this biological opinion because the *Status of the Critical Habitat Within the Action Area* section below fully addresses the designation-wide status of delta smelt critical habitat.

5.0 DELTA SMELT

Approach for Analyzing the Proposed Action

Modeling

The analysis provided by Reclamation is supported by CalSim II modeling. CalSim II is a monthly time-step model that predicts conditions throughout the CVP and SWP systems based on operational inputs over an 82-year 'synthetic' hydrology, which includes multiple examples of all water year types. Most operational actions included in the PA to provide protections for species will occur on a time-step shorter than the model's one-month intervals. For instance, real-time operations and re-assessment of them most often occur at time steps of 5 to 14 days. Because of this, assumptions are made for inputs to the model to try to best reflect how Reclamation expects short-term actions will play out on a monthly time scale. The monthly averages output by CalSim II may not capture the conditions that species experience in the Delta at any given time. Thus, the CalSim II operating assumptions and results are not fully reflective of conditions in the Delta in any given time period, but are helpful to guide our comparative analysis of expected differences among scenarios.

Reclamation prepared the CalSim II analyses for the Biological Assessment that was transmitted on January 31, 2019. The three CalSim II scenarios that were completed at the time were intended to reflect the Without Action scenario (WOA), the Current Operating Scenario (COS) and the Proposed Action (PA). Since that time, Reclamation has made substantial changes to the PA which are not reflected in the CalSim II modeling run for the PA. We report results from the model run for the PA in our analysis, but we have limited our use of quantitative comparisons among model runs and we have identified where we expect actual conditions to be different than what is reflected in the modeling. This focus on qualitative analysis is used to capture changes from the PA model run to the PA as proposed, as well as changes to the PA and potential real-time conditions that could not be modeled accurately using a monthly time-step.

Regulatory Context

The ESA requires action agencies to ensure that actions they authorize, fund or carry out are not likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. This is done through consultation with the Service and/or the National Marine Fisheries Service, which results in the Service providing an opinion on the proposed action and its effects on listed species and designated critical habitat. 16 USC § 1536. When an action agency modifies an ongoing action in a manner that has effects to listed species or designated critical habitat that were not previously analyzed in a biological opinion, the action agency must reinitiate consultation with the consulting agency. 43 CFR §402.16.

Previous Consultation

This biological opinion is prepared as a reinitiation of consultation on the coordinated operations of the CVP and SWP. There have been a series of biological opinions that have been prepared on ongoing operations. Each time, Reclamation and DWR have described their proposed action which has varied from the previous proposed action for consultation to some degree. The proposed action may include new activities proposed, or remove activities that are no longer undertaken or considered part of CVP and SWP operations.

During the last full reevaluation of the coordinated operations of the CVP and SWP in 2008, Reclamation and DWR's proposed action had adverse effects to delta smelt and designated critical habitat, such as high levels of entrainment leading to take of delta smelt in the south delta export facilities and habitat loss. The Service concluded these operations were likely to jeopardize delta smelt and adversely modify designated critical habitat. The Service developed a Reasonable and Prudent Alternative (RPA) to the proposed action that included actions to reduce entrainment, provide for increased high quality low-salinity zone habitat in certain year types, create additional subtidal habitat, and monitor ongoing operations. Reclamation provisionally accepted the RPA and began operating consistent with it in December 2008.

In the current PA, Reclamation has taken lessons learned from implementation of the 2008 RPA over the past 10 years and has proposed actions that are different from, but similar to, those included in the RPA. These actions continue to address entrainment risk, reduced habitat quality, and habitat restoration. In the current PA, Reclamation and DWR are proposing to operate the CVP and SWP in a manner that is intended to provide protection for delta smelt and other species. This was not the case in the action proposed for consultation in 2008. For this reason, the current PA is more protective of delta smelt than the action proposed in the 2008 Biological Assessment, and provides a very different analytical context for the Service's jeopardy and adverse modification determinations than was provided in 2008.

5.1 Environmental Baseline

The Environmental Baseline describes the past and present impacts of all Federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions, which are contemporaneous with the consultation in process (50 CFR 402.02). The key purpose of the Environmental Baseline is to describe the condition of the listed species and its critical habitat that exists in the Action Area in the absence of the action subject to this consultation. In this way, it provides a starting point for identifying effects of the action.

The Action Area for this consultation encompasses the entire range of delta smelt including all of the designated critical habitat for this species. Therefore, we did not include range-wide status of species and critical habitat sections in this biological opinion because the *Status of the Species within the Action Area* and *Status of the Critical Habitat Within the Action Area* sections below fully address the range-wide status. The purpose of discussing the status of the species and critical habitat is to present the appropriate information on the species' life history, its habitat and distribution, and other data on factors necessary to its survival and recovery, which provide important background necessary for formulating the biological opinion on the effects of the PA.

The Environmental Baseline does not include the effects of the action under review in the consultation. In this case, the effects of the action are those resulting from the coordinated operations of the CVP and SWP from now until 2030, as proposed by Reclamation in the BA, and are, therefore, not included in the Environmental Baseline for this consultation. 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 a 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 and other ecological changes stemming from long-established and more recently established non-native species, water quality degradation, and other effects on species from Federal, State, and private actions are also part of the baseline because they represent beneficial and detrimental influences on the delta smelt that exist at this time.

Like the hydrodynamic modeling studies reviewed in the effects analyses below, this without action scenario provides context for how the existence of the CVP and SWP facilities have affected and continue to affect the Environmental Baseline, including habitat conditions for species and critical habitat in the Action Area. Unlike the hydrodynamic modeling studies reviewed below, this without action scenario includes the existence of the dams and south Delta facilities, but removes operations of these facilities, because the action under this consultation is operations. Reclamation provided quantitative modeling and data and qualitative conceptual models of this scenario in their BA, which help support this context. Consistent with past consultations on the operations of the CVP and SWP, the dams and other existing project facilities are included in the Environmental Baseline.

The effects of past CVP/SWP operations are also part of the Environmental Baseline. Those effects have undergone consultation and contributed to the current condition of the species and critical habitat in the Action Area. Other past, present, and ongoing impacts of human and natural factors (including proposed Federal projects that have already undergone section 7 consultation) contributing to the current condition of the species and critical habitat in the Action Area are included in the Environmental Baseline for section 7 consultation purposes. A description of previous actions that have contributed to these current conditions are described below in *Factors Affecting Delta Smelt and Critical Habitat Within the Action Area*.

Under ESA section 7, each time the operations of the CVP and SWP are consulted on (e.g., 2005, 2008, and current), a new Federal action is proposed, and the previous consultation and the impacts of past and present operations of the CVP and SWP become part of the Environmental Baseline. The operation of the CVP and SWP since the water projects' inception is not one continuous Federal action in the context of ESA compliance. The CVP and SWP proposed action covered in the 2005 biological opinion was different from the proposed action consulted on in 2008, which is different from the Proposed Action analyzed in this biological opinion. Each had proposed action-specific components and operating criteria, so they are separate Federal actions with completed separate ESA section 7 consultations and analyses that are now part of the Environmental Baseline.

As described in our *Analytical Framework for the Jeopardy Determination* and *Analytical Framework for the Adverse Modification Determination* for this consultation, our analysis includes factors responsible for the range-wide condition (fully encompassed within the Action Area) of delta smelt and critical habitat. To determine the Environmental Baseline we considered the without action scenario, and the Current Operations scenario provided in the BA. As discussed above, the without action scenario provides context for how the existence of the CVP and SWP facilities shape the Environmental Baseline, including habitat conditions for species and critical habitat in the Action Area. A Current Operations scenario was also incorporated into the BA to provide context for how past and present operations have also shaped the Environmental Baseline, as well as to aid in identifying future effects of the PA. To provide a comprehensive description of the Environmental Baseline, a qualitative look at current operations of the CVP and SWP is added to the without action scenario to further inform the current condition of the species and critical habitat in the Action Area, along with all of the other factors contributing to the current condition. The Environmental Baseline provides the basis to determine the current range-wide status of the species and critical habitat in the Action Area to provide a complete picture for delta smelt and critical habitat at the time of this consultation. As stated above, the status of the delta smelt and its critical habitat within the Action Area also represents the range-wide status of the species and its critical habitat. The cumulative effects and effects of the Proposed Action are then added to this status and baseline to inform whether or not the Proposed Action is likely to jeopardize delta smelt and/or destroy or adversely modify delta smelt critical habitat.

5.1.1 Status of the Species Within the Action Area

Species Legal Status and Life Cycle Summary

The Service proposed to list the delta smelt (*Hypomesus transpacificus*) as threatened with proposed critical habitat on October 3, 1991 (Service 1991). The Service listed the delta smelt as threatened on March 5, 1993 (Service 1993), and designated critical habitat for the species on December 19, 1994 (Service 1994). The delta smelt was one of eight fish species addressed in the Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes (Service 1996). A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The review concluded that delta smelt remained a threatened species. A subsequent 5-year status review recommended uplisting delta smelt from threatened to endangered (Service 2010a). A 12-month finding on a petition to reclassify the delta smelt as an endangered species was completed on April 7, 2010 (Service 2010b). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted but precluded by other higher priority listing actions (Service 2010c). The Service reviews the status and uplisting recommendation for delta smelt during its Candidate Notice of Review (CNOR) process. Each year it has been published, the CNOR has recommended the uplisting from threatened to endangered. Electronic copies of these documents are available at https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=321.

The delta smelt is a small fish of the family Osmeridae. In the wild, very few individuals reach lengths over 3.5 inches (90 mm; Damon *et al.* 2016). At the time of its ESA listing, only the basics of the species' life history were known (Moyle *et al.* 1992). In the intervening 26 years, it has become one of the most studied fishes in the United States. Enough has been learned about the delta smelt to support its propagation in captivity over multiple generations (Lindberg *et al.* 2013), to support the development of complex conceptual models of the species life history (IEP 2015), and mathematical simulation models of its life cycle (Rose *et al.* 2013a). Any synthesis of the now extensive literature on the delta smelt requires drawing conclusions across studies that had disparate objectives, but several syntheses have been compiled from existing information (Moyle *et al.* 1992; Bennett 2005; IEP 2015; Moyle *et al.* 2016). In this BiOp, the Service relied on these previous syntheses where it remains appropriate to do so. We also relied on source study results and analyses of our own to synthesize across a rapidly growing body of scientific information.

The delta smelt has a fairly simple life history because a large majority of individuals live only one year (Bennett 2005; Moyle *et al.* 2016) and because it is an endemic species (Moyle 2002), comprising only one genetic population (Fisch *et al.* 2011), that completes its full life cycle in the northern reaches of the San Francisco Bay-Delta (Merz *et al.* 2011; Figure 5-1). The schematic of this simple life cycle developed by Moyle *et al.* (2016) and published again by Moyle *et al.* (2018) is shown in Figure 5-2. As described in detail in the *Status of the Critical Habitat in the Action Area*, most spawning occurs from February through May in various places from the Napa River and locations to the east including much of the Sacramento-San Joaquin Delta. Larvae hatch and enter the plankton primarily from March through May, and most individuals have metamorphosed into the juvenile life stage by June or early July. Most of the juvenile fish continue to rear in habitats from Suisun Bay and marsh and locations east principally along the Sacramento River-Cache Slough corridor (recently dubbed the 'North Delta Arc'; Moyle *et al.* 2010). The juvenile fish (or 'sub-adults') begin to develop into maturing adults in the late fall. Thereafter, the population spatial distribution expands with the onset of early winter storms and the first individuals begin to reach sexual maturity by January in some years, but most often in February (Damon *et al.* 2016; Kurobe *et al.* 2016). Delta smelt do not reach sexual maturity until they grow to at least 55 mm in length (~ 2 inches) and 50% of individuals are sexually mature at 60 to 65 mm in length (Rose *et al.* 2013b). In captivity delta smelt can survive to spawn at two years of age (Lindberg *et al.* 2013), but this appears to be rare in the wild (Bennett 2005; Damon *et al.* 2016; Figure 5-2). The spawning microhabitats of the delta smelt are unknown, but based on adult distribution data (Damon *et al.* 2016; Polansky *et al.* 2018) and the evaluation of otolith microchemistry (Hobbs *et al.* 2007a; Bush 2017), most delta smelt spawn in freshwater to slightly brackish-water habitats under tidal influence. Most individuals die after spawning, but as is typical for annual fishes, when conditions allow, some individuals can spawn more than once during their single spawning season (Damon *et al.* 2016). In a recent study spanning 2 to 3 months, captive males held at a constant water temperature of 12°C (54°F) spawned an average of 2.8 times and females spawned an average of 1.7 times (LaCava *et al.* 2015).

Figure 5-1. Delta smelt range map. Waterways colored in purple depict the delta smelt distribution described by Merz *et al.* (2011). The Service has used newer information to expand the transient range of delta smelt further up the Napa and Sacramento rivers than indicated by Merz *et al.* (2011). The red polygon depicts the boundary of delta smelt's designated critical habitat. The inset map shows the region known as the North Delta Arc shaded light green.

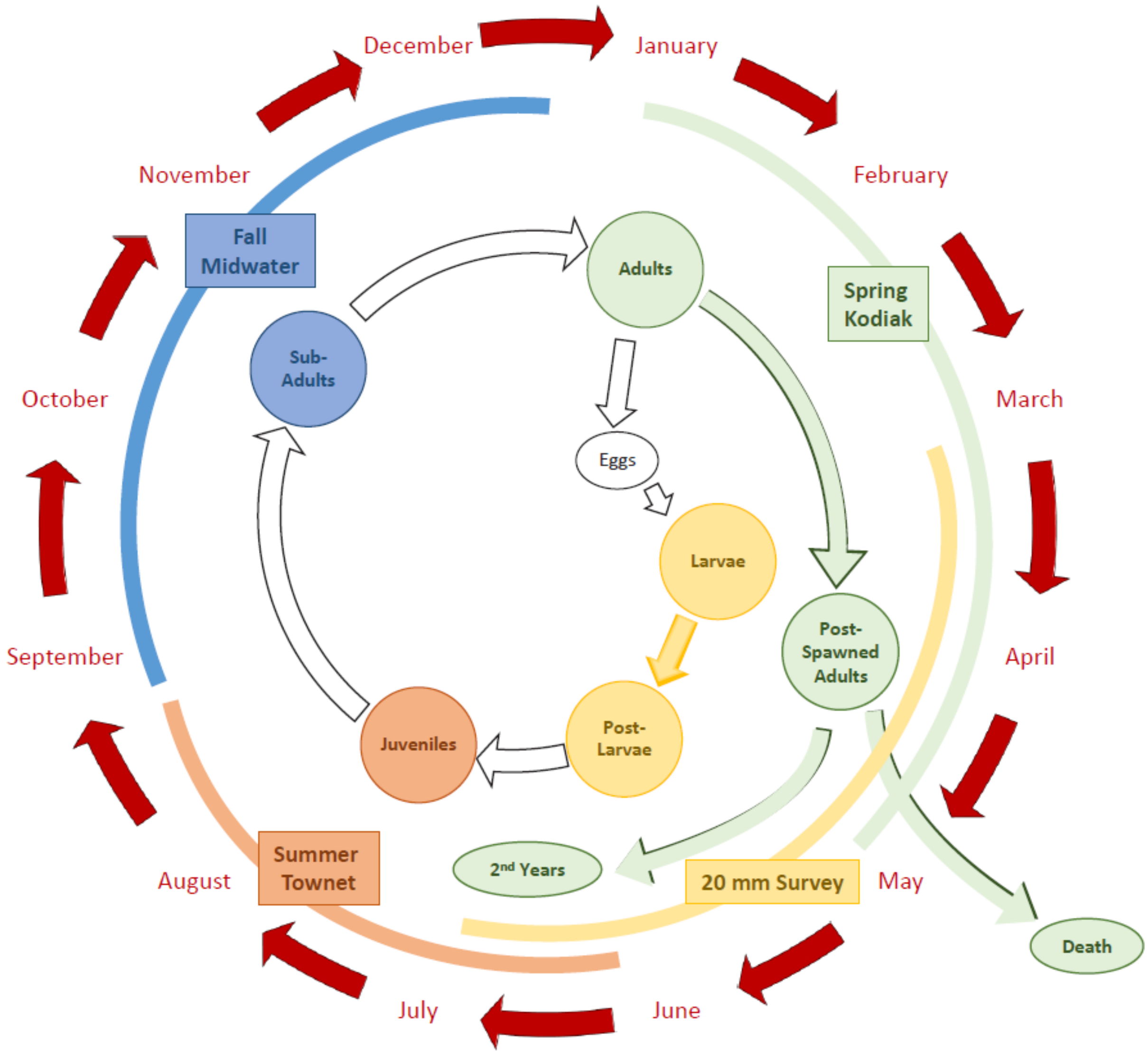


Figure 5-2. Schematic representation of the delta smelt life cycle. This conceptual model crosswalks delta smelt life stages with calendar months and current monitoring programs (prior to EDSM) used to evaluate the species' status. Source: Moyle *et al.* 2016

Table 5-1. 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	2019 state of scientific understanding
Spawning Habitat	Shallow fresh or slightly brackish edge-waters	No change
	Backwater sloughs	Possible, never confirmed. Potentially spawning sites have sandy substrates (Bennett 2005) and need not occur in sloughs. Backwater sloughs in particular tend to have silty substrates that would suffocate the 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 substrates oriented horizontally and a preference for gravel or sand that is more consistent with observations of other fishes in the family Osmeridae.
	Key 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 (Polansky *et al.* 2018).
	Adults could spawn from December-July.	Adults are virtually never fully ripe and ready to spawn before February and most spawning is completed by May (Damon *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 or both of downstream movement or decreasing outflow (Bush 2017). However, delta smelt larvae can feed in the same habitats they were hatched in and both larval and juvenile fish can rear in water with a salinity lower than 0.5 ppt (Nobriga 2002; Hammock *et al.* 2017).
	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, rip-rapping	No change, but seems likely to have more impact on spawning habitat than larval transport, which was subsequently shown to be related to swimming behavior timed to tidal flows (Bennett *et al.* 2002).
	2 ppt isohaline (X2) must be west of the Sacramento-San Joaquin River confluence to support sufficient larval and juvenile transport	Subsequent research showed the larvae distribute similarly relative to X2 regardless of where it resides (Dege and Brown 2004). X2 is generally west of the river confluence during February-June due to State Water Resources Control Board X2 standard; however, the standard does have a drought off-ramp.
	Maturation must not be impaired by pollutant concentrations	No change
	Additional flows might be required in the July-August period 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 because delta smelt were subsequently shown to no longer occupy the south Delta during July-August (Kimmerer 2008). Habitat changes in the central and south Delta have rendered it seasonally unsuitable to delta smelt during the summer (Nobriga *et al.* 2008); entrainment is seldom observed past June and the

		2008 Service BiOp RPA has a 25 degree Celsius off-ramp that usually triggers in 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 historical range for 2 ppt salinity (including its tidal time scale excursion into the Delta).	Recent research has suggested that the 1994 description of seasonal X2 movement is considerably less than what occurred pre-development (Gross *et al.* 2018). That said, X2 is generally in the specified region during February-June due to the State Water Resources Control Board X2 standard; however, the standard does have a drought off-ramp. Most juvenile delta smelt still rear in the low-salinity zone in the summer and fall, but it is now recognized that a few remain in the Cache Slough complex as well (Sommer and Mejia 2013; Bush 2017).
Adult migration	Adults require unrestricted access to spawning habitat from December-July	Adults disperse faster than was recognized in 1994; most of it is finished by the time Spring Kodiak Trawls start in January (Polansky *et al.* 2018), though local movements and possibly rapid longer distance dispersal occurs throughout the spawning season, which as mentioned above is usually February-May. The only known 'barriers' to adult dispersal are water diversions.
	Unrestricted access results from adequate flow, suitable water quality, and protection from physical disturbance	No change

Environmental Setting and History of Ecological Change in the Bay-Delta

This section briefly reviews environmental changes that have occurred since 1850; i.e., the California Gold Rush to the present. This section is subdivided into three parts. The first describes the condition that is believed to have existed in 1850. The second covers a period from about 1920 to 1967, which is the year prior to the initiation of SWP water exports from the Delta. The third sub-section covers 1968, the first year of CVP and SWP dual operations, to the present.

Over the past few years, the scientific information developed to understand pre- and post-water project changes to the estuary's landscape and flow regime has grown substantially. However, as with most scientific endeavors, there are some discrepancies that may affect some conclusions. For instance, Whipple *et al.* (2012) showed the difference between contemporary estimates of unimpaired Delta outflow that were used in the modeling studies reviewed below and measured data from the latter 19th century. These discrepancies can affect the conclusions about the natural hydrograph of the Bay-Delta ecosystem and should be kept in mind when reviewing what follows. The information on ecosystem changes that have accrued through time provides context for the current status of the delta smelt. We follow this review of historical ecosystem changes with reviews of relevant science – both old and new related to the status of delta smelt and the Service's current understanding of the primary constituent elements of its designated critical habitat (Table 5-1).

<u>The 1850 Bay-Delta estuary</u>: The historical Delta ecosystem was a large tidal marsh at the confluence of two floodplain river systems (Whipple *et al.* 2012; Andrews *et al.* 2017; Gross *et al.* 2018; Figure 5-3). The Delta itself experienced flooding over spring-neap tidal time scales and seasonal river runoff time scales. This variability in freshwater input to the estuary was likely important to seasonal and interannual variability in the productivity of the ecosystem for the same reasons that smaller-scale tidal marsh plain and floodplain inundation are today. Specifically, these flood cycles deliver organic carbon, but also increase the production of lower trophic levels due to lengthened water residence times and greater shallow, wetted surface areas (Sommer *et al*. 2004; Grosholz and Gallo 2006; Howe and Simenstad 2011; Enright *et al*. 2013). When freshwater flows out of the Delta and into the estuary, it can generate currents that aggregate particulate matter like sediment and phytoplankton (Monismith *et al*. 1996; 2002; MacWilliams *et al*. 2015) – and presumably also did so in the pre-development ecosystem. Prior to the invasion of the overbite clam, these sediment and phytoplankton aggregations, which occurred near the 2 ppt isohaline, demarcated an important fish nursery region (Turner and Chadwick 1972; Jassby *et al*. 1995; Bennett *et al*. 2002).

The estuary's natural hydrograph reached its annual base flows (annual minimum inputs of fresh water) in August or September toward the end of California's dry summers (Figure 5-4). Freshwater inputs would generally increase during the fall as precipitation in the watershed resumed. Delta outflow reached a broad winter through spring peak fueled first by precipitation followed by additional contributions from melting snow. The annual peak of Delta outflow often spanned January through May before declining back to base flow conditions by the late summer. The year-to-year variation in Delta outflow was considerable, often varying by about an order of magnitude during each month of the year. Water flowing from the Delta mixed into larger open-water habitats in Suisun and San Pablo bays, which themselves were fringed with marshes and tidal creeks. This pre-development ecosystem was shallower than the modern system. As a result, salinity responded more rapidly to changes in freshwater flow than it does now and less freshwater flow was needed to move salinity isohalines than is presently the case (Andrews *et al.* 2017; Gross *et al.* 2018). Like most native fish, the delta smelt evolved its life history to take advantage of this flow regime (Moyle 2002). In particular, its spawning period and early life stages overlap the months in which historical marsh-floodplain inundation and freshwater inputs to the estuary were highest, and water temperatures were cool, but not as cold as they are in the winter before spawning commences (see *Status of the Critical Habitat in the Action Area* for details of what is known about spawning and early life stages of delta smelt).

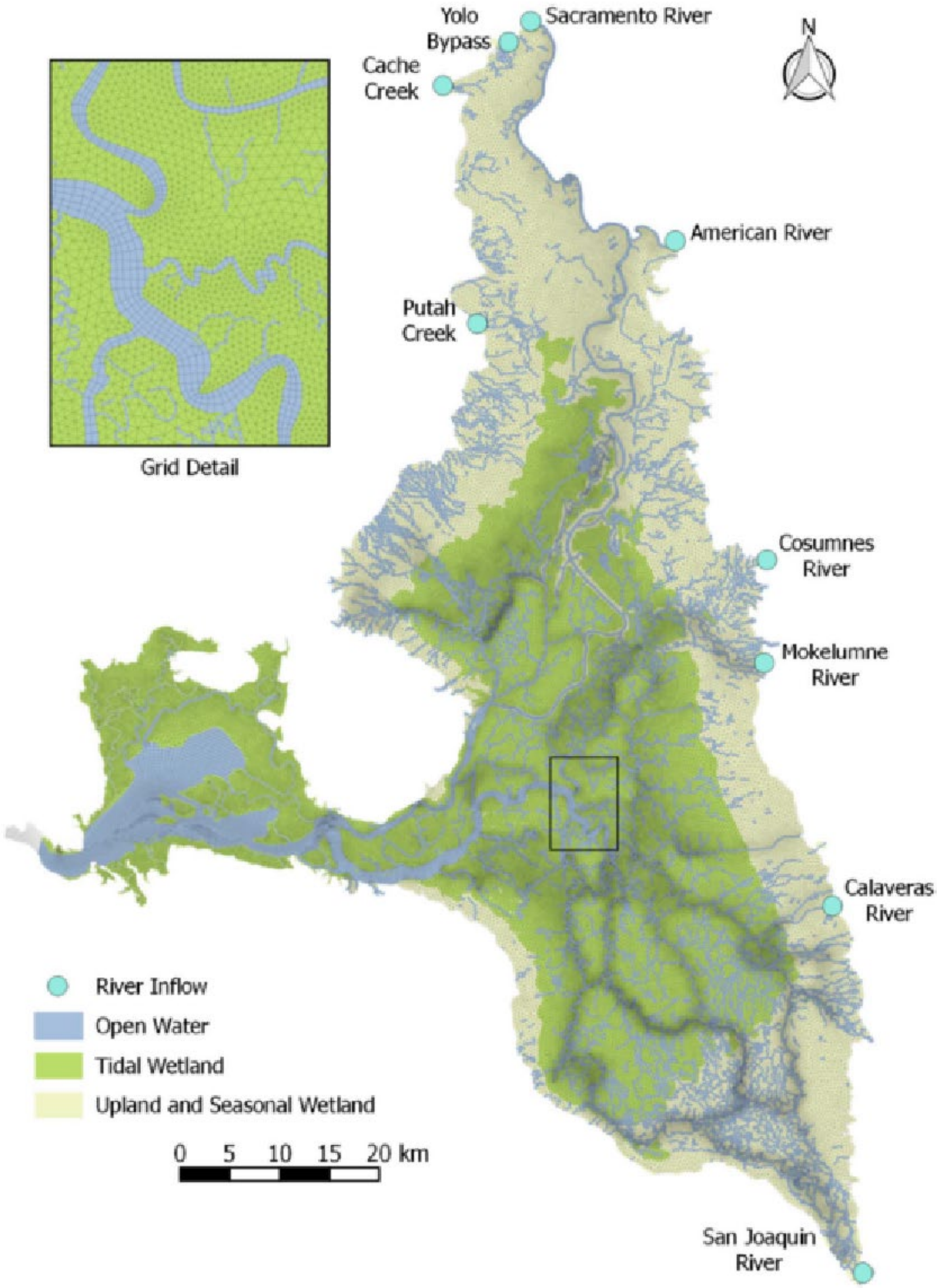


Figure 5-3. The circa 1850 Delta as depicted in the version of the UnTRIM 3-D hydrodynamic model described by Andrews *et al.* (2017). The model depicts an expansive tidal marsh area of approximately 2,200 km^2 or 850 square miles. Source: Andrews *et al.* (2017).

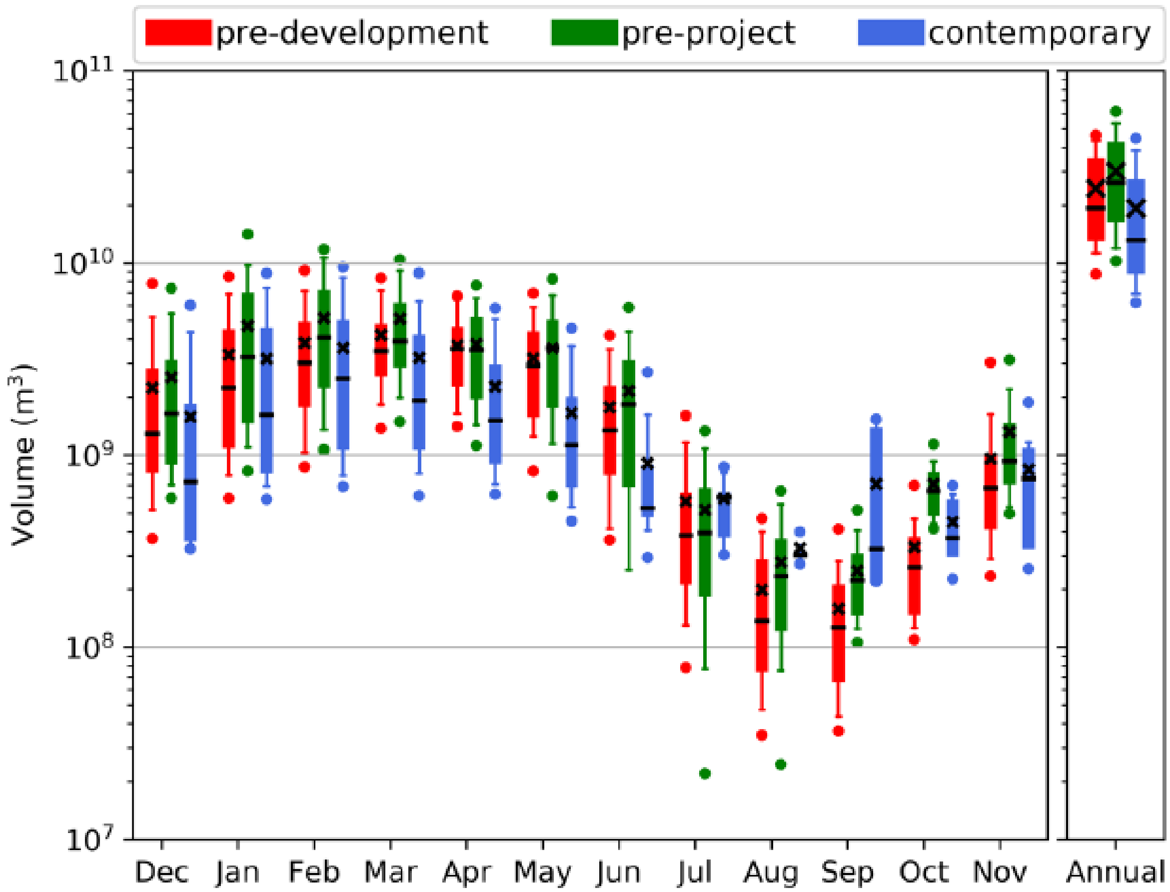


Figure 5-4. Boxplots of estimated Delta outflow by month for a pre-development Bay-Delta (circa 1850; red boxes), a pre-Central Valley Project and State Water Project Bay-Delta (circa 1920; green boxes), and a contemporary Bay-Delta (blue boxes; precise year not stated by the authors). Source: Gross *et al.* (2018). The inset labeled "Annual" on the x-axis is the boxplot summary of the sum of monthly outflows. Gross *et al.* (2018) attributed the higher outflow in the pre-project era relative to the pre-development era to the levees that had been constructed in the system by 1920.

Many tidal river estuaries form frontal zones where inflowing fresh water begins mixing with seawater (Peterson 2003). In the Bay-Delta, a frontal zone of biological importance is the low-salinity zone (LSZ) (Jassby *et al.* 1995). The LSZ is a mobile and variable habitat region that frequently overlaps the parts of the estuary where many delta smelt reside (see *Status of the Critical Habitat in the Action Area* for details). In the Bay-Delta the location and associated function of the LSZ have historically been indexed using a statistic called X2, which is the geographic location of 2 ppt salinity near the bottom of the water column measured as a distance from the Golden Gate Bridge (Jassby *et al.* 1995; MacWilliams *et al.* 2015; Figure 5-5). When Delta outflow is high, saline water is pushed closer to the Golden Gate, resulting in a smaller distance from the Golden Gate Bridge to X2. Conversely, when Delta outflow is low, salinity intrudes further into the estuary resulting in a larger distance from the Golden Gate Bridge to X2.

These changes in how salinity is distributed affect numerous physical and biological processes in the estuary (Jassby *et al.* 1995; Kimmerer 2002a,b; Kimmerer 2004; MacWilliams *et al.* 2015).

X2, rather than another salinity isohaline, was chosen as the low-salinity zone habitat metric because it is a frontal zone or boundary upstream of which, salinity tends to be the same from the surface of the water to the bottom, and downstream of which, salinity varies from top to bottom (Jassby *et al.* 1995). That variability in the vertical distribution of salinity is indicative of currents that help to aggregate sinking particles like sediment and phytoplankton, and as recently modeled, zooplankton (Kimmerer *et al.* 2014a), near X2.

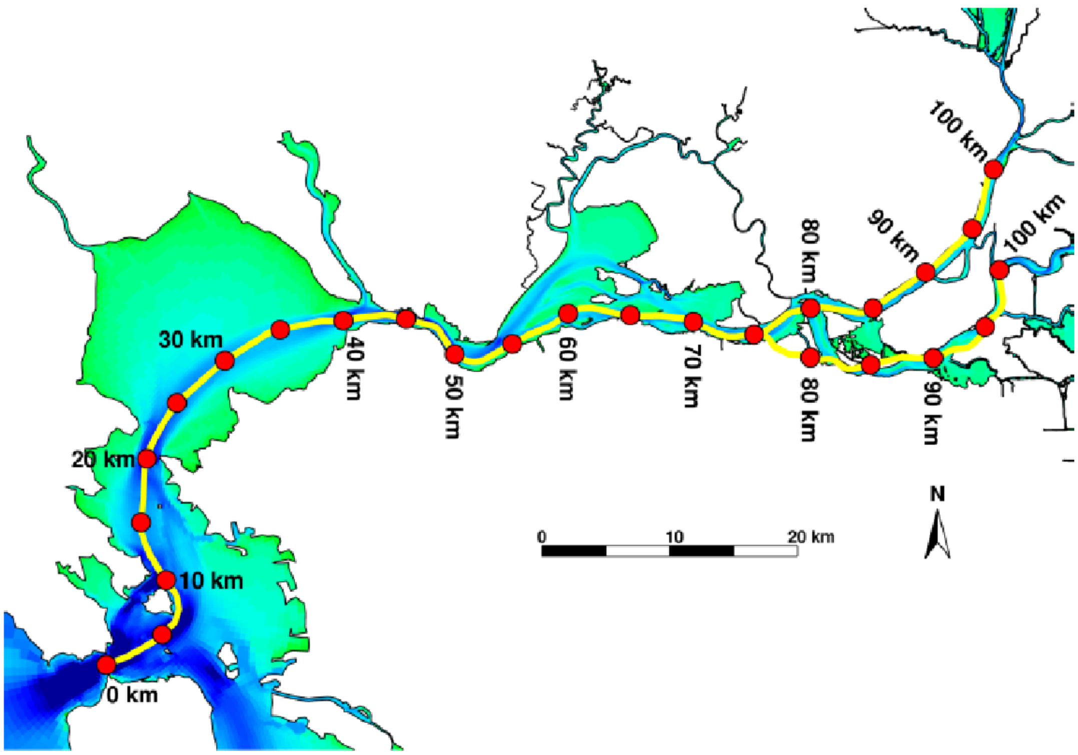


Figure 5-5. The northern reach of the Bay-Delta as depicted in the UnTRIM 3-D contemporary Bay-Delta model; greener colors represent shallower water and bluer colors represent deeper areas. The yellow lines depict the transect along which the location of X2 is estimated in the model and the associated red circles depict selected km distances from the Golden Gate Bridge along the northern axis of the estuary into the Sacramento and San Joaquin rivers for use in interpreting the variable locations of X2. Source: MacWilliams *et al.* (2015).

Pre-development outflows from the Delta were higher in the winter and spring than they are now while summer and fall outflows may have been lower (Andrews *et al.* 2017; Gross *et al.* 2018; Figure 5-4). Thus, X2 also varied more within years in the circa 1850 estuary than it now does. In the pre-development estuary, X2 would remain in San Pablo Bay for months at a time in the winter-spring of Above Normal and wetter water year types before retreating landward (upstream) in the summer-fall. In the contemporary estuary, X2 spends nearly all of its wet season time in Suisun Bay (landward or 'upstream' of historical) and dry season time between Collinsville and Rio Vista (~ 80 to 95 km; Figure 5-5). These contemporary dry season locations of X2 may be seaward or 'downstream' of historical locations (Gross *et al.* 2018).

There are no data on the timing and magnitude of biological productivity in the circa 1850 Bay-Delta, nor are we aware of any information on how delta smelt used the estuary at the time. However, inferences can be made based on general ecosystem function in the northern hemisphere temperate zone and contemporary information. The input of basal food web materials like nutrients and detritus likely co-varied with the timing, duration, and magnitude of freshwater flows (e.g., Delta inflow; Jassby and Cloern 2000), which would likewise have affected the timing, magnitude, and duration of inundation of the system's expansive floodplains (e.g., Whipple *et al.* 2012; Figure 5-3). The production of planktonic and epibenthic invertebrates from floodplains, tidal wetlands, and open-water habitats that fuel the production of juvenile fishes that feed in open waters may have generally increased during the spring and peaked during the summer in concert with seasonal variation in water temperature (e.g., Heubach 1969; Orsi and Mecum 1986; Merz *et al.* 2016). The summer months are the warmest months in the Bay-Delta region and thus, they support the highest *average* metabolic rates of invertebrates and fish, which rely on water temperature to control their body temperature and metabolic rates. However, there was likely to have been considerable species-specificity to this generalization (e.g., Ambler *et al.* 1985; Gewant and Bollens 2005) because the Bay-Delta's native biotic community includes numerous cold-water adapted species.

The seasonal timing of delta smelt reproduction (February-May; detailed below) would have more broadly coincided with the general timing of peak freshwater flow into the Bay-Delta (Figure 5-4). The higher outflow and shallower average depth of the system resulted in frequent occurrence of the LSZ in San Pablo Bay during the wet season. Thus, it is likely that delta smelt reared in San Pablo Bay, taking advantage of its greatly expanded low-salinity habitat area (see MacWilliams *et al*. 2015), to much greater extent prior to development of the system than they are able to now. Lower flows in the summer-fall likely caused delta smelt distribution to seasonally retract back into Suisun Bay/marsh and the Delta; ecosystems which were likely much more productive at the time due to the expansive tidal marshes and greater connection between land and water (Whipple *et al*. 2012). Delta smelt's population-level demand for prey annually peaks at some combination of water temperature and growth of the population's biomass. This timing could be estimated from the model developed by Rose *et al.* (2013a), but we are not aware that such a calculation exists.

<u>1920-1967</u>: By 1920, most of the Delta's tidal wetlands had been reclaimed (Whipple *et al.* 2012; Figure 5-6). The data provided by Gross *et al.* (2018; Figure 5-4) suggest that Delta outflow may have been a little higher circa 1920 than it had been circa 1850 due to levee construction. However, this may (Hutton and Roy 2019) or may not be consistent with historical observations (Whipple *et al.* 2012). Regardless, Delta outflow and several other net flow metrics from within the Delta did begin to decline between the early 1920s and 1967 (Hutton *et al.* 2017a; 2019). These changes occurred because of four factors: (1) water storage in the Bay-Delta watershed increased from about 4 MAF to about 40 MAF because of the construction of dams upstream of the Delta, (2) the CVP began exporting water from the Delta in 1951, (3) non-project water diversions within and upstream of the Delta increased, and (4) shipping channels

were dredged through the estuary and into the Sacramento and San Joaquin rivers. These changes facilitated a general water management strategy in California to store water during the wet season and re-distribute it during the dry season to provide a more reliable supply than was available naturally. In addition, the CVP and SWP have had to offset a considerable summertime water deficit to protect the quality of their exported water and to protect water quality for senior water rights holders in the Delta. These uses would be highly impaired without water released from CVP and SWP reservoirs during the summer and fall (Hutton *et al.* 2017b).

During the 1930s to 1960s, the navigation channels were dredged deeper (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton and to increase the capacity of the Delta to convey floodwaters. Channel deepening interacted with the simultaneously increasing water storage to change the Bay-Delta ecosystem into one in which Suisun Bay and the Sacramento-San Joaquin River confluence region became the largest and most depth-varying places in the typical range of the LSZ. Even with these changes, the LSZ remained a highly productive fish nursery habitat for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995).

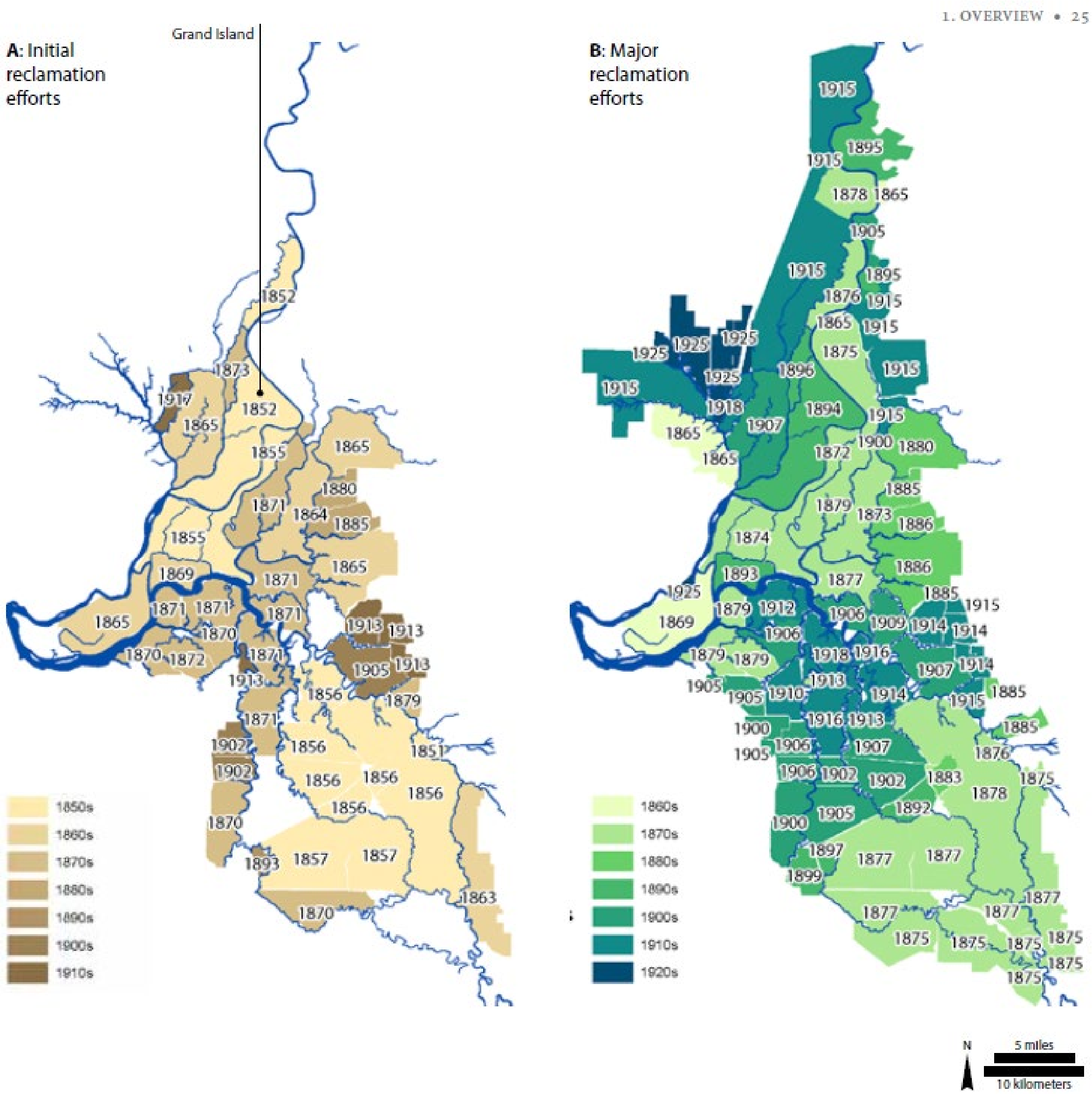


Figure 5-6. Maps of the Delta showing years of initial land reclamation attempts on the left and major land reclamation efforts on the right. Note that a large majority of the major reclamation efforts were underway by 1915 and the last efforts in the vicinity of Liberty Island began in 1925. Source: Whipple *et al.* (2012).

<u>1968-present</u>: The SWP began exporting water from the Delta in 1968 and its exports generally increased until about 1989 (Figure 5-7). CVP exports reached present-day levels by the end of the 1970s. During the 1980s water storage capacity in the Bay-Delta watershed reached its present-day level of a little over 50 MAF (Cloern and Jassby 2012; Hutton *et al.* 2017a). Thereafter, combined CVP-SWP exports began to increase in year-to-year variability, which increased the uncertainty about how much water would be supplied south of the Delta annually. This has combined with the increasing human demand for fresh water to result in a conflict between human water demand and environmental water uses, including the maintenance of the

hydraulic salinity barrier needed to protect exported water and other in-Delta water users from salinity intrusion (Hutton *et al.* 2017b; Reis *et al.* 2019).

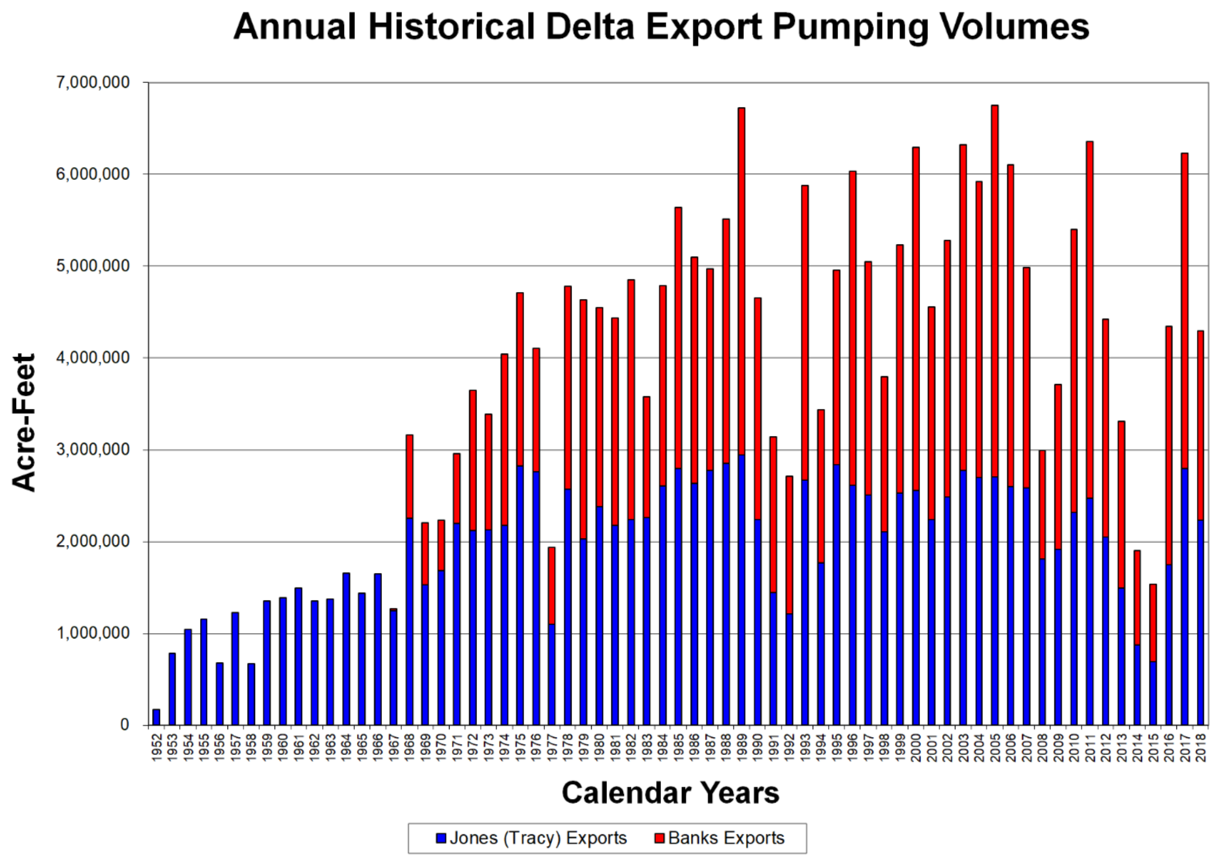


Figure 5-7. Time series of Central Valley Project and State Water Project exports from the Delta for 1952 through 2018. State Water Project exports began in water year 1968. Source: DAYFLOW data base.

The changes discussed above have continued to lower Delta outflow (Hutton *et al.* 2017a,b; Reis *et al.* 2019; Figures 5-8 and 5-9), though D-1641 appears to have halted the trend for years in which the eight river index is lower than 20 MAF (middle panel of Figure 5-8). In Figure 5-8, exports were modeled as depletions of water from the system, so the more negative the number on the y-axis of the middle panel, the higher the exports. Thus, the graphic shows that in years when the eight river index is more than 20 MAF, exports continue to increase, but in years when the eight river index is lower than 20 MAF, exports have been trending lower. Both of these trends cause the higher year-to-year variability in water exports shown in Figure 5-7.

In general, major changes to the flow regime of an aquatic ecosystem are expected to be accompanied by ecological change (Benson 1981; Bunn and Arthington 2002; Poff and Zimmerman 2010; Gillson 2011), and that is what has been observed over time in the Bay and Delta (e.g., Matern *et al.* 2002; Moyle and Bennett 2008; Winder *et al.* 2011; Feyrer *et al.* 2015; Conrad *et al.* 2016). Delta outflow is a driver of many ecological mechanisms in the Bay-Delta and an indicator of several others (Kimmerer 2002a). Thus, the changes to the estuary's freshwater flow regime have likely interacted with the changes to the estuary's landscape, specifically its deeper channels and greatly reduced land-water connections (Andrews *et al*. 2017), to lower the total biological productivity of the estuary. In addition, changes to the freshwater flow regime detailed above appear to have affected the reproductive success of fishes that use the Delta and Suisun Bay as rearing habitats. The evidence for this is that the native fish assemblage had reproductive seasons timed to winter-spring peak flows, whereas currently dominant non-native species generally spawn later in the spring and into the summer when inflows to the Delta are generally high to support human water use, but outflow from the Delta is generally low (Moyle 2002; Moyle and Bennett 2008). Reis *et al.* (2019) recently described super-critical water years with respect to Delta outflow. Several studies have indicated that low flow years and droughts in particular result in low native fish production in the Bay-Delta (Meng *et al.* 1994; Jassby *et al.* 1995; Kimmerer 2002b; Feyrer *et al.* 2015). Droughts recur and may contribute to cumulative impacts to native fishes like delta smelt. For instance, recent droughts have been particularly problematic for delta smelt (Moyle *et al.* 2018). Thus, the frequency of these super-critical water years, which has been much higher since 1968 than it was from 1920-1967 (Figure 5-9), is a conservation challenge that the Service and its partners have to contend with.

There are several fish species in the Bay-Delta that have historically been shown to have demonstrable positive population responses to freshwater flows into or out of the Delta. These include the well-described relationships for the survival of emigrating Sacramento basin Chinook salmon (*Oncorhynchus tschawytscha)* smolts with Sacramento River inflows (Kjelson and Brandes 1989; Perry *et al.* 2010), the relationship of Sacramento splittail (*Pogonichthys macrolepidotus*) production to Yolo Bypass flow (Moyle *et al.* 2004; Feyrer *et al.* 2006), and the 'fish-X2' relationships for striped bass, longfin smelt, and starry flounder (Turner and Chadwick 1972; Jassby *et al.* 1995; Kimmerer 2002b). The life-history of delta smelt with its affinity for fresh and low-salinity waters seems consistent with that of a fish one could expect to respond similarly to variation in Delta outflow or X2. Researchers searched for some form of analogous relationship for the delta smelt for several decades, but no persistent relationship was found (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995; Kimmerer 2002b; Bennett 2005; Mac Nally *et al.* 2010; Thomson *et al.* 2010; Miller *et al.* 2012). Further, Rose *et al.* (2013a,b) did not find salinity variation *per se* to have much impact on predictions of delta smelt population growth rate. The larger predicted impact in their individual-based model related to flow was due to simulated entrainment in exported water (Rose *et al.* 2013b; Kimmerer and Rose 2018). Although entrainment was predicted to lower the population growth rate, in and of itself, it could not convert a strongly positive growing population into a declining one without at least one additional factor impacting survival at the same time.

The Interagency Ecological Program (IEP) (2015) reported a correlation between February-May X2 and ratios of the 20-mm Survey index for delta smelt and either the Spring Kodiak Trawl (SKT) or Fall Midwater Trawl (FMWT) indices of the parental stock that produced the 20-mm fish. This relationship emerged in data beginning at the time of the pelagic organism decline (POD) in 2002. This relationship is stronger when considered in terms of salinity at Chipps Island (He and Nobriga 2018), possibly because salinity can be measured more accurately than Delta outflow when net freshwater flow is very low (Monismith 2016). Castillo *et al.* (2018)

used a simulation based on SKT data to suggest a link between Delta outflow and adult delta smelt abundance. In addition, several teams have reported statistical associations of delta smelt spatial distribution and salinity that imply the population spatial distribution co-varies with Delta outflow, X2, or similar indices of freshwater input to the estuary (Feyrer *et al.* 2007; 2011; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; 2013; Bever *et al.* 2016; Polanksy *et al.* 2018; Simonis and Merz 2019). The strength of this covariation and its management utility have been contested (e.g., Murphy and Hamilton 2013; Manly *et al.* 2015; Latour 2016; Polanksy *et al.* 2018) and supported (Sommer *et al.* 2011; Bever *et al.* 2016; Feyrer *et al.* 2016; Mahardja *et al.* 2017a) in several recently published papers.

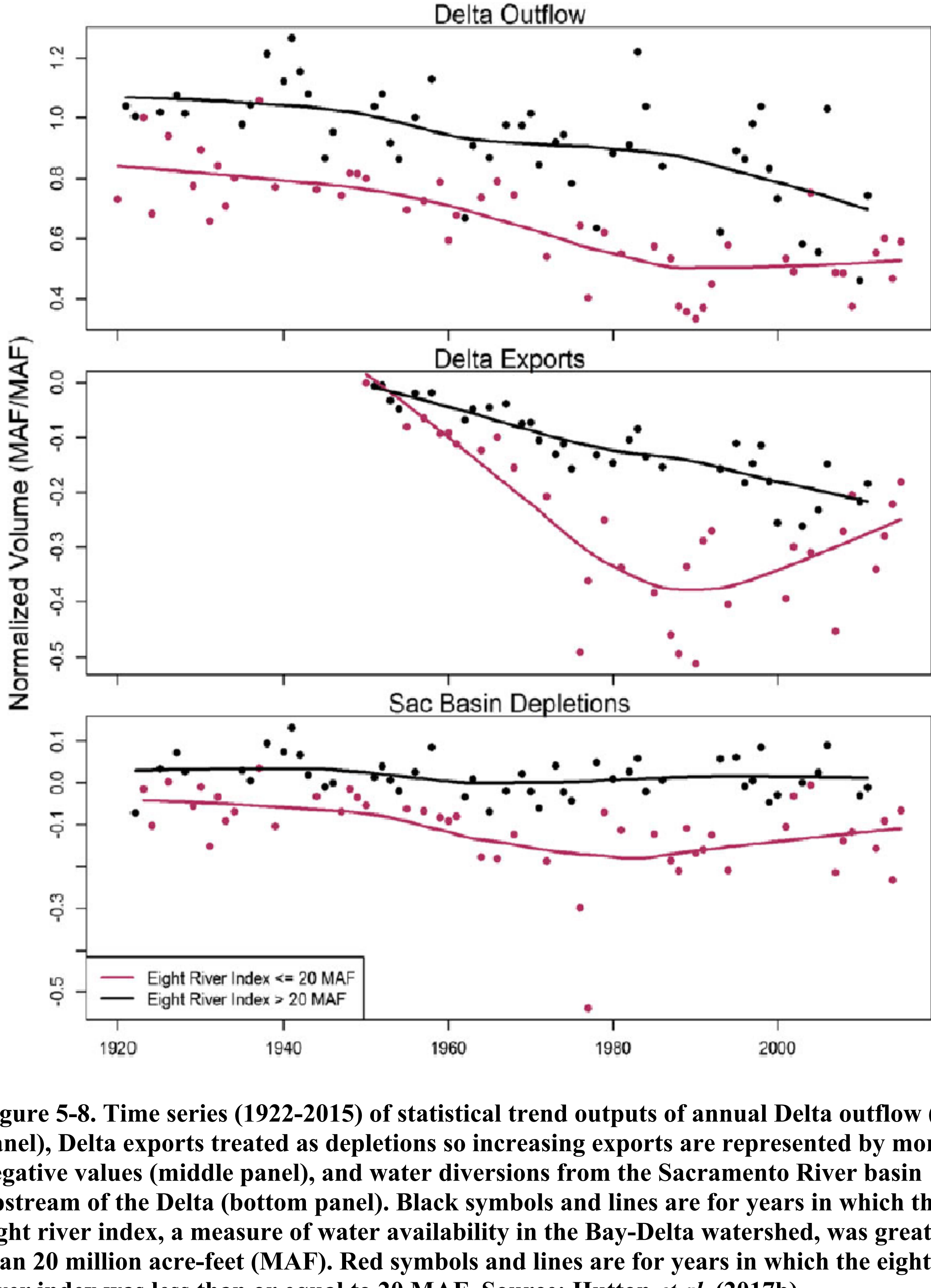


Figure 5-8. Time series (1922-2015) of statistical trend outputs of annual Delta outflow (top panel), Delta exports treated as depletions so increasing exports are represented by more negative values (middle panel), and water diversions from the Sacramento River basin upstream of the Delta (bottom panel). Black symbols and lines are for years in which the eight river index, a measure of water availability in the Bay-Delta watershed, was greater than 20 million acre-feet (MAF). Red symbols and lines are for years in which the eight river index was less than or equal to 20 MAF. Source: Hutton *et al.* (2017b).

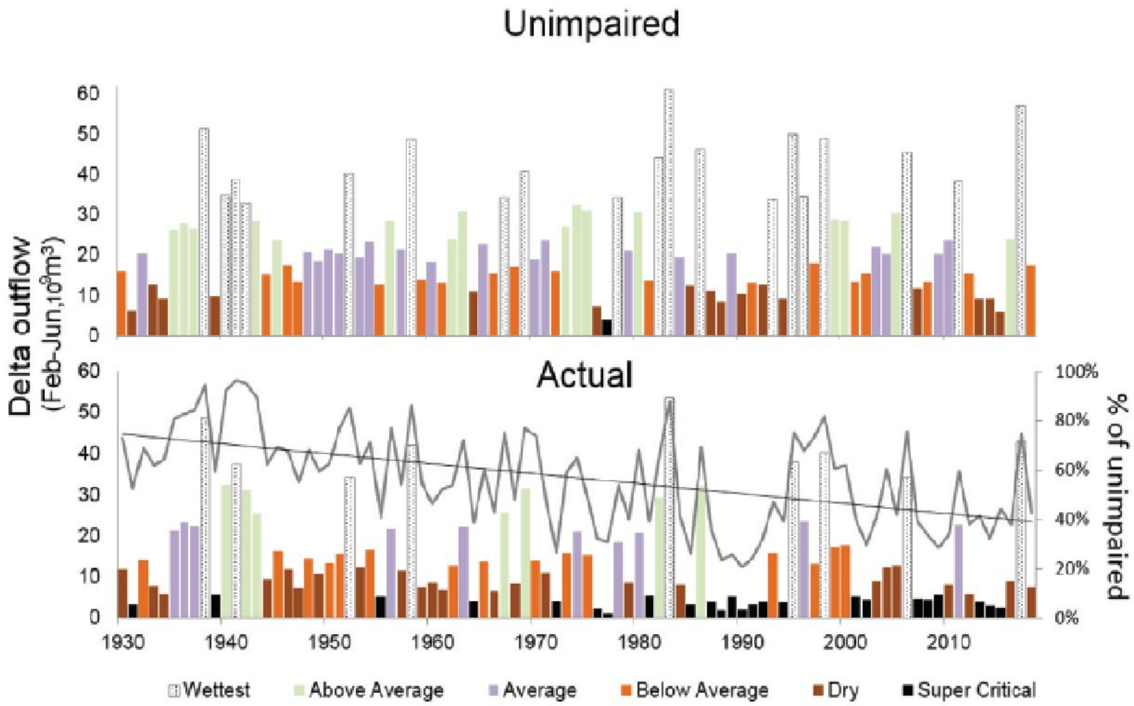


Figure 5-9. Time series of estimates of unimpaired (upper panel) and actual (lower panel) Delta outflow (February-June) color-coded according to six water year types, 1930-2018. The water year types based on basin precipitation are shown in the upper panel. In the lower panel, the water year types were re-assessed based on their fraction of the estimated unimpaired outflow. The long-term trend in this fraction as "% of unimpaired" is shown on the second y-axis of the bottom panel. Source: Reis *et al.* (2019).

Delta Smelt Population Trend

The California Department of Fish and Wildlife's (CDFW) Summer Townet Survey (TNS) (http://www.dfg.ca.gov/delta/data/townet/indices.asp?species=3) and FMWT Survey (http://www.dfg.ca.gov/delta/data/fmwt/indices.asp) are the two longest running indicators of the delta smelt's abundance trend. Indices of delta smelt relative abundance from these surveys date to 1959 and 1967, respectively (Figures 5-10 and 5-11). The FMWT index has traditionally been the primary indicator of delta smelt trend because it samples later in the life cycle, providing a better indicator of annual recruitment than the TNS (Service 1996). It has also sampled more consistently and more intensively than the TNS. The FMWT deploys more than 400 net tows per year over its four-month sampling season (September through December). The highest FMWT index for delta smelt (1,673) was recorded in 1970 and a comparably high index (1,654) was reported in 1980 (Figure 5-11). The last FMWT index exceeding 1,000 was reported in 1993. The last FMWT indices exceeding 100 were reported in 2003 and 2011. In 2018, the FMWT index was zero for the first time. The TNS index for delta smelt has been zero four times since 2015. Thus, the TNS and FMWT have recorded a 40-50 year decline in which delta smelt went from a minor (but common) species to essentially undetectable by these long-term surveys (Figures 5-10 and 5-11).

Following the ESA listing of the delta smelt, the CDFW launched a 20-mm Survey (1995) and a SKT Survey (SKT; 2002) to monitor the distribution and relative abundance of late larval stage and adult delta smelt, respectively. These newer indices have generally corroborated the trends implied by the TNS and the FMWT (Figures 5-10 and 5-11). The CDFW methods generate abundance indices from each survey but each index is on a different numeric scale. This means the index number generated by a given survey only has quantitative meaning relative to other indices generated by the same survey. Further, the CDFW indices lack estimates of uncertainty (variability) which limits interpretation of abundance changes from year to year even within each sampling program. The Service recently completed a new delta smelt abundance indexing procedure using data from all four of these surveys (Polansky *et al.* 2019). The Service method improves upon the CDFW method because it generates abundance indices in units of numbers of fish, including attempts to correct for different sampling efficiencies among surveys, and the method includes measures of uncertainty. Service indices of spawner abundance based on combined January and February SKT sampling are listed with their confidence intervals in Table 5-2. The estimates show the most recent 18 years of the delta smelt's longer-term decline in numbers of fish as best as they can be approximated with currently available information. The 2019 abundance estimate of 5,610 is the lowest on record, though the upper confidence limit for the 2019 estimate overlaps the lower confidence limits from 2016 and 2018. This indicates there is more than a five percent chance that the 2019 abundance index is not different from 2016 and 2018. Regardless of this recent year uncertainty, the 2019 abundance index is much lower than peak abundance estimates in Table 5-2 which themselves are all based on data streams that started after the species had already declined considerably (Figures 5-10 and 5-11).

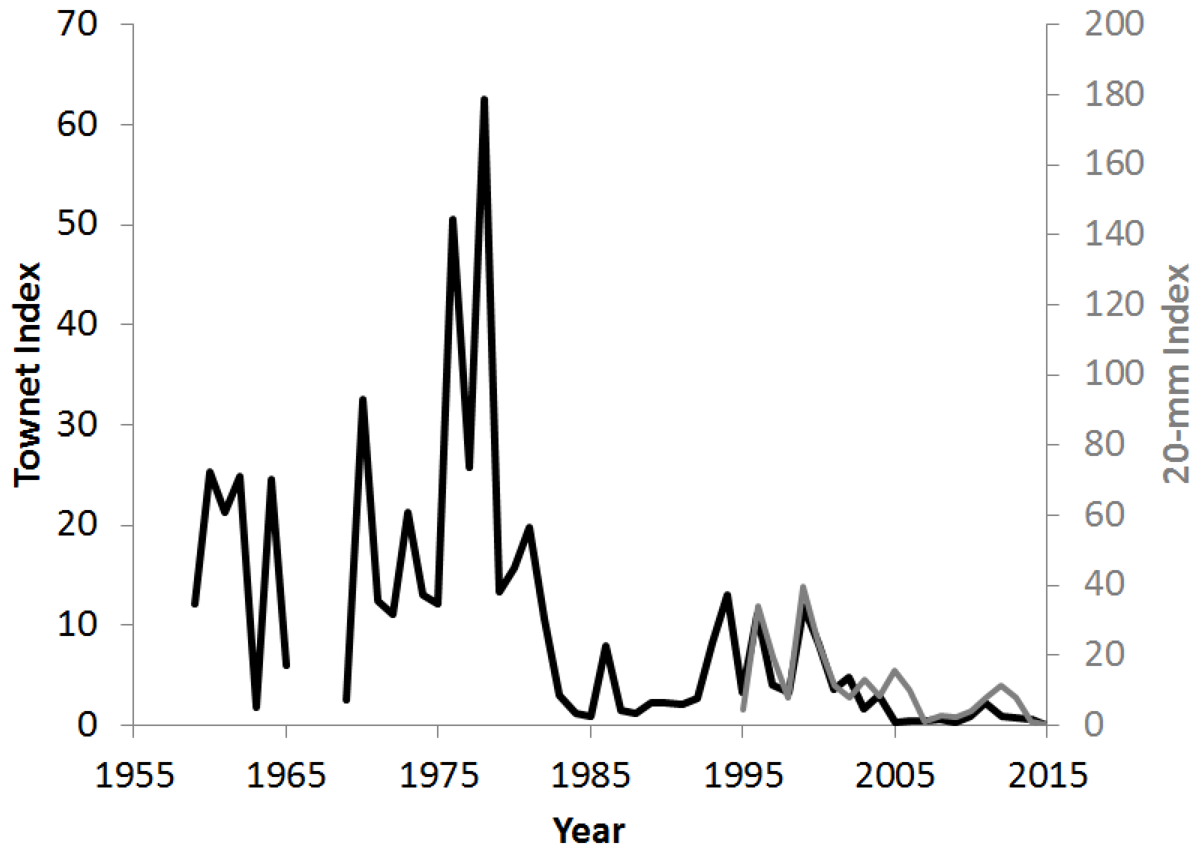


Figure 5-10. Time series of juvenile and larval delta smelt relative abundance as depicted by the California Department of Fish and Wildlife's Summer Townet Survey and 20-mm Survey, respectively. The townet survey began in 1959 and the 20-mm Survey began in 1995. The second y-axis was scaled to better align the indices which are calculated on different numeric scales.

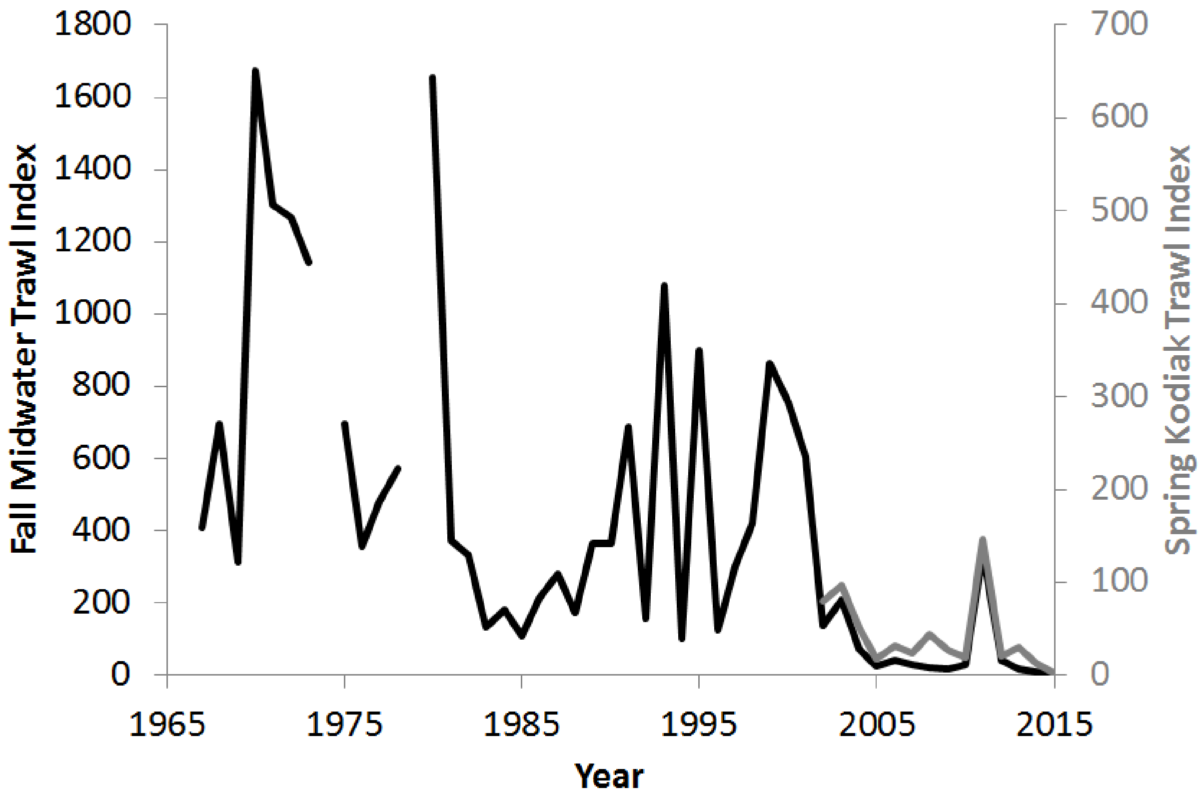


Figure 5-11. Time series of juvenile and larval delta smelt relative abundance as depicted by the California Department of Fish and Wildlife's Fall Midwater Trawl Survey and Spring Kodiak Trawl Survey, respectively. The midwater trawl survey began in 1967 and the Kodiak trawl survey began in 2002. The second y-axis was scaled to better align the indices which are calculated on different numeric scales.

Table 5-2. Estimates of adult delta smelt population size during January-February of 2002 through 2019 with 95% confidence intervals.

			95% Confidence Interval			**Number of Delta Smelt Caught in the SKT Survey**		
Year	Abundance Estimate	Standard Error	Lower Bound	Upper Bound		January	February	Year-to-Year Ratio
2002	1,093,244	195,329	760,332	1,523,294		262	394	NA
2003	996,055	261,205	581,197	1,597,198		NA	232	0.91
2004	966,981	262,190	553,729	1,573,002		380	300	0.97
2005	715,858	147,190	470,572	1,044,828		220	218	0.74
2006	272,327	42,400	198,681	364,438		44	84	0.38
2007	449,466	128,731	249,216	749,168		109	107	1.65
2008	509,428	188,396	236,859	963,839		132	36	1.13
2009	1,166,145	523,856	459,083	2,464,804		579	61	2.29
2010	251,863	54,580	161,753	374,582		88	57	0.22
2011	461,599	202,547	185,712	962,088		177	128	1.83
2012	1,177,201	328,682	662,728	1,939,836		320	287	2.55
2013	333,682	89,809	191,886	541,064		100	125	0.28
2014	308,972	91,474	167,858	522,884		148	55	0.93
2015	213,345	76,639	101,434	397,439		21	68	0.69
2016	25,445	9,584	11,661	48,622		7	6	0.12
2017	73,331	23,342	38,010	128,459		18	8	2.88
2018	26,649	21,397	5,215	82,805		10	4	0.36
2019	5,610	4,395	1,138	17,135		1	1	0.21

Under the without action scenario described in the BA, the status of the delta smelt would be improved because there would be no entrainment or salvage loss, OMR flows would generally be positive, Delta outflow would likely be higher in the spring but lower in the summer and fall, the location of X2 and the LSZ would likely be more favorable for delta smelt during some seasons and hydrologic year types, more sediment supply in the winter and spring would increase turbidity, and there would be more spawning substrate during the high-flow winter/spring period. However, this without action condition is considered with the current condition of the species (which is a result of all factors that have impacted the species within the Action Area) to provide the “snapshot” of the species’ health at this point in time. As discussed above, the current status of delta smelt is poor. The anticipated status between now and 2030 is also relevant to this BiOp to consider when addressing effects of the action in the aggregate. The Service developed three mathematical models to explore expected delta smelt population trends between now and the latter 2020s (Appendix 1). All three models are ‘state-space models’ that statistically separate the uncertainty (or variability) caused by imprecise sampling (observation error) from variability caused by other sources, often referred to as process noise. State-space models propagate both sources of uncertainty throughout the time series of their calculations.

The first model predicts delta smelt abundance at more than one life stage. Here this model is referred to as a multiple life stage model. Note that Table 5-2 presents estimates of adult abundance from January-February surveys because these months have been the focus of regulatory efforts over the past few years. In contrast, all three models described in this section use estimates of adult abundance from February-March. Thus, the abundance indices used in this model exploration are not the same ones listed in the table, though they are correlated (r=0.78). The multiple life stage model also estimated survival of each new generation of recruits at three subsequent points in their life cycle. The model was fit to abundance data for each life stage for the years 1995-2017, and allowed a change in either the expected survival or recruitment beginning in December 2008 to coincide with issuance of the previous delta smelt water operations BiOp.

The other two models are variations of an annual time-step model, i.e., they are models in which delta smelt abundance was only estimated at the adult life stage each year. One of the annual time-step models used a change-point for years ≥ 2009 and the other did not. This change-point is a statistical term reflecting that the model has a different expected population growth rate and a separate estimate of uncertainty for 1995-2008 than it does for 2009-2017. The rationale for exploring two alternative annual time-step models was (1) to determine whether there was evidence for a change in population growth rate coincident with the delta smelt and anadromous fish biological opinions, and (2) whether such a change would affect predictions of future abundances. The annual time-step models were fit to adult abundance data for 2002-2017. One of the metrics evaluated below is the delta smelt's population growth rate (and its predicted future population growth rates). These are denoted by the Greek letter lambda (λ). When the population growth rate was higher than 1 (meaning that a given year's adult population was larger than the prior year), the population had increased (or was predicted to increase), and when $\lambda < 1$, it had decreased (or was predicted to decrease). Because the delta smelt population was declining over the modeled period, the average and median λ were lower than 1. Further details are provided in Appendix 1. These models take into account population trends based on abundance indices which are informed by long-term monitoring data for periods before and after the 2008 BiOp was issued. This information is useful to understand the effects of the PA because it provides context for how past and current operations have shaped the Environmental Baseline and contributed to the current condition of delta smelt in the Action Area.

All three models fit the 2002-2017 adult abundance data well (Figure 5-12). The multiple life stage model indicated that winter survival increased during 2009-2017, but that summer and fall survival have likely decreased since 2008 (Appendix 1). The annual time-step models were noisier and, therefore, results were less clear. This is somewhat expected since the annual time-step models fit to fewer life stages and therefore cannot capture variation that affects recruitment and survival at a time step shorter than the full life span of the delta smelt.

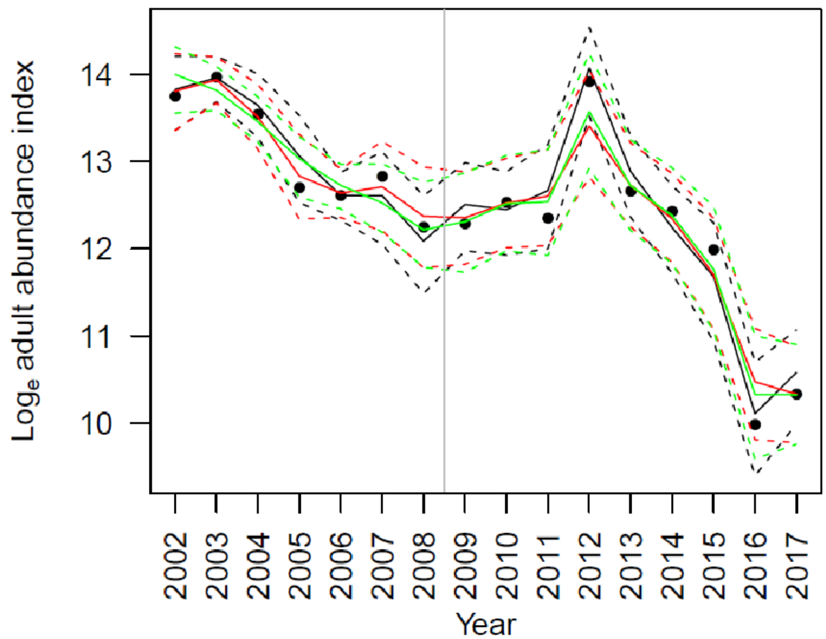


Figure 5-12. Estimated adult delta smelt abundance indices (on a natural log scale) for 2002-2017 (black circles; Appendix 1). The solid lines are predictions of the abundance indices from the three models described above (black=stage structured, red=annual model without a change-point, and green=annual model with a 2009 change-point). The solid lines are the mean prediction and the dashed lines represent the limits of the 95% central Bayesian credible intervals. Source: Service unpublished data analysis (Appendix 1).

Despite the differences in signal to noise ratio in the alternative model constructs, Figure 5-13 shows that all three generated similar predictions of the population growth rate λ, though the annual model lacking a 2009 change point did not track the multiple life stage model predictions as well as the annual model that included the change point. Regardless, Figures 5-12 and 5-13 confirm that each of the three models would on average be expected to generate similar future projections of population growth rate, and by extension, abundance.

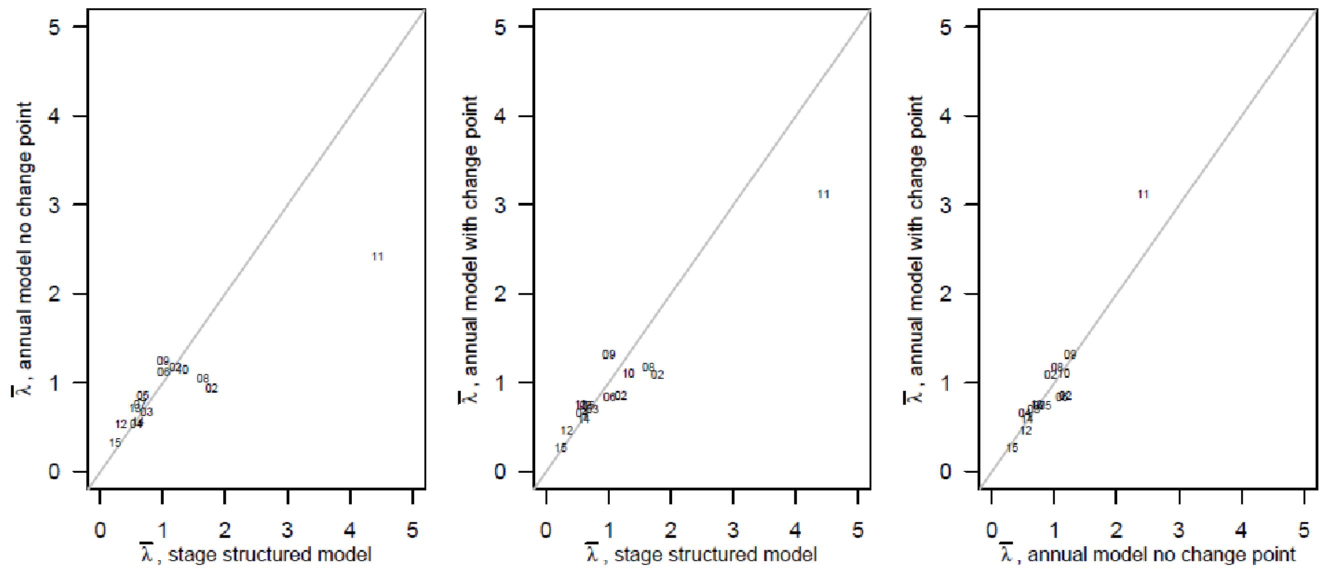


Figure 5-13. Scatterplots of mean population growth rate (λ) from the three population trend models described above. Data points are labelled by the cohort year. Source: Service unpublished data analysis.

Projections of delta smelt abundance indices over a 10-year period were made using the multiple life stage model and the annual model with a 2009 change point (Figure 5-14). Both models tend to predict continued decline whether or not pre-2009 or post-2008 vital rates were used to make the projections. This provides evidence that the delta smelt population has a high chance of continuing to decline.

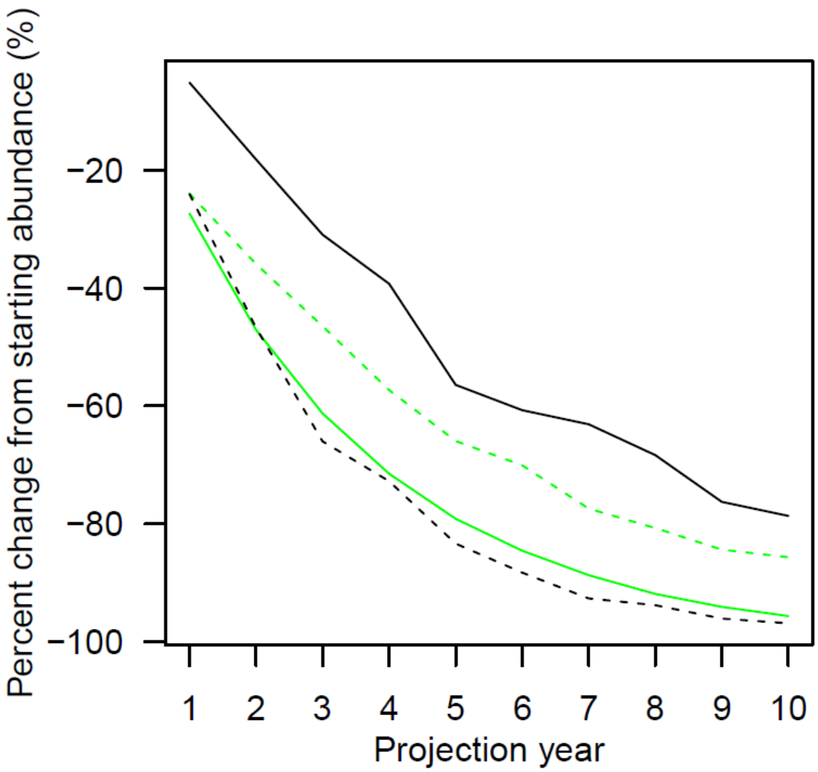


Figure 5-14. Median future abundance index predictions for delta smelt based on two of the three models described above: black=stage-structured, and green=annual model with a 2009 change-point. Solid lines reflect predictions made using pre-2009 vital rates and dashed lines reflect predictions made using ≥ 2009 vital rates. Source: Service unpublished data analysis.

Climate Change

Climate projections for the San Francisco Bay-Delta and its watershed indicate that changes will be substantial by mid-century and considerable by the year 2100. Climate models broadly agree that average annual air temperatures will rise by about 2°C at mid-century and about 4°C by 2100 if current atmospheric carbon emissions accelerate as currently forecasted (Dettinger *et al.* 2016). It remains highly uncertain whether annual precipitation in the Bay-Delta watershed will trend wetter or drier (Dettinger 2005; Dettinger *et al.* 2016). The warmer air temperature projections suggest more precipitation will fall as rain rather than snow and that storms may increase in intensity, but will have more dry weather in between them (Knowles and Cayan 2002; Dettinger 2005; Dettinger *et al.* 2016). The expected consequences are less water stored in spring snowpacks, increased flooding and an associated decrease in runoff for the remainder of the year (Hayhoe *et al.* 2004). Changes in storm tracks may lead to increased frequency of flood and drought cycles during the 21st century (Dettinger *et al.* 2015).

As of 2009, sea level rise had not had much effect on X2 (Hutton *et al.* 2017b). However, additional sea level rise is another anticipated consequence of a warming global climate and if it is not mitigated, sea level rise will likely increase saltwater intrusion into the Bay-Delta (Rath *et al.* 2017). For instance, the 6 inches of sea level rise modeled in CalSim II for the 2030 condition in the Proposed Action would be expected to move X2 about 1 km landward without higher outflow to compensate (Rath *et al.* 2017). Thus, it is likely that CalSim II had to add more outflow to meet D-1641 standards at times during the 82-year Proposed Action simulation than it would have had to if an older baseline were being modeled. During the summer of 2015, variation in sea level interacted with very low Delta inflows to cause frequent recurrence of net negative Delta outflow (Monismith 2016).

Since the early 1980s, climate change is thought to have increased wind speed along the central California coast, resulting in a more frequent and longer lasting upwelling season (Garcia-Reyes and Largier 2010). Coastal upwelling causes colder deep water to rise to the ocean surface, bringing with it nutrients that stimulate the coastal food web. One effect of wind blowing over the estuary is that it resuspends sediment deposited in shallow areas like San Pablo Bay, Grizzly Bay, and Honker Bay (Ruhl *et al*. 2001). Thus, higher wind speeds blowing onto the coast might be expected to result in higher turbidity of the water in parts of the estuary. In contrast to this expectation, Bever *et al*. (2018) reported a recent reduction in wind speed over the Bay-Delta during 1995-2015, which these authors associated with lower turbidity in Suisun Bay. The Service notes these contrasting results for completeness but we cannot reconcile these opposing trends in wind speed at this time. We show below that Secchi disk depth (an indicator of water turbidity) have not increased since the mid-1980s near the (mobile) location of X2 even though suspended sediment concentrations in Suisun Bay have decreased since about 2000 (Schoellhamer 2011; Bever *et al*. 2018).

Central California's warm summers are already a source of energetic stress for delta smelt and warm springs can already severely compress the duration of their spawning season (Rose *et al.* 2013a,b). We expect warmer estuary temperatures to present a significant conservation challenge for delta smelt in the coming decades (Brown *et al.* 2013; 2016a; Figure 5-15). Feyrer *et al.* (2011) and Brown *et al.* (2013; 2016a) have evaluated the anticipated effects of projected climate change on several delta smelt habitat metrics. Collectively, these studies indicate the future will bring chronically compressed fall habitat, fewer 'good' turbidity days (defined by the authors as a mean turbidity greater than or equal to 18 NTU), a spawning window of similar duration but that is shifted 2 to 3 weeks earlier in the year, and a substantial increase in the number of days delta smelt will need to endure lethal or near lethal summer water temperatures.

The delta smelt lives at the southern limit of the inland distribution of the family Osmeridae along the Pacific coast of North America. The anticipated effects of a warming climate are expected to create increasing temperature related challenges for delta smelt at some future point. The amount of anticipated change to the regional climate expected in the near term is lower than it is for the latter half of the century (Figure 5-15). Therefore, it is less certain that any measurable change from current conditions will occur in the next approximately 10 years than by 2050 or 2100. For the time being, water temperatures are stressful to delta smelt, but not of themselves lethal in most of the upper estuary (Komoroske *et al.* 2015).

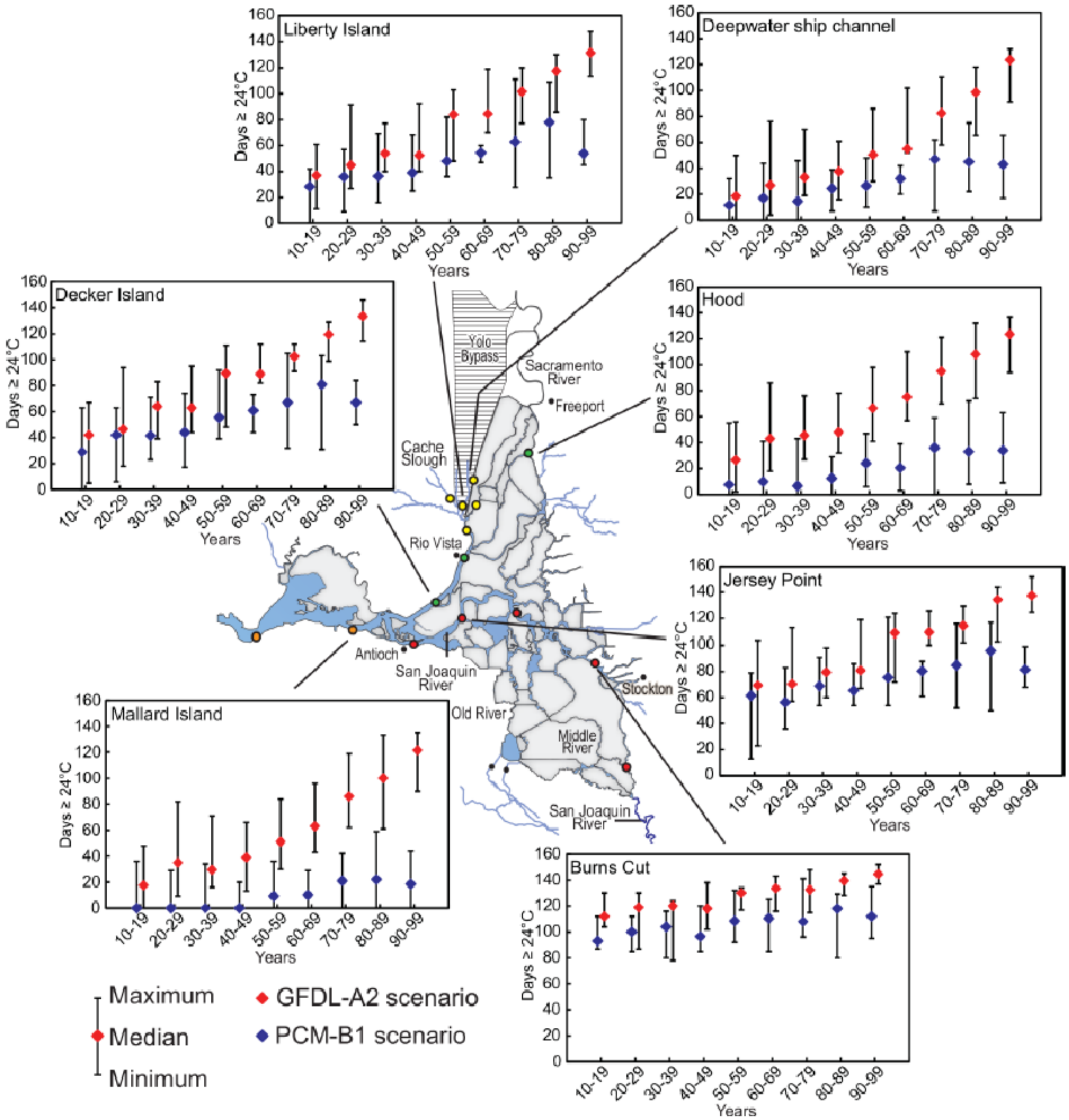


Figure 5-15. Plots of median, maximum, and minimum number of days each year with an estimated average daily water temperature greater than or equal to 24°C (75°F) at selected sites in the Delta by decade for the 21st century. The water temperature threshold reflects one chosen by the authors to represent near lethal conditions for delta smelt. Source: Brown ***et al.*** **(2016a).**

Recovery and Management

Following Moyle *et al.* (1992), the Service (1993) indicated that SWP and CVP exports were the primary factors contributing to the decline of delta smelt 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). In addition, prolonged drought during 1987-1992, in-Delta water diversions, reduction in food supplies by nonindigenous aquatic species (specifically overbite clam and nonnative copepods), and toxicity due to agricultural and industrial chemicals were also factors considered to be threatening the delta smelt. In the Service's 2008 BiOp, the RPA required protection of all life stages from entrainment and augmentation of Delta outflow during the fall of Wet and Above-Normal years as classified by the State of California (Service 2008). The expansion of entrainment protection for delta smelt in the 2008 BiOp was in response to large increases in juvenile and adult salvage in the early 2000s (Kimmerer 2008; Brown *et al.* 2009). The fall X2 requirement in the 2008 RPA was in response to increased fall exports that had reduced variability in Delta outflow and lowered habitat suitability during the fall months and the 2008 proposed action was anticipated to reduce it further (Feyrer *et al.* 2011).

The Service's (2010c) recommendation to uplist delta smelt from threatened to endangered included a discussion of threats related to reservoir operations and water diversions upstream of the estuary as additional water operations mechanisms interacting with exports from the Delta to restrict the LSZ and concentrate delta smelt with competing and predatory fish species. In addition, Brazilian waterweed (*Egeria densa*) and increasing water transparency were considered new detrimental habitat changes. Predation was considered a low-level threat linked to increasing waterweed abundance and increasing water transparency. Additional threats considered potentially significant by the Service in 2010 were entrainment into power plant diversions, contaminants, and reproductive problems that can stem from small population sizes. Conservation recommendations included: establish Delta outflows proportionate to unimpaired flows to set outflow targets as fractions of runoff in the Central Valley watersheds; minimize reverse flows in Old and Middle rivers; and, establish a genetic management plan for captive-reared delta smelt with the goals of minimizing the loss of genetic diversity and limiting risk of extinction caused by unpredictable catastrophic events. The Service (2012) recently added climate change to the list of threats to the delta smelt.

Maintaining protection of the delta smelt from excessive entrainment, improving the estuary's flow regime, suppression of nonnative species, increasing zooplankton abundance, and improving water quality are among the actions the Service has previously indicated are needed to recover the delta smelt.

There have been several recent papers suggesting it is time to consider supplementation of the wild delta smelt population with captive-bred fish as part of a broad-based conservation strategy to avoid extinction in the wild, also known as extirpation (Moyle *et al.* 2016; 2018; Hobbs *et al.* 2017; Lessard *et al.* 2018). This year, pilot research conducted by DWR has demonstrated that captive-bred delta smelt held within steel enclosures can survive in the Delta for at least 30 days. This is long enough to show that the fish can feed themselves and did not die from acute water toxicity in either of two locations tested thus far. The fish will be evaluated for chronic toxic exposure, but that work is not finished. These results are promising and similar research is planned for later this year and next.

The status of the delta smelt is poor as is the status of their critical habitat (see *Status of the Critical Habitat Within the Action Area*). The current estimated delta smelt population sizes are so low that it seems unlikely the species can be habitat- or food-limited even though both physical and food web-related habitat attributes have degraded over time. It is more likely that delta smelt have been marginalized by non-native fishes and invertebrates that compete with and prey on them. When fish populations reach very low levels, they can fall victim to demographic problems (often termed Allee effects in the scientific literature). These include problems concentrating enough individuals in particular locations for successful spawning, successful feeding, or maintaining large enough egg supplies, or shoals and schools of juvenile and adult fish to provide effective protection from predators (Liermann and Hilborn 2001; Keith and Hutchings 2012). Supplementation may help the Service and its partners reach delta smelt abundance levels that help to mitigate demographic problems. The Service anticipates that this will be an aspect of ongoing research into meeting the near term supplementation goal described in the PA.

Summary of the Status of Delta Smelt

Under the without action scenario described in the BA, the status of the delta smelt would be improved because the threats caused by or exacerbated by operations of the CVP and SWP would be lessened. For instance, there would be no entrainment, and the seasonal contraction of the LSZ would not be as pronounced. This without action condition is considered with the current condition of the species (which is a result of all factors impacting the species within the Action Area) to provide the "snapshot" of the species' health at this point in time. The relative abundance of delta smelt has reached very low numbers for a small forage fish in an ecosystem the size of the Bay-Delta and the species is approaching extinction in the wild (Moyle *et al.* 2016; 2018; Hobbs *et al.* 2017). The extremely low 2018-2019 abundance indices reflect decades of habitat change and marginalization by non-native species that prey on and out-compete delta smelt. The anticipated effects of climate change on the Bay-Delta and its watershed such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflow, and the potential for frequent extreme drought, indicate challenges to delta smelt survival will increase.

5.1.2 Status of the Critical Habitat Within the Action Area

Legal Status

The Service designated critical habitat for the delta smelt on December 19, 1994 (Service 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; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Service 1994).

Conservation Role of Delta Smelt Critical Habitat

The Service's 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 Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Bay-Delta estuary must provide suitable habitat all year, every year. The primary constituent elements considered essential to the conservation of the delta smelt as they were characterized in 1994 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 (Service 1994). The Service recommended in its designation of critical habitat for the delta smelt that salinity in Suisun Bay should vary according to WY type, which it does. For the months of February through June, this element was codified by the State Water Resources Control Board's (SWRCB) "X2 standard" described in D-1641 and the SWRCB's current Water Quality Control Plan.

Detailed Review of the Reproductive Biology of Delta Smelt

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. Delta smelt are believed to spawn in fresh and low-salinity water (Hobbs *et al.* 2007a; Bush 2017). Therefore, freshwater flow affects how much of the estuary is available for delta smelt to spawn (Hobbs *et al.* 2007a). This is one mechanism in which interannual variation in Delta outflow could play a role in the population dynamics of delta smelt. Given the timing of delta smelt reproduction, Delta outflow during February through May would be most important for this mechanism. During this time of year, variation in Delta outflow is largely driven by weather variation and regulated by the SWRCB D-1641.

The locations of delta smelt spawning are thought to be influenced by salinity (Hobbs *et al.* 2007a), but the duration of the spawning season is thought to be driven mainly by water temperature (Bennett 2005; Damon *et al.* 2016), which is largely a function of regional air temperature (Wagner *et al.* 2011). Thus, the spawning season duration does not appear to be a freshwater flow mechanism, but rather, a climate-driven mechanism (Brown *et al.* 2016a). Delta smelt can start spawning when water temperatures reach about 10°C (50°F) and can continue until temperatures reach about 20°C (68°F; Bennett 2005; Damon *et al.* 2016). The ideal spawning condition occurs when water temperatures remain between 10°C and 20°C throughout February through May. Few delta smelt ≤ 55 mm in length are sexually mature and 50% of delta smelt reach sexual maturity at 60 to 65 mm in length (Rose *et al.* 2013b). During January and February, many delta smelt are still smaller than these size thresholds (Damon *et al.* 2016). Thus, if water temperatures rise much above 10°C in January, the "spawning season" can start before many individuals are mature enough to actually spawn. If temperatures continue to warm rapidly toward 20°C in early spring, that can end the spawning season with only a small fraction of 'adult' fish having had an opportunity to spawn, and perhaps only one opportunity to do so. Delta smelt were initially believed to spawn only once before dying (Moyle *et al.* 1992). It has since been confirmed that delta smelt can spawn more than once if water temperatures remain suitable for a long enough time, and if the adults find enough food to support the production of another batch of eggs (Lindberg *et al.* 2013; Damon *et al.* 2016; Kurobe *et al.* 2016). In a recent study spanning 2 to 3 months, captive males held at a constant water temperature of 12°C (54°F) spawned an average of 2.8 times and females spawned an average of 1.7 times (LaCava *et al.* 2015). As a result, the longer water temperatures remain cool, the more fish have time to mature and the more times individual fish can spawn. Most adults disappear from monitoring programs by May, suggesting they have died (Damon *et al.* 2016; Polansky *et al.* 2018).

The reproductive behavior of delta smelt is only known from captive specimens spawned in artificial environments and most of the information has never been published, but is currently being revisited in new research. Spawning likely occurs mainly 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*), are sand or small gravel (Hirose and Kawaguchi 1998; Quinn *et al.* 2012).

The duration of the egg stage is temperature-dependent and averages about 10 days before the embryos hatch into larvae (Bennett 2005). It takes the fish about 30-70 days to reach 20-mm in length (Bennett 2005; Hobbs *et al.* 2007b). Similarly, Rose *et al.* (2013b) estimated that it takes delta smelt an average of slightly over 60 days to reach the juvenile life stage. 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. Thus, subtracting 60 days from April and July indicates that most spawning occurs from February-May.

Hatching success is highest at temperatures of 15-16°C (59-61°F) and lower at cooler and warmer temperatures and hatching success nears zero percent as water temperatures exceed 20°C (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of February-May, but ripe female delta smelt have been observed as early as January and larvae have been collected as late as July, suggesting that spawning itself may extend into June in years with exceptionally cool spring weather.

Detailed Review of the Habitat Use and Distribution of Delta Smelt

Because the delta smelt only lives in one part of one comprehensively monitored estuary, its general distribution and habitat use are well understood (Moyle *et al.* 1992; Bennett 2005; Hobbs *et al.* 2006; 2007b; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; Merz *et al.* 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013; Mahardja *et al.* 2017a; Simonis and Merz 2019). The delta smelt has been characterized as a semi-anadromous species (Bennett 2005; Hammock *et al.* 2017) and Sommer *et al.* (2011) characterized the species as a partial diadromous migrant, recognizing individual variation in its life-history. However, both terms emphasize a life cycle in which delta smelt spawn in freshwater and volitionally move 'downstream' into brackish water habitat, which is only one endpoint among several individual life cycle strategies that have recently been confirmed through the use of otolith microchemical analyses (Bush 2017). In addition, semi-anadromy and partial diadromy are scale-dependent terms which have caused confusion among researchers and managers alike. For instance, some individual delta smelt clearly migrate between fresh and brackish water during their lives (Bush 2017). Other individuals could appear to have done so based on otolith microchemistry but in reality have moved very little and simply experienced annual salinity variation, which can be very high in much of the range of delta smelt (see Hammock *et al.* 2019). Other individual delta smelt are clearly freshwater and brackish-water resident throughout their lives (Bush 2017). As a result, there are both location-based (*e.g.*, Sacramento River around Decker Island) and conditions-based (low-salinity zone) habitats that delta smelt permanently occupy. There are habitats that some delta smelt occupy seasonally (*e.g.*, for spawning), and there are habitats that a few delta smelt occupy transiently, which we define here as occasional use. Transient habitats include distribution extremes from which delta smelt have occasionally been collected, but were not historically collected every year or even in most years. Thus, the Service suggests the delta smelt may be best characterized as an upper estuary resident species with a population-scale distribution that expands and contracts as freshwater flow seasonally (and interannually) decreases and increases, respectively. This influence of freshwater flow inputs on delta smelt distribution could in turn influence mechanisms that affect the species' population dynamics when those mechanisms are linked to where the fish reside or how they are distributed in the estuary. We note that water temperature, turbidity, water diversion rates, prey availability, and possibly other factors would also affect these spatial recruitment and survival mechanisms.

Delta smelt have been observed as far west as San Francisco Bay near the City of Berkeley, as far north as Knight's 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 (Merz *et al.* 2011; Figure 5-1). These extremes of the species' distribution extend beyond the geographic boundaries specified in the critical habitat rule. However, most delta smelt have been collected from locations within the critical habitat boundaries. In other words, observations of delta smelt outside of the critical habitat boundaries reflect transient habitat use rather than permanent or seasonal habitat use. The Napa River is the only location outside of the critical habitat boundaries that may be used often enough to be considered a seasonal habitat rather than a transient one.

The fixed-location habitats that delta smelt permanently occupy span from the Cache Slough complex down into Suisun Bay and Suisun Marsh (Figure 5-16). The reasons delta smelt are believed to permanently occupy this part of the estuary are the presence of fresh- to low-salinity water year round 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 (Nobriga *et al.* 2008; Feyrer *et al.* 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013; Hammock *et al.* 2015; 2017; 2019; Bever *et al.* 2016; Mahardja *et al.* 2019; Simonis and Merz 2019). Field observations are increasingly being supported by laboratory research that explains how delta smelt respond physiologically and behaviorally to variation in water quality that can vary with changes in climate, freshwater flow and estuarine bathymetry (e.g., Hasenbein *et al.* 2013; 2016b; Komoroske *et al.* 2014; 2016).

The principal variable-location habitat that delta smelt permanently occupy is the LSZ (Moyle *et al.* 1992; Bennett 2005). The LSZ is a dynamic habitat with size and location that respond to changes in tidal and river flows (Jassby *et al.* 1995; Kimmerer *et al.* 2013; MacWilliams *et al.* 2015; 2016; Bever *et al.* 2016). The LSZ generally expands and moves downstream as river flows into the estuary increase, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under lower flow conditions. As river flows decrease, the LSZ contracts and moves upstream. This is perhaps the most frequently assumed freshwater flow mechanism in discussions about X2 regulations, but as shown by Kimmerer *et al.* (2009; 2013), it does not appear to be a major explanatory mechanism for most fishes including the delta smelt.

The LSZ often encompasses many of the permanently occupied fixed locations discussed above. It is treated separately here because delta smelt distribution tracks the movement of the LSZ somewhat (Moyle *et al.* 1992; Dege and Brown 2004; Feyrer *et al.* 2007; 2011; Nobriga *et al.* 2008; Sommer *et al.* 2011; Bever *et al.* 2016; Manly *et al.* 2015; Polansky *et al.* 2018; Simonis and Merz 2019). Due to its historical importance as a fish nursery habitat, there is a long research history into the physics and biology of the LSZ. The LSZ is frequently defined as waters with a salinity range of about 0.5 to 6 ppt (Kimmerer 2004). This and similar salinity ranges reported by different authors were chosen based on analyses of historical peaks in chlorophyll concentration and zooplankton abundance. Most delta smelt collected in the 20-mm Survey and TNS have been collected at salinities of near 0 ppt to 2 ppt and most of the (older) delta smelt in the FMWT have been collected from a salinity range of about 1 to 5 ppt (Kimmerer *et al.* 2013). These fish of different life stages do not tend to be in dramatically different places (Murphy and Hamilton 2013; Figure 5-16), suggesting that some of the change in occupied salinity with age is due to the seasonal increases in salinity that accompany lower outflow in the summer and fall.

Each year, the distribution of delta smelt seasonally expands when adults disperse in response to winter flow increases that also coincide with seasonal increases in turbidity and decreases in water temperature (Sommer *et al.* 2011; Figure 5-16). 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 the larger sloughs of Suisun Marsh. Some delta smelt seasonally and transiently occupy Old and Middle rivers in the south Delta each year, but face a high risk of entrainment when they do (Kimmerer 2008; Grimaldo *et al.* 2009). The expanded adult distribution initially affects the distribution of the next generation because delta smelt eggs are adhesive and not believed to be highly mobile once they are spawned (Mager *et al.* 2004). Thus, the distribution of larvae reflects a combination of where spawning occurred and freshwater flow when the eggs hatch.

In summary, the delta smelt population spreads out in the winter and then retracts by summer into what is presently a bi-modal spatial distribution with a peak in the LSZ and a separate peak in the Cache Slough complex. Most individuals occur in the LSZ at some point in their life cycle and the use of the Cache Slough complex diminishes in years with warm summers (Bush 2017).

Microhabitat Use: The delta smelt has been historically characterized as a pelagic fish, meaning one with a spatial distribution that is skewed away from shorelines (Moyle *et al.* 1992; Sommer *et al.* 2007). This has led to some confusion among researchers and managers alike – usually perpetuating a strawman argument that delta smelt either occupy deep-water habitats or shallow-water habitats. Then, catch data from shallow habitats get used to refute the pelagic characterization, but catches in shallow-water say nothing more about a pelagic tendency than catches in deep water would say about a nearshore habitat tendency. The long-term monitoring programs used to characterize delta smelt status and trend are offshore sampling programs – meaning pelagic sampling programs, and surface-trawling appears to be particularly effective at capturing delta smelt away from shorelines (Mitchell *et al.* 2017). However, numerous studies have reported collecting delta smelt from nearshore environments using fishing gear like beach seines and fyke nets from locations that often had a water depth less than or equal to 1 meter (just over three feet) (e.g., Matern *et al.* 2002; Nobriga *et al.* 2005; Gewant and Bollens 2012; Mahardja *et al.* 2017b). Further, it has been established that onshore-offshore movements are one behavior option delta smelt and other fishes can use to maintain position or move upstream in a tidal-flow influenced estuary (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015). Captive delta smelt have been shown to avoid in-water structure like submerged aquatic vegetation (SAV) (Ferrari *et al.* 2014). SAV tends to grow where tidal current velocities are low, which is a habitat attribute that has also been associated with wild delta smelt (Hobbs *et al.* 2006; Bever *et al.* 2016). Thus, the proliferation of SAV in areas that might otherwise be attractive to delta smelt represents a significant habitat degradation, not only because it creates structure in the water column, but also because it is associated with higher water transparency (Hestir *et al.* 2016), and a fish fauna that delta smelt does not seem to be able to coexist with (Nobriga *et al.* 2005; Conrad *et al.* 2016). Based on our review, the Service suggests that the characterization of delta smelt as an open-water fish appears to be accurate and does not imply occupation of a particular water column depth. The species does appear to have some affinity for surface waters (Burau and Bennett 2015; Mitchell *et al.* 2017), but like any microhabitat descriptor, this is not intended to reflect the location of all individuals because delta smelt are not limited to surface waters (Feyrer *et al.* 2013).

Although the delta smelt is generally an open-water fish, depth variation of open-water habitats is an important habitat attribute (Moyle *et al.* 1992; Hobbs *et al.* 2006; Bever *et al.* 2016). In the wild, delta smelt are most frequently collected in water that is somewhat shallow (4-15 ft deep) where turbidity is often elevated and tidal currents exist, but are not excessive (Moyle *et al.* 1992; Bever *et al.* 2016). For instance, in Suisun Bay, the deep shipping channels are poor quality habitat because tidal velocity is very high (Hobbs *et al*. 2006; Bever *et al.* 2016), but in the Delta where tidal velocity is slower, offshore habitat in Cache Slough and the Sacramento Deepwater Shipping Channel is used to a greater extent (Feyrer *et al.* 2013; CDFW unpublished data).

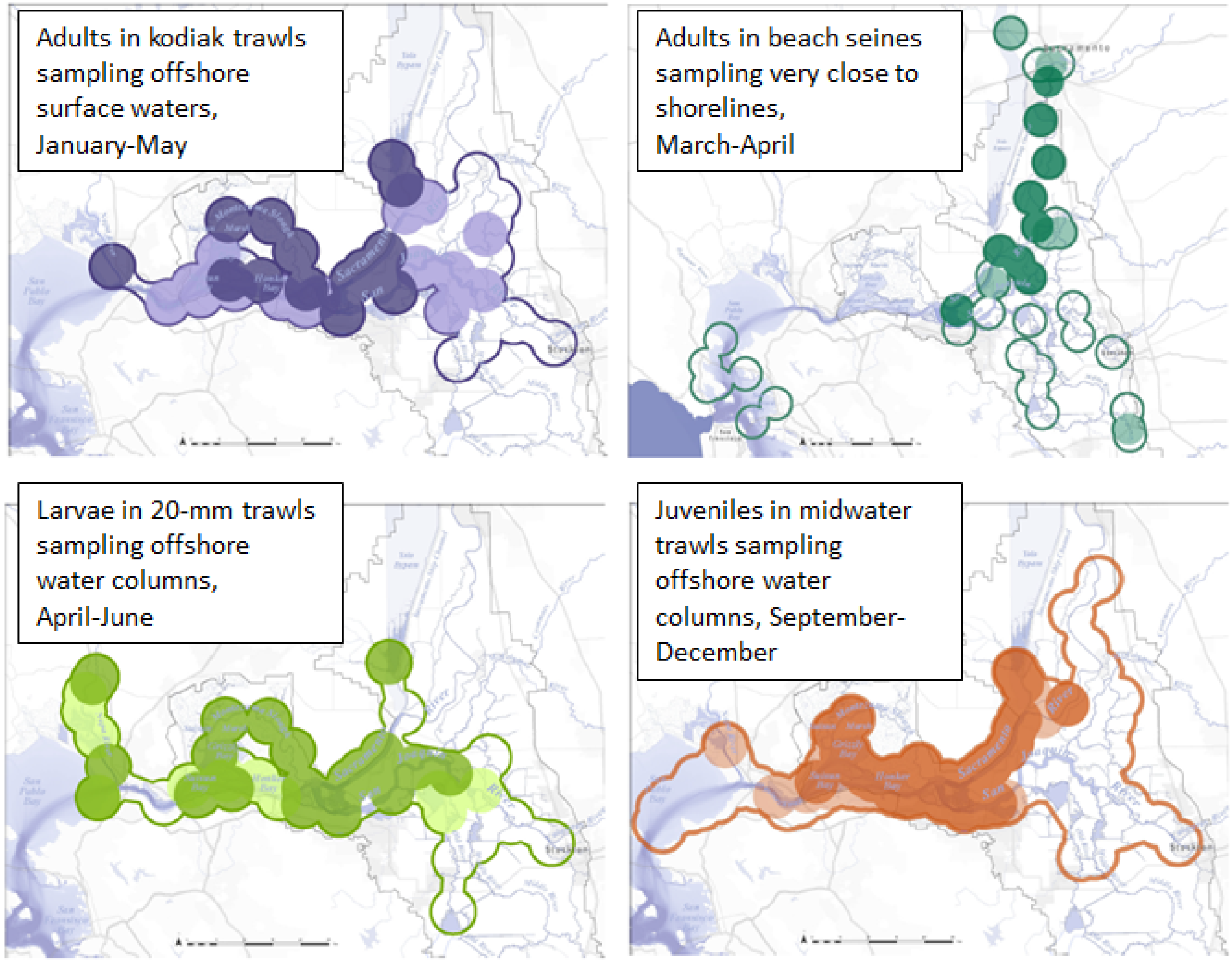


Figure 5-16. Maps of multi-year average distributions of delta smelt collected in four monitoring programs. The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the delta smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of delta smelt collections occurred. Note the lack of sampling sites in Suisun Bay and marsh for the beach seine (upper right panel). Source: Murphy and Hamilton (2013).

Description of the Primary Constituent Elements (PCE)

The original descriptions of the primary constituent elements are compared and contrasted with current scientific understanding in Table 5-1. According to the BA, the status of the delta smelt critical habitat would be improved under the without action scenario with respect to PCE 1-Physical Habitat because there would be a higher supply of spawning substrate during the winter and spring and with respect to PCE 2-Water because there would be higher winter-spring inflow and accompanying sediment into the Delta resulting in increased turbidity during winter and spring, and the potential for higher resuspension of sediment as well as during summer and fall through resuspension of sediment (Schoellhamer 2011), though this would be affected somewhat by wind speeds (Bever *et al*. 2018). The location of X2 would on average be further westward/downstream in the months that larval and juvenile delta smelt would be rearing (June through November). However, this without action condition is considered with the current condition of the critical habitat (which is a result of all factors impacting the critical habitat within the Action Area) to provide the "snapshot" of the critical habitat's health at this point in time.

Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat (Service 1994). As reviewed above, physical habitat in the Bay-Delta has been substantially changed with many of the changes having occurred many decades ago (Andrews *et al.* 2017; Gross *et al.* 2018). Physical habitat attributes are important in terms of spawning substrate, rearing habitat in terms of how geographic location and bathymetry affect tidal current velocities (Bever *et al.* 2016), and possibly, foraging opportunities near the edges of emergent marshes (Whitley and Bollens 2014; Hammock *et al.* 2019a). Information on spawning habitat is incomplete. Eggs of delta smelt are demersal and adhesive and therefore could be attached to any number of substrates. It is difficult to protect spawning habitat without knowing what it is.

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 (Service 1994). Certain conditions of turbidity, water temperature, and food availability characterize suitable 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: Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid can include clay, silt, particulate organic matter, algae, dissolved colored organic compounds, and other microscopic organisms. In the Bay-Delta, turbidity results mainly from sediment suspended in the water column and to a lesser degree phytoplankton (Cloern and Jassby 2012). Turbidity can play an important role in structuring fish communities; one mechanism by which this can occur is the scale dependence in how fish of different sizes can have their prey detection enhanced or impaired (Utne-Palm 2002). Turbidity typically lowers the reactive distance of fishes feeding on zooplankton or each other. However, if the turbidity increases prey contrast (which it often does for fish larvae and planktivorous species), then it can enhance the feeding of these small fishes while still impairing the ability of their predators to see them.

The delivery of suspended sediment to the estuary increased substantially following the era of hydraulic gold mining in the watershed (Schoellhamer 2011). It increased again during rapid regional population growth and development after World War II. Since then, the delivery of new sediment to the estuary has declined (Wright and Schoellhamer 2004; Schoellhamer 2011). In addition, summertime phytoplankton production has been greatly diminished (Cloern and Jassby 2012). These changes have resulted in a general clearing of the estuary's waters (Figure 5-17); however, the clearing trend has been strongest in the Delta where expansive beds of SAV further filter fine sediment from the water (Kimmerer 2004; Feyrer *et al*. 2007; Nobriga *et al*. 2008; Hestir *et al*. 2016). Water exports from the south Delta may also have contributed to the trend toward clearer estuary water by removing suspended sediment in exported water (Arthur *et al.* 1996); however, the contribution of exports to the total suspended sediment budget in the estuary is small (Schoellhamer 2012).

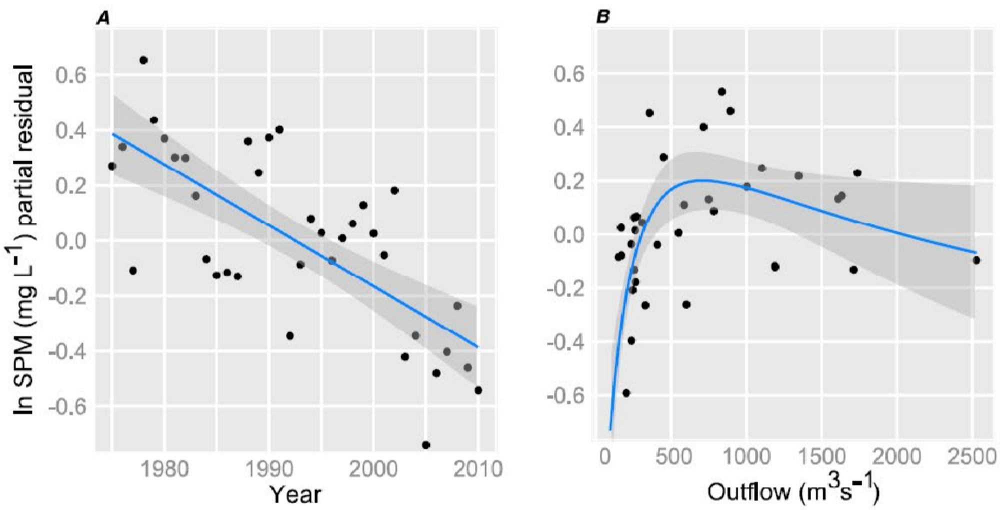


Figure 5-17. Partial residual plots for a regression model that accounts for variability in annual average concentration of suspended particulate matter at IEP station D8 in Suisun Bay as a result of its long-term trend (left panel) and its relationship to annual average Delta outflow (right panel). The blue lines are loess smoothers and the gray shading is the 95% confidence interval around the line. Source: Cloern and Jassby (2012).

The available catch data for delta smelt imply the species has an affinity for turbid water throughout most, if not all, of its free-swimming life (e.g., Nobriga *et al.* 2005; 2008; Feyrer *et al.* 2007; 2011; Grimaldo *et al.* 2009; Kimmerer *et al.* 2009; Mahardja *et al.* 2017a; Polansky *et al.* 2018; Simonis and Merz 2019), but there have been some recent suggestions that turbidity in the water affects the ability of fishing gears to catch delta smelt perhaps more than it is an actual habitat attribute (Latour 2016). The aquaculture techniques developed for delta smelt include rearing in black tanks under low light conditions because the fish are sensitive to highly lit circumstances (Lindberg *et al.* 2013; Hasenbein *et al.* 2016a). In addition, the tanks are circular and kept free of in-water structures. These captive rearing techniques are consistent with inhabitation of low visibility environments in the wild such as maintaining a spatial association with turbid water.

Below, we review process-based laboratory research that supports the 'turbidity as habitat' hypothesis. Then, we summarize long-term data on Secchi disk depths to demonstrate how water has remained relatively turbid where estuarine physics (Monismith *et al*. 1996; 2002) interacting with shallow water wind wave mixing (Ruhl *et al*. 2001; Bever *et al*. 2016) may contribute to an important refuge for delta smelt even though the biological productivity of this region has been substantially diminished (i.e., that phytoplankton currently contributes less to the turbidity than it once did). This turbid-water refuge occurs in the LSZ and is one of only two remaining in the range of the delta smelt. Turbid water may be a needed present-day habitat attribute because it provides cover for foraging delta smelt (Ferrari *et al*. 2014). By extension, it may be a factor modulating feeding success; one recent study found histopathologic evidence of elevated delta smelt feeding success in the turbid Cache Slough Complex and Suisun Marsh (Hammock *et al*. 2015); a follow-up study found elevated stomach fullness of delta smelt inhabiting the LSZ even though they were spatially disconnected from where zooplankton density was highest (Hammock *et al*. 2017). These findings are also qualitatively consistent with a more macroscopic study of the Delta's fish assemblages that found most native fishes, including delta smelt, to be more common in lower productivity turbid habitats than higher productivity SAV habitats (Nobriga *et al*. 2005). For these reasons, the Service believes delta smelt's association with turbid water, which in the present state of the Bay-Delta system is mainly caused by sediment suspended in the water, is a true habitat association.

It has been shown experimentally that delta smelt larvae require particles in the water to see their transparent prey (Baskerville-Bridges *et al.* 2004). Thus, without some kind of turbidity in the water, delta smelt larvae will starve to death. Another recent laboratory study using late larval stage delta smelt found that feeding success and survival varied across a gradient of turbidity (Hasenbein *et al.* 2016a). The results implied bell-shaped response curves in which both survival and feeding success were highest at intermediate values, though the results among treatment levels were only significantly different in a few cases. A similar experiment using 120-day-old juvenile delta smelt produced different results (Hasenbein *et al.* 2013). In this experiment, the authors reported that feeding success decreased as turbidity was increased; however, their results indicate that statistically speaking, turbidity had no effect except at the highest treatment level. The highest treatment level was 250 NTU which is exceptionally turbid water. It is worth noting two things about these studies. First, the turbidity in the tanks was created using algae, which is not the dominant source of water turbidity in the estuary. Second, in the studies described by Hasenbein *et al.* (2013; 2016b), the experiments were conducted under low light conditions even when turbidity was low (~ 1 lux). In the wild, a surface-oriented fish might have the benefit of both turbidity and high light conditions similar to those that experimentally optimized successful first feeding (Baskerville-Bridges *et al.* 2004).

In another laboratory experiment, the vulnerability of delta smelt to predation by largemouth bass was lower in a circa 3 NTU treatment (again, using algae) than a clear-water treatment (Ferrari *et al.* 2014). In a DNA-based diet study of field-caught predators, the predation of delta smelt larvae was strongly affected by water turbidity (Schreier *et al.* 2016). Thus, the available evidence suggests that delta smelt require turbid water to succeed in the contemporary Bay-Delta food web.

In fish survey data, the longest-term indicator of water turbidity is Secchi disk depth measurements that for several decades have accompanied most individual net tows. Secchi disk depths are basically inverses of turbidity because the less turbid the water is, the deeper into the water column a Secchi disk remains visible. The FMWT Secchi disk depth data set summarized below dates to 1967 (Figure 5-18).

The Secchi disk depth information suggests the increasing water clarity trends discussed above are not uniform across the upper estuary (Figure 5-18). From a regional perspective, they have been most pronounced in the San Joaquin River half of the Delta where SAV proliferation has been most expansive (Feyrer *et al.* 2007; Nobriga *et al.* 2008; Hestir *et al.* 2016). Consistent with this, boxplots depicting the time series of Secchi disk depth measurements from the FMWT show the previously reported increasing trend is most pronounced when and where the Secchi disk depths were taken in fresh water (upper left panel of Figure 5-18). In this upper left panel for which the Secchi disk depth data were summarized only when and where salinity was lower than 1.25 ppt, the previously reported trend of increasing water transparency is apparent; median Secchi disk depths have increased from about 0.5 meters with extreme values seldom exceeding 1 meter early in the time series to medians typically exceeding 1 meter and extreme values near 4 meters in recent years. When data summaries include these freshwater samples along with samples from the LSZ, the trend and extreme data points remain (upper right panel of Figure 5-18). This could lead to the erroneous conclusion that Secchi disk depths have been similarly increasing in the LSZ.

However, it is also important to consider the hydrodynamic aspect of water turbidity in the estuary. As mentioned above, X2 is a boundary upstream of which salinity tends to be the same from the surface of the water to the bottom, and downstream of which salinity varies from top to bottom (Jassby *et al.* 1995). That variability in salinity from surface to bottom waters is indicative of a front that helps to aggregate turbidity near X2. This does not mean it all aggregates precisely at X2; tidal dispersion results in a spatially complex distribution of sinking particles widely distributed in the LSZ (Kimmerer *et al.* 2014a). Thus, when the FMWT Secchi disk depth data set are constrained to brackish water samples, the long-term trend looks very different (lower panels of Figure 5-18). There is still an increasing trend over time, but it is much more modest. In particular, at a salinity near 2 to 5 ppt, Secchi disk depths have not consistently increased since the mid-1980s and observations exceeding 1 meter are still rare. Thus, there is a turbid water refuge for delta smelt that persists in the LSZ similar to the one that persists in the Cache Slough Complex.

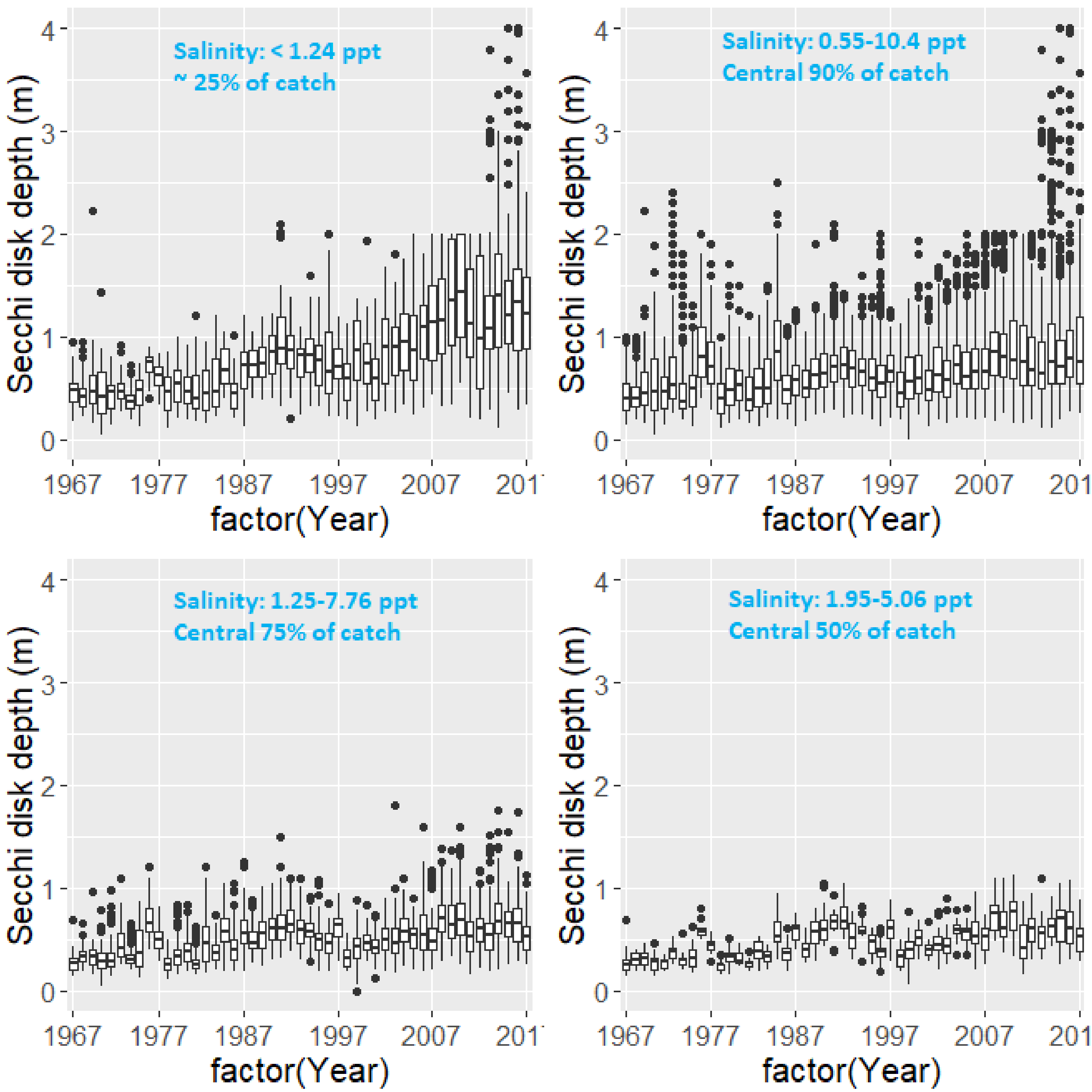


Figure 5-18. Boxplot time series of Secchi disk depth measurements taken during the California Department of Fish and Wildlife Fall Midwater Trawl Survey, 1967-2017. The boxes depict the central 50% of observations; the line through each box is the median. The black circles are observations outside the central 95% of observations. The data have been grouped into four salinity bins based on statistical summaries of delta smelt data (Kimmerer *et al.* 2013). The salinity range graphed is reported on each panel as is the predicted fraction of FMWT delta smelt catch. Source: Service unpublished data analysis using a specific conductance to salinity conversion described by Schemel (2001) and generalized additive model results provided by W. Kimmerer.

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 metabolic and growth rates which in turn can affect their susceptibility to contaminants (Fong *et al*. 2016), food limitation (Rose *et al*. 2013a), and readiness to spawn (Hobbs *et al.* 2007b). Water temperature is not strongly affected by variation in Delta inflows or outflows except at the margins of the Delta where these inflows enter (Kimmerer 2004). 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), but the system rapidly re-equilibrates once air temperatures begin to warm. Thus, like duration of the spawning season, other water temperature-driven mechanisms affecting recruitment and survival are not freshwater flow mechanisms.

Research initially suggested an upper water temperature limit for delta smelt of about 25°C, or 77°F (Swanson *et al.* 2000). Newer research suggests delta smelt temperature tolerance decreases as the fish get older, but is a little higher than previously reported, ranging from nearly 30°C or 86°F in the larval life stage down to about 25°C in post-spawn adults (Komoroske *et al.* 2014). These are upper *acute* water temperature limits meaning these temperatures will kill, on average, one of every two fish. Subsequent research into delta smelt's thermal tolerances indicated that molecular stress response begins to occur at temperatures at least 4°C cooler than the acute thermal maxima (Komoroske *et al.* 2015).

In the laboratory and the wild, delta smelt appear to have a physiological optimum at temperatures of about 16-20°C or 61-68°F (Nobriga *et al.* 2008; Rose *et al.* 2013a; Eder *et al.* 2014; Jeffries *et al.* 2016). Most of the upper estuary exceeds this water temperature from May or June through September (Komoroske *et al.* 2015). Thus, during summer, many parts of the estuary are energetically costly and physiologically stressful to delta smelt (Komoroske *et al.* 2014). 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 much higher summer inflows 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 where summer inflows are low to non-existent, are also typically warmer than they are along the Sacramento River. This may have consequences for the survival of freshwater-resident delta smelt during comparatively warm summers (Bush 2017).

Food: Food and water temperature are strongly interacting components of the "Water" element of delta smelt critical 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.

The open-water habitat use of delta smelt is reflected in their diet composition, which is largely made up of planktonic and epibenthic crustaceans (Moyle *et al.* 1992; Nobriga 2002; Hobbs *et al.* 2006; Slater and Baxter 2014). Some of the epibenthic crustaceans discussed below (e.g., amphipods and mysids) ascend into the water column at times (Kimmerer *et al.* 2002) and are therefore available to predators foraging in the open water. A large majority of the identifiable prey of delta smelt larvae is copepods, particularly the early life stages of copepods (Nobriga 2002; Hobbs *et al.* 2006; Slater and Baxter 2014). Juvenile delta smelt feeding in the summer months also have copepod-dominated diets, but these larger individuals tend to eat adult copepods and also begin to include prey taxa in their diets that grow larger than copepods (Slater and Baxter 2014; Figure 5-19). The older juveniles and adults continue to prey on copepods, but have less reliance on them and greater diet diversity (Moyle *et al.* 1992; Slater and Baxter 2014; Whitley and Bollens 2014; Figures 5-20 and 5-21). All of the delta smelt's major prey taxa (e.g., copepods, amphipods) are ubiquitously distributed, but which prey species are present at particular times and locations changes from early morning to mid-day, season to season, and has changed dramatically over time (Kimmerer *et al.* 2002; Winder and Jassby 2011; Kratina *et al.* 2014). The latter two have likely affected delta smelt feeding success (Kimmerer and Rose 2018).

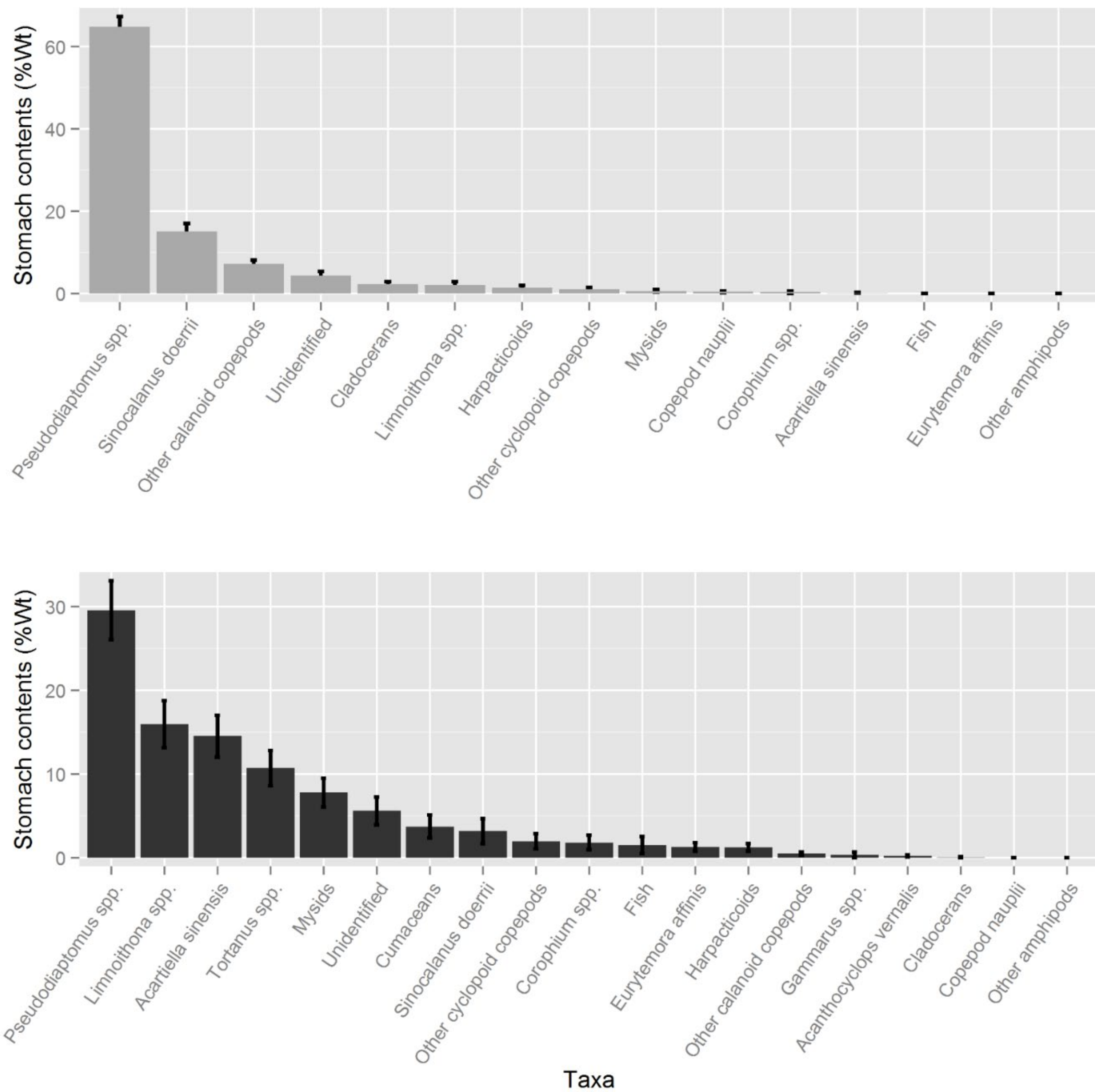


Figure 5-19. Diet compositions of delta smelt collected by the Summer Townet Survey upper panel for stations with a salinity lower than 0.55 ppt and lower panel for stations with a salinity greater than or equal to 0.55 ppt. Of the prey taxa listed on the x-axis, the ones that are *not* copepods are Cladocerans, Mysids, Corophium spp., Fish, Other Amphipods, Cumaceans, and Gammarus spp. Source: supplemental material for Hammock *et al.* (2017).

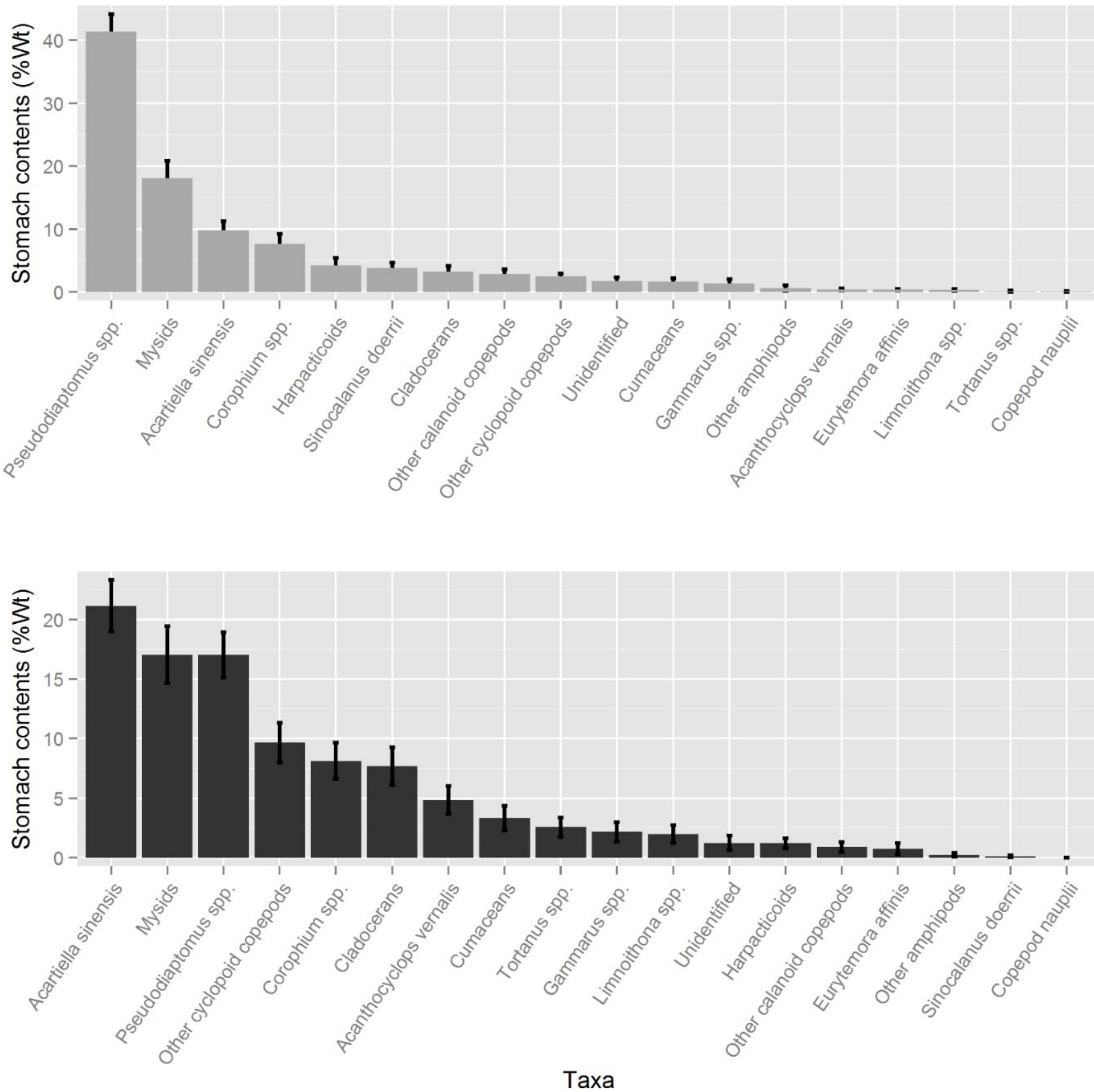


Figure 5-20. Diet compositions of delta smelt collected by the Fall Midwater Trawl Survey upper panel for stations with a salinity lower than 0.55 ppt and lower panel for stations with a salinity greater than or equal to 0.55 ppt. Of the prey taxa listed on the x-axis, the ones that are *not* copepods are Cladocerans, Mysids, Corophium spp., Other Amphipods, Cumaceans, and Gammarus spp. Source: supplemental material for Hammock *et al.* (2017).

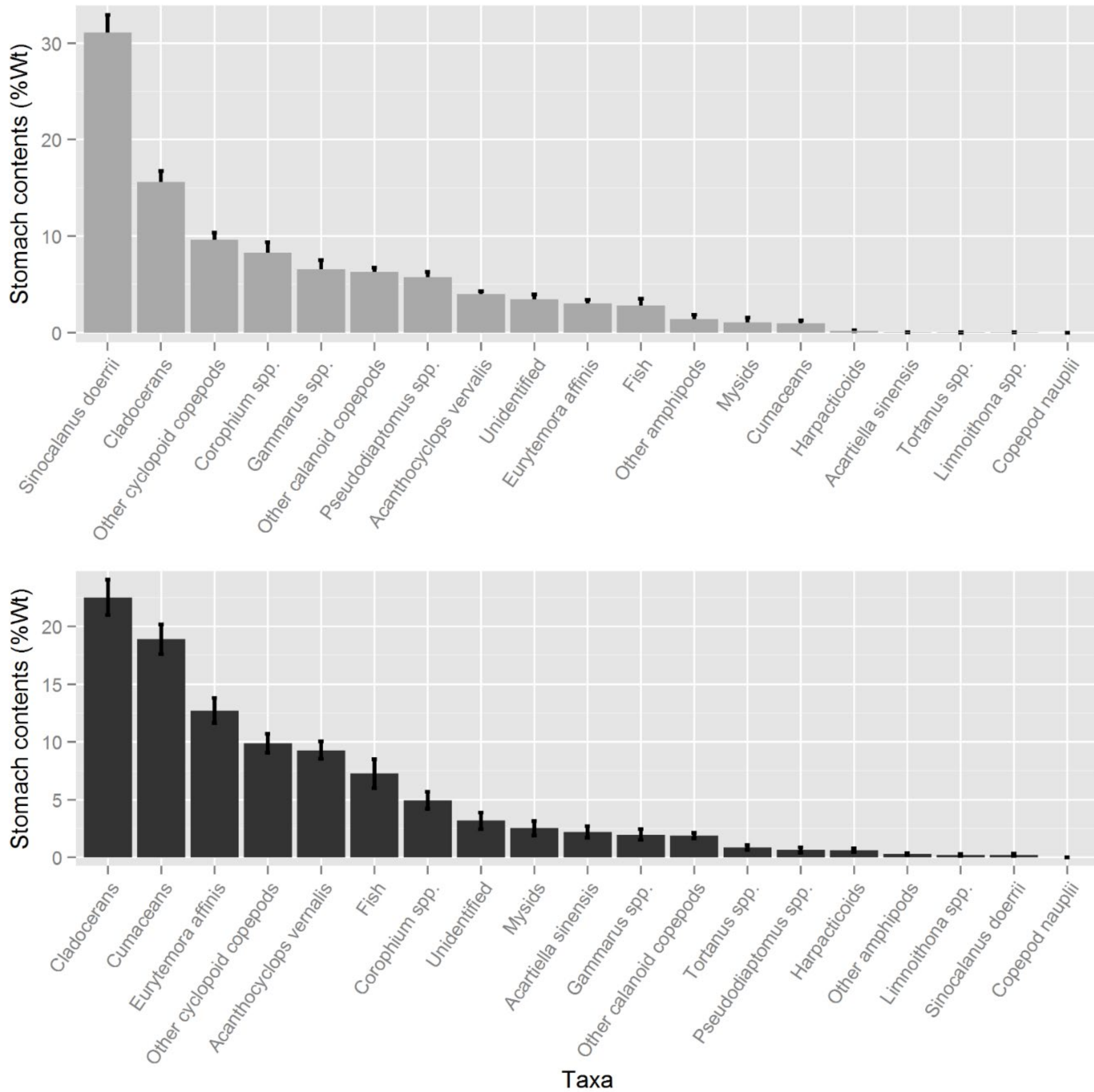


Figure 5-21. Diet compositions of delta smelt collected by the Spring Kodiak Trawl Survey upper panel for stations with a salinity lower than 0.55 ppt and lower panel for stations with a salinity greater than or equal to 0.55 ppt. Of the prey taxa listed on the x-axis, the ones that are *not* copepods are Cladocerans, Mysids, Corophium spp., Fish, Other Amphipods, Cumaceans, and Gammarus spp. Source: supplemental material for Hammock *et al.* (2017).

An influence of copepod production on the production of delta smelt has been a common finding in quantitative modeling research on delta smelt's population dynamics (Mac Nally *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Rose *et al.* 2013a; Hamilton and Murphy 2018; Kimmerer and Rose 2018). In response, the PA includes several project elements intended to increase food supplies for the delta smelt. Thus, comprehensive review of historical changes in the Bay-Delta food web is warranted for this BiOp to assist the reader in understanding the

Service's conclusions in the Effects Analyses for the species and its critical habitat in this biological opinion.

The earliest published paper on a freshwater flow influence on fish production in the Bay-Delta posited that the mechanisms producing striped bass worked primarily through the LSZ food web (Turner and Chadwick 1972). Specifically, these authors suggested that higher Delta inflow stimulated the food web that supported striped bass and increased turbidity which hid them from their predators. Because IEP monitoring was originally set up to better understand striped bass recruitment, the IEP has monitored the pelagic food web extensively since the 1970s (Brown *et al.* 2016b).

The varied sources of primary productivity that fuel estuarine fish production are an area of active research in the Bay-Delta (Sobczak *et al.* 2002; 2005; Grimaldo *et al.* 2009; Howe and Simenstad 2011; Schroeter *et al.* 2015). As is the general case in open-water food webs of estuaries and coastal marine systems, diatoms are the dominant source of primary productivity supporting open-water fish production (Sobczak *et al.* 2002; 2005; Grimaldo *et al.* 2009). Phytoplankton-based and submerged aquatic vegetation-based food webs can be separated on the basis of stable isotopes of carbon and nitrogen, but phytoplankton-based food web paths cannot be clearly separated from pathways based on terrestrial vegetation using these isotopes (Grimaldo *et al.* 2009; Schroeter *et al.* 2015). Sulfur isotopes may provide greater ability to discern among sources within and near tidal marsh environments, but to date, have not been extensively evaluated in the Bay-Delta (Howe and Simenstad 2011). The production of littoral and bottom-feeding fishes is supported by a greater fraction of non-planktonic primary producer sources (Grimaldo *et al.* 2009; Schroeter *et al.* 2015). These non-planktonic food web pathways likely have some importance to delta smelt (Whitley and Bollens 2014; Hammock *et al.* 2019).

There may be tremendous potential for benthic and epiphytic processes to periodically subsidize delta smelt's food supply, and these subsidies may occur at critical times of need, yet such pathways remain underemphasized and understudied. It is common for estuarine amphipods to rise into the water column to relocate to newly formed depositional areas, where they feed on deposited detritus and other organic materials; their successive landward movements via repeated use of selective tidal stream transport (STST, or "tidal surfing") diminish in terms of distance of upstream travel, but ultimately place them within depositional habitats (Hough and Naylor 1992; Forward and Tankersley 2001; Naylor 2006). This behavior results in the amphipods spending a great deal of time in the water column, especially when the water is dimly lit. Being in the water column may make the amphipods more available as prey for delta smelt, but the amphipods are nevertheless energetically tied to benthic basal resources, despite their spending a great deal of time in the water column (i.e., they are still energetically tied to primary production that is bottom-associated: vascular plant detritus, phytodetritus, or benthic microalgae, as opposed to phytoplankton). Mysids, on the other hand, are harder to generalize, as some species are herbivorous, some are predatory, and some are omnivorous. They also use STST, which likely increases their availability to (adult) delta smelt (Wooldridge and Erasmus 1980; Orsi 1986). Thus, depending on mysid species, they may or may not link delta smelt to benthically driven energy pathways.

Jassby *et al*. (1993) estimated benthic microalgae to be responsible for nearly 30% of the primary production in upper San Francisco Bay, inclusive of delta smelt habitat. Light penetration has since improved as turbidity has decreased (Parker *et al*. 2012), and so this ~30% contribution may have increased dramatically. Jassby *et al*. (1993) provided no estimate for epiphytic microalgae associated with SAV and the zones of emergent grass stems (in marshes) that are near the surface and within the photic zone. Even if the photic zone is just a few centimeters deep, these substrates, when added together, can provide very large surface areas for epiphytic production.

There are two clam species that affect phyto- and zooplankton biomass within the distribution of the delta smelt population. The freshwater *Corbicula fluminea*, which has been in the Delta and its tributary rivers since the 1940s, and the estuarine overbite clam *Potamocorbula amurensis*, which started invading the estuary in 1986 and was well-established within a year (Alpine and Cloern 1992). The freshwater clam can suppress diatom production in shallow freshwater habitats (Lucas *et al.* 2002; Lopez *et al.* 2006). However, the overbite clam appears to have a larger impact on the food web than the freshwater clam (Alpine and Cloern 1992; Jassby *et al.* 2002; Kimmerer and Thompson 2014), so the focus of this review will be on the overbite clam.

In the 1970s and early 1980s, scientists had learned that year-to-year variation in Delta inflow (or salinity at Chipps Island) - especially during the spring and summer - drove the year-to-year variation in the productivity of the low-salinity zone food web (Cloern *et al.* 1983; Knutson and Orsi 1983). In wet years, the flow brought a lot of nutrients and organic carbon into the low-salinity zone (Jassby and Cloern 2000) where it fueled food web production as Delta outflow seasonally decreased into an optimal range estimated by Cloern *et al.* (1983) to be about 100 to 350 cubic meters per second (about 3,500 to 12,400 cfs). In dry years, elevated salinity allowed a marine clam (*Mya arenaria*) to colonize Suisun Bay and graze the diatoms down to low levels. This in turn lowered the production of the mysid shrimp (*Neomysis mercedis*), which was a key food source for several fish species, particularly striped bass (Knutson and Orsi 1983; Orsi and Mecum 1996; Feyrer *et al.* 2003). This stimulation of mysid shrimp production was one of the food web mechanisms that Turner and Chadwick (1972) had hypothesized led to higher striped bass production in higher flow years. Similar 'fish-flow' relationships were later established for longfin smelt (*Spirinchus thaleichthys*) and starry flounder (*Platyichthys stellatus*); both of these fish are also mysid shrimp predators and were shown to have step-declines in their abundance indices associated with the overbite clam invasion (Kimmerer 2002b).

The overbite clam, once established (~ 1987), resulted in a permanent source of loss to diatoms and copepods in the LSZ that resulted in rapid step-declines in the abundance of the most important historical food web components: diatoms, mysid shrimp, and *Eurytemora affinis*; the latter is a copepod that was a major prey for both the opossum shrimp (Knutson and Orsi 1983) and delta smelt (Moyle *et al.* 1992). Unlike striped bass, longfin smelt, and starry flounder, no change in delta smelt abundance occurred coincident with the establishment of the overbite clam (Stevens and Miller 1983; Jassby *et al.* 1995; Kimmerer 2002b; Mac Nally *et al.* 2010; Thomson *et al.* 2010). However, the average size of delta smelt declined somewhat (Sweetnam 1999; Bennett 2005).

Some scientists have hypothesized that the diatom decline was caused by wastewater treatment plant inputs of ammonium or changes in the ratios of dissolved forms of nitrogen that support aquatic plant growth more than by overbite clams (Glibert *et al.* 2011; Dugdale *et al.* 2012; Parker *et al.* 2012; Wilkerson *et al.* 2015). One piece of evidence used to support this hypothesis is an observation that ammonium was frequently crossing a critical 4 micro-molar threshold concentration for diatom growth at about the same time the overbite clam became established. These researchers have established that uptake of dissolved ammonium inhibits the growth rate of diatoms in the Bay-Delta. However, diatoms can still grow on ammonium, and actually take it into their cells preferentially over nitrate; they just grow more slowly using ammonium as their cellular nitrogen source (Glibert *et al.* 2015). This means that 'but for' the overbite clam, the diatom population in the LSZ would eventually build up enough biomass each year to metabolize ambient ammonium concentrations to levels below the 4 micro-molar threshold and then increase their growth rate using the nitrate that is also in the water. Thus, although nitrogen chemistry could be a problem, a more fundamental one is that as Delta outflow declines during the spring into early summer to levels that could enable diatom blooms, the water temperature is rising and that supports reproduction of the overbite clam. With help from a few other abundant grazers (Kimmerer and Thompson 2014), the growing overbite clam population depletes diatoms faster than they can metabolize the ammonium in the water. Thus, clam grazing is the fundamental reason that summer-fall diatom blooms no longer occur (Cloern and Jassby 2012; Kimmerer and Thompson 2014; Cloern 2019). During spring when Delta outflow is higher, outflow can interact with other factors to limit diatom accumulation as well (Dugdale *et al.* 2012; 2016). Note that Dugdale *et al.* (2016) suggested that available estimates of the overbite clam grazing rate were over-estimates, but this assertion has been contested (Kimmerer and Thompson 2014; Cloern 2019).

The largest source of dissolved ammonium is the Sacramento Regional Wastewater Treatment Plant. Upgrades to the facility are expected to occur in 2021-2023, which will result in reductions in dissolved ammonium concentrations in the Delta. It is scheduled to significantly reduce its nitrogen effluent concentrations beginning in 2023. Once that happens, it should become apparent within a few years how important ammonium ratios are in limiting diatom production in the Bay-Delta.

Because the overbite clam repressed the production of historically dominant diatoms and zooplankton, there were numerous successful invertebrate species invasions and changes in plant communities that followed for a decade or so thereafter (Kimmerer and Orsi 1996; Bouley and Kimmerer 2006; Winder and Jassby 2011). Changing nutrient ratios (including the forms of nitrogen and the ratios of nitrogen and phosphorus) necessary for plant growth may also have contributed to changing phytoplankton and plant communities (Glibert *et al.* 2015; Dahm *et al.* 2016). In addition, extreme drought and propagule pressure are also thought to have directly contributed to the zooplankton species changes (Winder *et al.* 2011). The most important changes for delta smelt have been changes to the copepod community. The copepod invasions of the late 1980s and early 1990s actually helped stem (but not recover the system from) what had been a major decline in copepod abundance (Winder and Jassby 2011). Prior to the overbite clam, delta smelt had diets dominated by *E. affinis* from the time the larvae started feeding in the spring until at least the following fall (Moyle *et al.* 1992). The overbite clam suppressed the production of *E. affinis* (Kimmerer *et al.* 1994; Kimmerer and Orsi 1996) and that seems to have opened the door for several non-native copepods including *Pseudodiaptomus forbesi*, which became the new main prey of delta smelt from late spring into the fall (Moyle *et al.* 1992; Nobriga 2002; Hobbs *et al.* 2006; Slater and Baxter 2014; Hammock *et al.* 2017; Figures 5-19 and 5-20).

There is general agreement among quantitative delta smelt models that the production of copepods including *P. forbesi* are important to recruitment and survival (Kimmerer 2008; Maunder and Deriso 2011; Miller *et al.* 2012; Hamilton and Murphy 2018; Kimmerer and Rose 2018; Simonis and Merz 2019). Recognition of *P. forbesi*'s importance to delta smelt led to substantial research into this non-native copepod's population dynamics (Kimmerer and Gould 2010; Sullivan *et al.* 2013; Kimmerer *et al.* 2014b; Kayfetz *et al.* 2017; Kimmerer *et al.* 2018a,b). The delta smelt's primary historical prey (*E. affinis*) bloomed from within the LSZ and had peak abundance near X2 (Orsi and Mecum 1986). This copepod still blooms each spring, but disappears by summer due to overbite clam grazing (Kimmerer *et al.* 1994). The same thing happens to *P. forbesi* in the LSZ (Kayfetz *et al.* 2017). However, the *P. forbesi* population survives the summer because its center of reproduction is in freshwater habitats landward of the LSZ. It would disappear from the LSZ altogether were it not for a constant replenishment (or subsidy) from upstream where the overbite clam and a predatory non-native copepod are less abundant. It is the combination of tidal mixing and Delta outflow that seems to provide this subsidy (Kimmerer *et al.* 2018a,b). Thus, this subsidy of *P. forbesi* to delta smelt inhabiting the turbid water refuge of the LSZ appears to be of substantial importance – particularly during the summer and fall.

The most obvious test of whether the overbite clam affected delta smelt is a before-after comparison. As mentioned above, this has been tested several times and no obvious effect like the ones reported for striped bass, longfin smelt, and starry flounder has been established. Rather, the first big decline in delta smelt abundance occurred prior to the overbite clam invasion and the second one about 15 years afterward. Thus, if copepod production limits delta smelt production, it is either a part-time limit (e.g., Hamilton and Murphy 2018), or (a) it was a limiting factor prior to the overbite clam, and (b) it did not become a further limit until sometime thereafter. These are not mutually exclusive hypotheses.

Contaminants: Research conducted over the past 10 years suggests that delta smelt are fairly susceptible to contaminants (e.g., Connon *et al.* 2009; 2011a,b; Hasenbein *et al.* 2014; Jeffries *et al.* 2015; Jin *et al.* 2018). The effects of ambient Sacramento River water, pyrethroid pesticides, several herbicides, copper, and ammonium have all been examined and all of these compounds have shown at least sub-lethal effects represented by changes in gene expression. In some cases, delta smelt were exposed to higher than observed concentrations of some compounds in order to estimate their LC_{50}, the estimated concentration that kills half of the test fish over the study duration. Exposure durations have varied widely among studies (4 hour to 1 week), which limits the ability to quantitatively compare toxicity among studies. The loading of some contaminants into the habitats occupied by delta smelt can be functions of freshwater flow inputs (e.g., Kuivila and Moon 2004; Weston *et al.* 2014; 2015) so in some instances, the impacts of contaminants can be freshwater flow mechanisms. However, the impacts of others may be related to where individuals are located (Hammock *et al.* 2015), what delta smelt eat, or water temperature-based demand for prey, all of which could affect the quantities of biomagnifying substances that get ingested over the life span of the fish.

Primary Constituent Element 3: "River flow" was originally believed to be critical as transport flow to facilitate an extended spawning migration by adult fish and the transport of offspring to LSZ rearing habitats (Service 1994). However, it has since been shown that although some individual fish may embark on what could be considered a short spawning migration, there is no population-scale spawning migration *per se*, and that most transport and retention mechanisms for delta smelt (and their prey) involve the selective use of tidal currents rather than net flows (Kimmerer *et al.* 1998; 2002; Bennett *et al.* 2002; Kimmerer *et al.* 2014a; Bennett and Burau 2015). River flow includes both inflow to and outflow from the Delta, both of which influence the net movements of water through the Delta and further into the estuary (Kimmerer and Nobriga 2008). As mentioned above, these variations in freshwater flow affect the spatial distribution of salinity including X2, which in turn exert some influence on the distribution of delta smelt (Sweetnam 1999; Dege and Brown 2004; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Sommer *et al.* 2011; Manly *et al.* 2015; Polansky *et al.* 2018; Simonis and Merz 2019).

Net water movements in the Delta have recently been reconstructed and analyzed for long-term trend attribution (Hutton *et al.* 2019; Figure 5-22). This analysis demonstrated several net flow variables have experienced strong time trends since water exports from the Delta began. In particular, cross-Delta flows have increased during the summer and fall, Rio Vista flows have decreased in the winter and spring and increased in the summer, Jersey Point flow and Old and Middle river flow (OMR) have decreased year-around. The change attribution indicated that CVP and SWP operations were predominantly the source of these net flow changes except for Jersey Point flow in the spring, which is also strongly influenced by in-Delta irrigation demand. The net flow changes ultimately influence Delta outflow, which as discussed above, has been trending downward for more than 100 years.

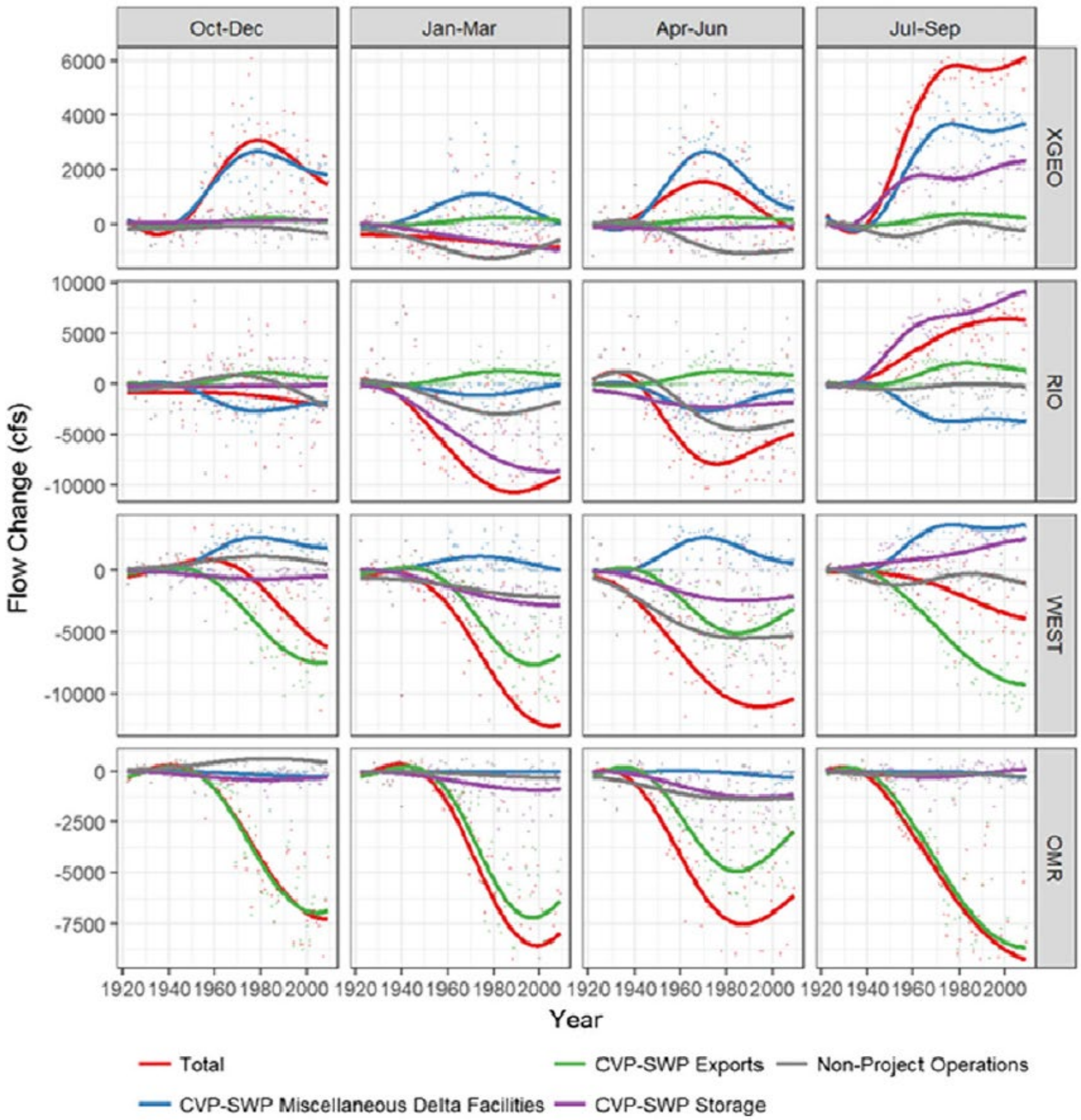


Figure 5-22. Time series (1922-2009) of statistical trend outputs of annual cross Delta flows (XGEO), net flow at Rio Vista (RIO), net flow at Jersey Point on the San Joaquin River (WEST), and net flow in Old and Middle rivers (OMR). For XGEO net north to south flows have positive values. For RIO and WEST, net seaward (downstream) flows have positive values. For OMR, which seldom has positive values, net north to south flows are depicted as negative values. The colored lines reflect the statistical trend in the time series with the different colors reflecting the relative contributions of the sources listed in the legend. Source Hutton *et al.* (2019).

A concise summary of the contemporary Delta outflow hydrograph is shown in Figure 5-23. A value on the y-axis of 0.5 suggests that an outflow on a given day has had an equal chance of being at least as high as one or in some cases all three of the chosen thresholds. Delta outflow at least as high as the Roe Island standard freshens the estuary enough for delta smelt to spawn in typically brackish regions like the Napa River and western Suisun Marsh, and tends to reduce the likelihood of entrainment. Delta outflows at least as high as the Chipps Island standard tend to generate LSZ coverage throughout much or all of Suisun Bay. Outflows near the Collinsville standard are associated with a typical X2 slightly upstream of the confluence of the Sacramento and San Joaquin rivers with low-salinity conditions extending into, but not throughout Suisun Bay and marsh. The water management response to D-1641 has been to increase the intra-annual variability in outflows. The greater intra-annual variability is related to the more frequent meeting of these flow thresholds in the winter and spring as required by D-1641, with lower frequency in the fall. This pattern is especially pronounced for outflows greater than or equal to 7,100 cfs ("Collinsville") and 11,400 cfs (Chipps Island; Figure 5-23). The same pattern is visible for 27,200 cfs ("Roe Island"; Figure 5-23), but with less change (mainly days 100-150 and 325-350, which correspond to April and the November-December transition). This does more closely mimic the timing and duration of the natural Delta outflow hydrograph than occurred during the 1968-1994 period, though the magnitude is considerably lower as discussed above (Figures 5-4, 5-8, and 5-9). Note that the DAYFLOW calculations used to make Figure 5-23 can be highly uncertain at values lower than about 10,000 cfs (Monismith 2016).

The tidal and net flow of water toward the south Delta pumping plants is frequently indexed using OMR (Grimaldo *et al.* 2009; Andrews *et al.* 2016; Figure 5-22). The tidal and net flows in Old and Middle rivers influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at the Banks and Jones facilities (Kimmerer 2008; 2011; Grimaldo *et al.* 2009). Currently available information indicates that OMR is a very good indicator of larval delta smelt entrainment risk (Kimmerer 2008; 2011). When the fish reach the juvenile stage, they can leave the south Delta to avoid adverse water temperatures (Kimmerer 2008). When maturing adults disperse the following winter, their advection into the south Delta can be affected by OMR flow, but turbidity is also an important mediator of their entrainment risk (Grimaldo *et al.* 2009). The Service's experience, particularly since 2008, is that the risk of seeing entrained fish in CVP or SWP fish salvage is low if south Delta turbidity remains less than 12 NTU. This experience is reflected in the PA.

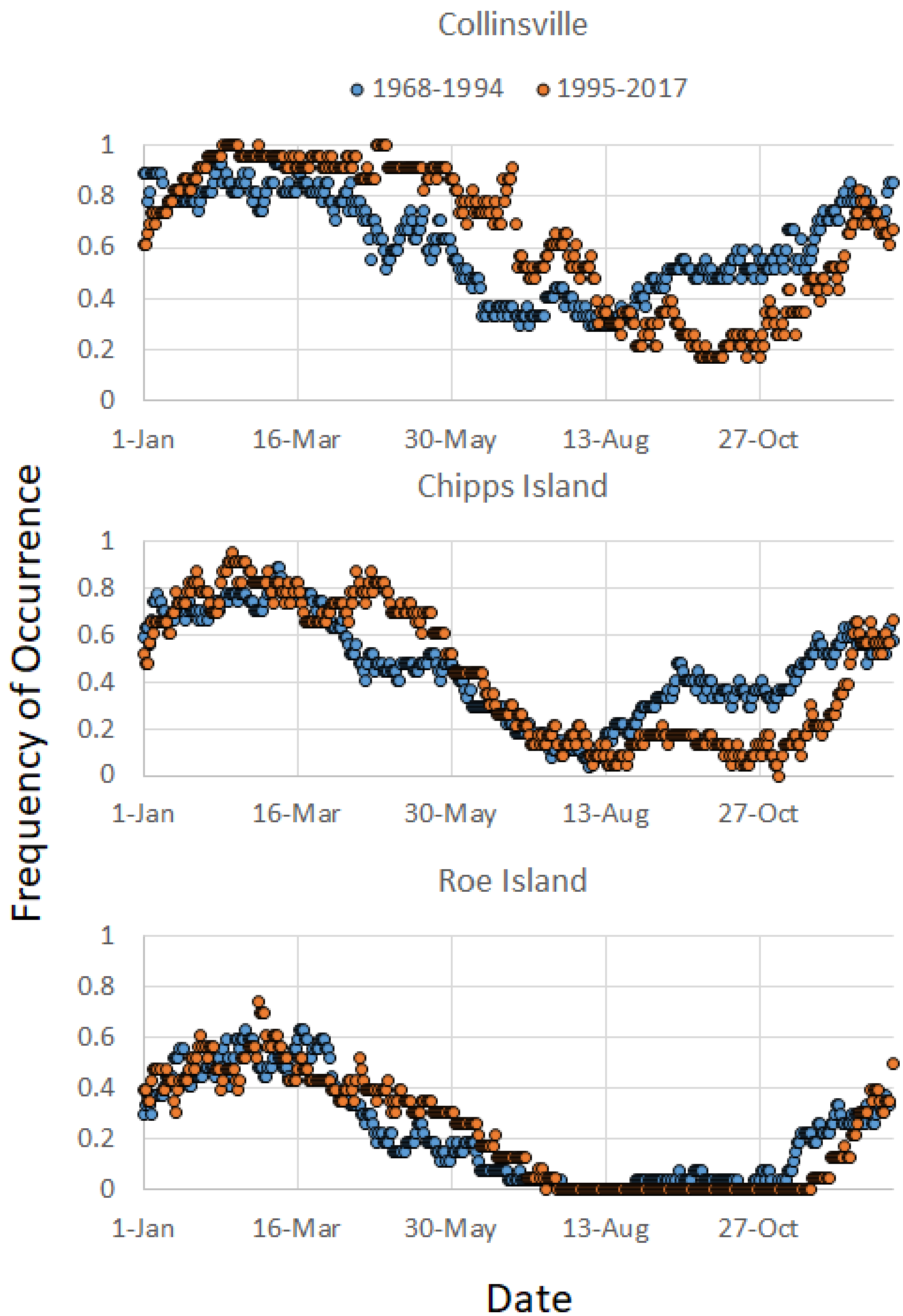


Figure 5-23. Daily frequency that the Net Delta Outflow Index (NDOI) was at least as high as the steady-state thresholds for the D-1641 'X2 standard' for January 1 to December 31, 1968-1994 (pre-Bay Delta Accord; blue symbols) and 1995-2017 (post Bay Delta Accord; orange symbols). The X2 standards outlined in the Bay Delta Accord were adopted into D-1641. The steady-state NDOI thresholds used to calculate the frequencies were Roe Island ≥ 27,200 cfs, Chipps Island ≥ 11,400 cfs, and Collinsville ≥ 7,100 cfs. For reference, a frequency of 0.5 means an NDOI at least as high as the threshold occurred half of the time

on a given day. Note that this plot is intended to provide a concise view of the seasonality of Delta outflow. It is not intended to reflect anything about compliance or non-compliance with D-1641, which can be based on Delta outflow, salinity, or X2. Source: Service unpublished analysis of the DAYFLOW database.

Primary Constituent Element 4 "Salinity": Fish assemblages are able to lessen competition among species and life stages by partitioning habitats. For instance, some fish species and life stages are more shoreline oriented whereas others are more offshore oriented. Some species are better adapted to midwater or surface waters, while others are more adapted to stay close to the substrate. Some fish are tolerant of turbidity, while others are not. In estuaries, salinity is often a dominant factor separating different groups of fishes (e.g., Bulger *et al.* 1993; Edgar *et al.* 1999). Similarly, in the Bay-Delta, dominant fishes replace one another at several places along the salinity gradient (Feyrer *et al.* 2015).

Delta smelt is part of the fish assemblage that uses the low-salinity waters of the estuary (Kimmerer *et al.* 2009; 2013). Thus, the Primary Constituent Element "Salinity" helps define its nursery habitat (Service 1994). Freshwater flow into the estuary, and Delta outflow in particular, is the most significant mechanism affecting the salinity distribution of the estuary (Jassby *et al.* 1995; MacWilliams *et al.* 2015). Thus any recruitment or survival mechanisms that change in intensity as functions of salinity, or where particular ranges of salinity are distributed, are ultimately freshwater flow mechanisms (see Kimmerer 2002a). As discussed above, these may include the spatial extent of spawning habitat (Hobbs *et al.* 2007a), the availability of low velocity water refuges that remain turbid (Bever *et al.* 2016), and population-scale entrainment in water diversions (Kimmerer and Nobriga 2008; Kimmerer 2008). Some contaminant exposure and dilution mechanisms are also related to changes in freshwater flow inputs. For instance, the toxicity of water in creeks flowing into Suisun Marsh and the Delta can increase when storms increase flows that mobilize contaminated sediment (Weston *et al.* 2014; 2015). At a larger spatial-temporal scale, water toxicity varies regionally and seasonally, and may on average, be higher in years with low winter-spring inflows (Werner *et al.* 2010).

Initial research indicated that delta smelt have an upper acute salinity tolerance of about 20 ppt (Swanson *et al.* 2000) which is about 60% of seawater's salt concentration of 32-34 ppt. Newer research suggests that some individual delta smelt can acclimate to seawater, but that about one in three juveniles and one in four adults die within a few days if they are rapidly transitioned from low-salinity water to marine salinity water (Komoroske *et al.* 2014). The survivors can live for at least several weeks in seawater, but lose weight (Komoroske *et al.* 2014; 2016). This clear evidence of physiological stress for delta smelt exposed to seawater has not been observed at lower salinity challenges – including salinities as high as 18-19 ppt. Different molecular responses have been observed, particularly at salinities higher than 6 ppt (Komoroske *et al.* 2016). These different molecular responses may reflect physiological stress, but this is not certain. There are currently several published studies that have examined aspects of delta smelt physiology at salinities in the 12-19 ppt range; none have found obvious evidence of an inability of the delta smelt to adjust its physiology to handle salinity in this range (Komoroske *et al.* 2014; 2016; Kammerer *et al.* 2016; Davis *et al.* 2019).

These findings are interesting because peak catches of early life stage wild delta smelt have occurred in fresh- or very low-salinity water and peak catches of juvenile and sub-adult fish have occurred at salinities that typify the LSZ. This contrast between where most wild delta smelt have been collected and what laboratory research indicates they can tolerate suggests one of three things. One possibility is there is a persistent laboratory artifact, though we are not aware of what such an artifact would be. A second possibility is that the analyses that have been done to date may not have accounted for change through time that has covaried with declining catches. For instance, in a recent analysis of the SKT Survey, Castillo *et al.* (2018) found that when salinity was higher during sampling (i.e., during periods of low outflow) delta smelt and other fishes were collected from a higher mean salinity. The third possibility is that a discrepancy between field salinity distribution and laboratory results may be evidence that delta smelt's distribution along the estuary salinity gradient is due to a factor or factors other than salinity *per se*. Historically, delta smelt's prey were most abundant in the LSZ, but that has not been the case for more than 30 years. One explanation that may better align with recent laboratory research is that turbidity is the more important physical habitat attribute. Relatively turbid waters occur as a mobile front within the LSZ (Figure 5-18), occur regularly in Grizzly and Honker bays (Bever *et al.* 2016), and the Cache Slough complex (Sommer and Mejia 2013), all of which are places delta smelt have frequently been collected. This could mean that hiding from predators or minimizing competition are the more relevant drivers of delta smelt distribution. The Service has permitted the use of cultured fish enclosures placed along the estuary salinity gradient to explore this possibility.

The Service used the FMWT data to re-evaluate delta smelt salinity distribution and included equivalent data for five other open-water species to provide context. We analyzed the data separately for pre- and post-overbite clam eras given the large changes in food web function and fish distribution that occurred following its invasion (e.g., Kimmerer 2002b; Kimmerer 2006). To generate Figure 5-24, we converted the specific conductance data recorded during FMWT sampling to salinity using the equation provided by Schemel (2001) and created salinity bins spanning 1 ppt. We normalized the catch of each species each year relative to salinity so that years of high abundance would not contribute to the results more than years of low abundance. We did this by setting each year's maximum catch of each species to one, and converting smaller catches to fractions of these annual maxima. We then summarized the results with boxplots that show the interannual variability in normalized catch relative to the salinity gradient. Note that catch data were converted to biomass estimates before normalizing.

Of the species summarized in Figure 5-24, the delta smelt showed the smallest change in distribution relative to salinity after the overbite clam invasion. This is partly because delta smelt is the only one that has never been recorded at a salinity higher than about 20 ppt, which is consistent with previous field data summaries and the laboratory results reviewed above. There are small modes in delta smelt biomass in the LSZ and a general tapering off (with occasional exceptions in particular 1 ppt bins) out to 20 ppt. The northern anchovy data show the skew toward more marine waters that was described by Kimmerer (2006). Longfin smelt and age-0 striped bass had a more even distribution relative to salinity after the overbite clam than they did before. In contrast, American shad had a relatively even distribution across the salinity gradient before the overbite clam, but its distribution has been skewed into somewhat fresher water since. Threadfin shad appear to have greater relative use of the LSZ since the overbite clam, and perhaps higher salinity water more generally. Collectively, these data suggest some re-distribution of the upper estuary fish assemblage has occurred since the 1980s. We note that because mean salinity of the FMWT sampling grid has increased as well (Feyrer *et al.* 2007; 2011) some of these changes may also reflect that trend (e.g., northern anchovy, longfin smelt, striped bass, and threadfin shad). In contrast, the shift toward fresher water by American shad and the lack of major change by delta smelt suggest these species' spatial distribution has

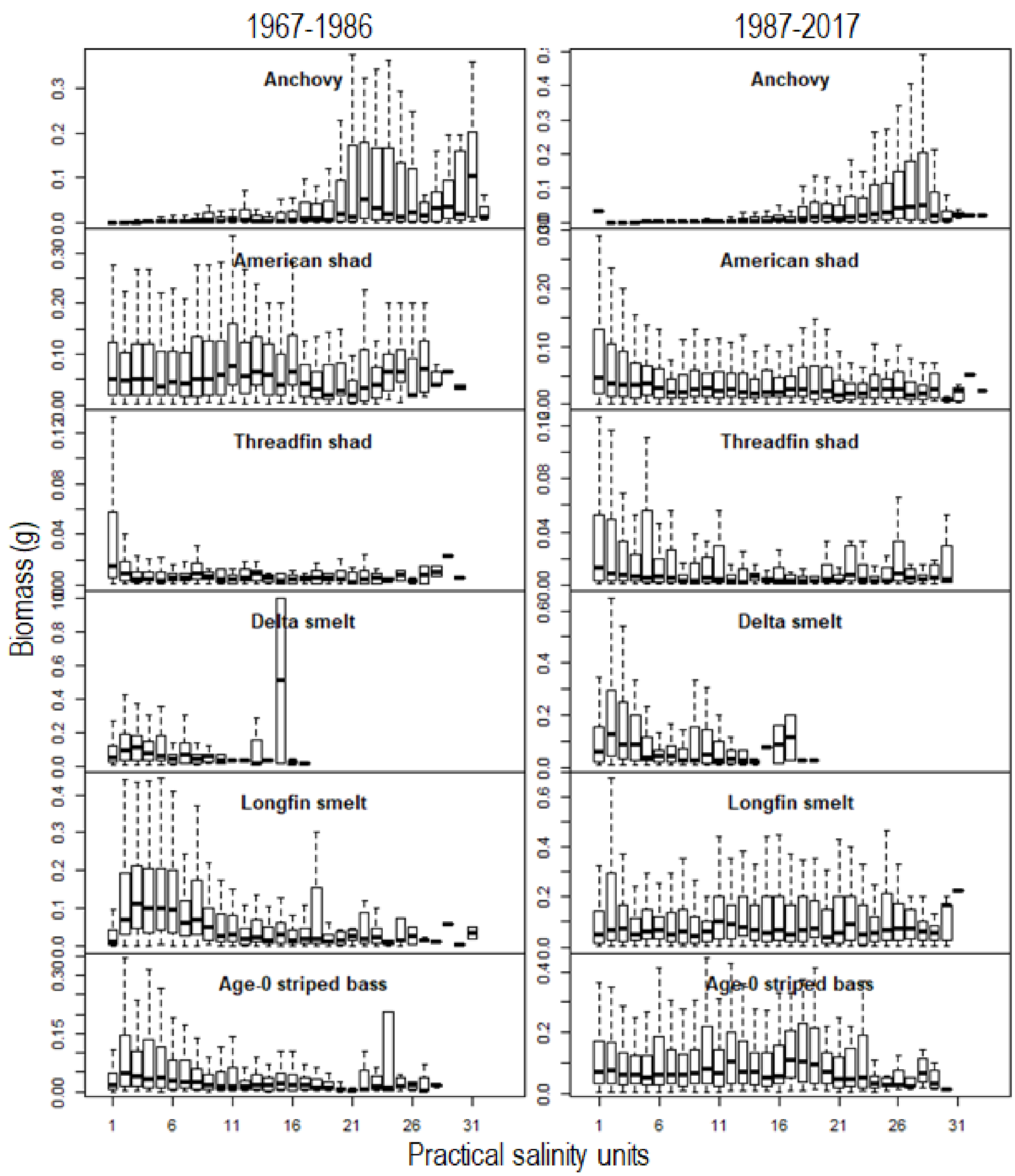


Figure 5-24. Salinity distributions of Fall Midwater Trawl catch for six pelagic San Francisco Estuary fishes, summarized by pre-overbite clam invasion years (1967-1986) and post-invasion years (1987-2017). Each Fall Midwater Trawl sample was associated with a

specific conductance measurement, which was converted to practical salinity units. Annual frequencies of positive catches for each species, binned into one salinity unit increments, were divided by the total positive catch for each year-species combination, to yield proportional positive catch by salinity. Proportions represented annual distributions along the salinity gradient. Within each salinity bin and across years, the distributions of proportional catches were summarized with boxplots.

changed – if it had not, they would be distributed in more saline water like the other four species. For delta smelt, this distribution shift to the east is consistent with what has been reported previously (Feyrer *et al.* 2007; 2011; Sommer *et al.* 2011; Sommer and Mejia 2013).

Summary of Status of Delta Smelt Critical Habitat

The Service's 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. Since the implementation of the RPA in the Service's 2008 BiOp, there has been much lower likelihood of water operations that are highly detrimental to the spawning migration of adult delta smelt, the spawners themselves, or larval transport. Under the without action scenario described in the BA, the status of delta smelt critical habitat would be improved because there would be high winter-spring inflow and sediment into the Delta resulting in increased turbidity during winter and spring, as well as during summer and fall through resuspension of sediment, and there would be on average more low-salinity habitat available for rearing larval and juvenile smelt. This without action condition is considered with the current condition of the critical habitat (which is a result of all factors impacting the critical habitat within the Action Area) to provide the "snapshot" of the critical habitat's health at this point in time.

The delta smelt's critical habitat, which is synonymous with the downstream waters of the Action Area, is currently not adequately serving its intended conservation role and function because there are very few locations that consistently provide all the needed habitat attributes for larval and juvenile rearing at the same times and in the same places (Table 5-3). The Service's review indicates it is rearing habitat that remains most impacted by ecological changes in the estuary, both before and since the delta smelt's listing under the Act. As described above, those changes have stemmed from chronic low outflow, changes in the seasonal timing of Delta inflow, and lower flow variability, species invasions and associated changes in how the upper estuary food web functions, declining prey availability, high water temperatures, declining water turbidity, and localized contaminant exposure and accumulation by delta smelt.

Table 5-3. Summary of habitat attribute conditions for delta smelt in six regions of the estuary that are permanently or seasonally occupied in most years.

	Landscape	Turbidity	Salinity	Temperature	Food
Montezuma Slough	Appropriate	Appropriate	Appropriate *when outflow is sufficient, or when the SMSCG are operated to lower salinity*	Usually appropriate	Appropriate
Suisun Bay (including Honker and Grizzly bays)	Appropriate except in shipping channel	Usually appropriate	Appropriate *when outflow is sufficient*	Usually appropriate	Depleted
West Delta	Limited area 4 to 15 feet deep	Marginal, declining	Appropriate	Can be too high during summer	Depleted
North Delta (Cache Slough region)	Appropriate	Appropriate	Appropriate	Can be too high during summer	Appropriate, but associated with elevated contaminant impacts
Sacramento River above Cache Slough confluence	Limited area 4 to 15 feet deep; swift currents	Marginal except during high flows, declining	Appropriate, but possibly lower than optimal	Usually appropriate	Likely low due to swift currents and wastewater inputs
South Delta	Appropriate except too much coverage by submerged plants	Too low	Appropriate	Too high in the summer	Appropriate

5.1.3 Factors Affecting Delta Smelt and Critical Habitat Within the Action Area

The Environmental Baseline includes State, tribal, local, and private actions already affecting the species or that will occur contemporaneously with the consultation in progress. Unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultations are also part of the Environmental Baseline, as are Federal and other actions within the Action Area that may benefit listed species or critical habitat.

There have been numerous consultations on effects to delta smelt and critical habitat completed since the species was listed in 1993. The previous partial and completed consultations related to CVP/SWP water operations are reviewed in the *Consultation History* section of this biological opinion. A summary of select projects and consultations that have played significant roles in shaping the current conditions of the delta smelt and its critical habitat are summarized in Table 5-4.

Table 5-4. Summary of select projects and consultations for the delta smelt that are part of the Environmental Baseline for this consultation.

Consultation	Description
2008 OCAP Biological Opinion	In December 2008, the Service issued a biological opinion that concluded the coordinated operations of the CVP and SWP was likely to jeopardize the continued existence of delta smelt and destroy or adversely modify its critical habitat. Key elements of the Service's 2008 RPA were: RPA Component 1: The objective of Component 1 (comprised of Actions 1 and 2) is to reduce entrainment of pre-spawning adults by controlling OMR flows during periods of elevated entrainment risk. Action 1 is designed to protect migrating delta smelt. Action 2 is designed to protect adult delta smelt that are residing in the Delta prior to spawning. Overall, RPA Component 1 increases the suitability of spawning habitat for delta smelt by decreasing the amount of Delta habitat affected by the CVP and SWP export pumping plants' operations prior to, and during, the critical spawning period; RPA Component 2: The objective of Component 2 (Action 3) is to limit entrainment of larval and juvenile delta smelt by reducing net negative flow conditions in the central and south Delta, so that larval and juvenile delta smelt can successfully rear in the Delta and move downstream when appropriate; RPA Component 3: The objective of Component 3 (Acton 4) is to improve fall habitat conditions for delta smelt by increasing Delta outflow during fall of Wet and Above Normal years to re-establish variability in habitat conditions during this time of year; RPA Component 4: The objective of Component 4 (Action 6) is to restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh to increase prey production for delta smelt; and RPA Component 5: Component 5 provides for monitoring and reporting. Reclamation and DWR shall ensure that information is gathered and reported to ensure: (1) proper implementation of the restoration actions, (2) that the physical results of the restoration actions are achieved, and (3) that

	information is gathered to evaluate the effectiveness of these actions on the targeted life stages of delta smelt so that the actions can be refined, if needed. For more information, the 2008 Service BiOp can be found at: https://www.fws.gov/sfbaydelta/documents/SWP-CVP_OPs_BO_12-15_final_signed.pdf
California EcoRestore	This State of California-led initiative proposes to restore at least 30,000 acres of tidal wetlands, floodplain, upland, riparian, and fish passage improvements in the Delta by 2020. This includes 8,000 acres of tidal habitat required under the 2008 BiOp. To date, the following tidal marsh restoration projects have begun construction: Tule Red, Yolo Flyway Farms, and Decker Island Tidal Marsh Restoration Projects. These projects have been designed to provide food web benefits to delta smelt. Although projects have been chosen to receive funding, no projects have been completed (fully constructed) to date. The ROC PA includes a commitment by Reclamation and DWR to complete the remainder of the 8,000 acres of tidal habitat restoration by 2030.
South Delta Temporary Barriers Project (SDTBP)	The SDTBP consists of three rock barriers that DWR uses to increase water levels, circulation, and water quality in the southern Delta for local diverters, and a fourth barrier at the head of Old River (HORB) intended to incentivize salmonid fishes to migrate through the Delta via the mainstem San Joaquin River. The three ag barriers are in place from April 15 to September 30 each year. The HORB has been seasonally installed most years since 1963 in the fall, and 1992 in the spring. Prior to explicit limits on OMR flows, the installation of the HORB during spring could increase juvenile delta smelt salvage because the barrier resulted in more negative OMR if exports were not reduced. The OMR flow limits in the ROC PA will continue to help minimize the entrainment risk associated with the south Delta barriers. On March 7, 2018, the Service completed a biological opinion to the Corps and DWR on the seasonal installation of temporary barriers, including the HORB. Under the ROC PA, DWR and Reclamation propose to not install the HORB for the duration of this consultation.
NMFS 2009 Biological Opinion	NMFS issued its current coordinated operations of the CVP and SWP BiOp on June 4, 2009. The NMFS BiOp covers: Central California Coast steelhead and its critical habitat; Sacramento River winter-run Chinook salmon; Central Valley spring-run Chinook salmon; Central Valley steelhead; Southern Distinct Population Segment (DPS) of Northern American green sturgeon; and Southern resident DPS of killer whales. NMFS determined that the action was likely to jeopardize these species and destroy or adversely modify their critical habitat, except the Central California Coast steelhead, and included an RPA (NMFS 2009).

	Key elements of the NMFS RPA in the 2009 BiOp are: ● A new temperature management program for Shasta Reservoir and the Sacramento River below Keswick Dam; ● Long-term passage prescriptions at Shasta Dam to allow re-introduction of listed salmonids; ● Flow and temperature criteria in Clear Creek below Whiskeytown Dam; ● A new screened pumping plant in Red Bluff to replace the Red Bluff Diversion Dam (completed in 2012); ● Improved juvenile salmonid fish rearing habitat in the lower Sacramento River and Delta; ● Delta Cross Channel gate closure beyond the mandates of D-1641; ● An OMR flow limit of -5000 cfs from January 1 through June 30 with density-based triggers that can limit OMR flow to less negative values; ● A limit on the ratio of exports to San Joaquin River inflow during April and May; ● Required studies of acoustic tagged steelhead in the San Joaquin Basin to evaluate the effectiveness of the RPA and refinements as necessary; ● New flow management standard, temperature management plan, additional technological fixes to temperature control structures, and long-term fish passage above Folsom Dam for steelhead on the American River; ● New minimum flow regime for steelhead in the Stanislaus River and long-term fish passage evaluations above Goodwin, Tulloch, and New Melones Dam; and A hatchery genetics management plan for Nimbus Hatchery for steelhead and fall-run Chinook salmon.
Water Quality Control Plan	The SWRCB has issued numerous orders and decisions regarding water quality and water right requirements. The current Water Quality Control Plan for the Bay-Delta (WQCP) including the water quality objectives in D-1641 (issued December 29, 1999) and subsequent revisions in 2000 and 2006. The various flow objectives and export limits in D-1641 are designed to protect the estuary ecosystem, in-Delta agriculture and regional municipal water quality. These objectives include salinity and minimum outflow requirements throughout the year, and an 'X2 standard' and export to inflow ratio limits in February through June. The water quality objectives vary within and between years according to the Sacramento Valley 40-30-30 WY Index. These water quality standards were incorporated into the ROC BA.

	The SWRCB is also in the process of updating the WQCP. The update has been broken into four phases, some of which are proceeding concurrently. Phases 1 and 2 are currently in progress; Phase 1 involves updating San Joaquin River flow and southern Delta water quality requirements. Phase 2 focuses on the Sacramento River basin and the Delta. Phase 3 will involve implementation of Phases 1 and 2 through changes to water rights and other measures. This phase will require a series of hearings to determine the appropriate allocation of responsibility between water rights holders within the scope of the Phase 1 and Phase 2 plans. Phase 4 will involve developing and implementing flow objectives for priority Delta tributaries upstream of the Delta.
Central Valley Project Improvement Act	In 1992, the CVP was reauthorized through the Central Valley Project Improvement Act (CVPIA) (Public Law 102-575, Title 34) adding mitigation, protection, and restoration of fish and wildlife as a project purpose. Further, the CVPIA specified that the dams and reservoirs of the CVP should now be used "first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement." The CVPIA includes actions to benefit fish and wildlife. Section 3406(b)(1) is implemented through the Anadromous Fish Restoration Program (AFRP). Section 3406(b)(1) provides for modification of the CVP operations to meet the fishery restoration goals of the CVPIA, so long as the operations are not in conflict with the fulfillment of the Secretary's contractual obligations to provide CVP water for other authorized purposes. The DOI decision on Implementation of Section 3406(b)(2) of the CVPIA, dated May 9, 2003, provides for the dedication and management of 800,000 acre-feet of CVP-water each year. This water has been used to augment flows below CVP dams and to temporarily reduce CVP exports in the spring. DOI manages and accounts for (b)(2) water pursuant to its May 9, 2003 decision and court decisions, including *Bay Institute of San Francisco v. United States*, 66 Fed. Appx. 734 (9th Cir. 2003), as amended, 87 Fed. Appx. 637 (2004). Additionally, DOI is authorized to acquire water to supplement (b)(2) water, pursuant to Section 3406(b)(3), but has seldom done so.
2014-2016 Drought Operations	The drought conditions during 2014-2016 resulted in low reservoir storages which limited the ability of the CVP and SWP to meet their obligations and comply with the WQCP. During 2014, 2015 and 2016, Reclamation and DWR petitioned the SWRCB on several occasions to temporarily modify the terms of their water rights permits. The SWRCB Executive Director approved Orders for temporary urgency changes to D-1641 standards to help Reclamation and DWR deliver minimum water

	supplies. The granted requests and information related to the drought workshops can be found online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/index.shtml. An emergency drought barrier was installed in False River between Jersey and Bradford Islands during May and June 2015 to prevent salinity intrusion into the central Delta during a period of extremely low (sometimes net negative) Delta outflow. The barrier allowed the CVP and SWP to meet salinity standards revised per the Temporary Urgency Change Petitions (TUCPs) while conserving limited water supply in the Project reservoirs. The barrier was removed in the fall of 2015. The barrier was installed during what is typically the peak of delta smelt larval density. The barrier may have prevented some delta smelt from utilizing False River for migration or dispersal, possibly increasing the risk of predation for fish in Franks Tract. Similar drought operations could be considered in the future when exceptionally dry conditions return to California.
Channel Maintenance Dredging and Sand Mining Projects	The Corps has consulted annually with the Service to conduct maintenance dredging in the Suisun Bay Federal Navigation Channels (SBFNC). The SBFNC include several reaches: Bulls Head Channel, Suisun Bay Main Channel and New York Slough. Maintenance activities have included the use of hydraulic suction dredging and mechanical clamshell dredging. Delta smelt have historically been entrained with the hydraulic suction dredging. Thus, the Corps has used clamshell dredging since 2015 to minimize its incidental take. The Corps has also annually consulted with the Service to conduct its operations and maintenance dredging in the Sacramento River Deep Water Ship Channel (SRDWSC) and Stockton Deep Water Ship Channel (SDWSC). Portions of each channel are dredged annually to maintain the current navigational depths. The SRDWSC begins in the city of West Sacramento and extends southwest to Collinsville. The SDWSC extends from New York Slough near Pittsburg to Stockton along the San Joaquin River. The SRDWSC varies in width from 200 to 400 ft. The ship channel was proposed to be deepened and widened as authorized under the Water Resources Development Act of 1986 (Public Law 99-662). The channel was proposed to be deepened along its entire length and widened to bottom widths ranging from 250 to 400 ft. Due to funding and other constraints, this PA has not been completed. Since 2014, only the reach from river mile (RM) 35 to the turning basin of the SDWSC has been deepened and the only widening that occurred was that necessary to maintain a 1:3 side slope for the deeper channel segment. The shipping channel maintenance projects use a hydraulic cutter head suction dredge. In 2016, operational changes were made to reduce delta smelt

	entrainment. In 2015, the Service requested cessation of fish monitoring surveys associated with dredging to minimize incidental take of delta smelt. Jerico Products, Hanson Marine Operations, and their joint-venture partnership Suisun Associates are commercial sand mining companies that have leases in Suisun Bay and the west Delta to collect sand for construction-related materials using hydraulic dredging methods. The Corps consulted with the Service in 2014 on their ten-year marine sand-mining lease project proposal. The amount and seasonal timing of sand mining are largely dictated by demand for sand and the weather. Generally, sand mining peaks in the summer and early fall when commercial and residential construction is also at its annual peak. July – October sand mining historically makes up over 43% of the total annual volume. The Service's biological opinion prohibits mining near the shoreline and in shallow areas, help protect delta smelt spawning habitat and fringing marsh habitats. Bathymetric surveys provide a basis for routine monitoring of subtidal conditions in areas where mining takes place and could be used to detect and assess biologically significant changes in subtidal habitat. This bathymetric monitoring is required as part of the Corps permit. Tracking mining locations serves to ensure that mining occurs only within designated lease areas.
Dredging Projects	The Service completed consultation with the Corps on the San Francisco Bay to Stockton Navigational Improvements Project on October 3, 2019. This project would deepen portions of the shipping channel in San Pablo Bay and Suisun Bay. The modeling analysis indicates that the change in channel depth will have effects to the size and location of the LSZ in some year types. The project will beneficially reuse dredge materials at habitat restoration sites.
Levee Projects	In March of 2015, the Corps completed a draft general reevaluation study of the American River Common Features project for the City of Sacramento and surrounding areas. This study addressed the flood risk management system for the American and Sacramento Rivers and five other smaller channels which are sources of potential flooding. These areas overlap the Action Area for the ROC PA. The Common Features project will remediate levee seepage along approximately 22 miles of the American River. It will also strengthen and raise 12 miles of Sacramento River levee in Natomas. Lastly, the authorization included seepage remediation and higher levees along four stretches of the American River and 5 miles of the Natomas Cross Canal levee. The Small Erosion Repair Program (SERP) provides a streamlined process for DWR to identify, obtain regulatory authorization for, and construct minor levee repairs on levees maintained by DWR within the Sacramento River Flood Control Project area. The SERP covers approximately 300 miles

	of levees and represents an initial five-year effort. After the first phase, the Interagency Flood Management Collaborative Program Group will evaluate the program's success and, if warranted, SERP may be expanded to include sites repaired by local agencies throughout the Sacramento-San Joaquin watershed. Similar to previous initiatives, these small levee repairs will slowly increase levee riprapping along the Sacramento River, further degrading the quality of habitat for delta smelt.
Aquatic Weed Control	The California Division of Boating and Waterways (DBW) is the lead agency for controlling aquatic weeds in the Delta, its tributaries, and Suisun Marsh. This includes controlling water hyacinth, Brazilian water weed, curly-leaf pondweed and Spongeplant. These programs are not intended to eradicate these species, rather they attempt to control their spread and to seasonally manage the intensity of infestations. Thus far, the program has not been successful. Herbicide treatments in the Delta are authorized to occur from March 1 through November 30. DBW is permitted to treat 15,000 acres in the following areas over a 5-year increment. Much of this acreage is within the critical habitat boundaries for delta smelt.
Suisun Marsh Plan	On June 10, 2013, the Service issued a biological opinion for the *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* (Suisun Marsh Plan). This biological opinion covers the continued operation and maintenance of managed wetlands in the Suisun Marsh that are an important component of the Pacific Flyway and habitat for several resident ESA-listed plants and animals. The Suisun Marsh Plan also covered new managed wetland activities; dredging; bank protection, including new riprap; and the installation of fish screens. The opinion also included a programmatic restoration plan for restoring 5,000 to 7,000 acres of natural tidal marsh in the Suisun Marsh. Details of the project-level activities associated with the managed wetlands can be found online at: https://www.fws.gov/sfbaydelta/documents/2012-F-0602-2_Suisun_Marsh_Solano_County_Corps_programmatic.pdf.
Scientific Monitoring and Research	Numerous State and Federal agencies and their partners conduct scientific monitoring and research in the Bay-Delta. Most of the incidental take of delta smelt is covered under a biological opinion for the IEP. However, the IEP has for many years, limited its incidental take to much lower numbers that what was authorized under its biological opinion and works with the Service to set a take limit for its activities each year. The rest of the directed scientific take of delta smelt is covered via a few recovery permits held by other entities. Some sampling occurs year-around throughout the known range of the delta smelt and several IEP monitoring programs target delta smelt in particular. Other very long-running monitoring programs (described in more detail in the *Status of the Species* section) were not designed to target delta smelt but historically have routinely collected them and over time, they became foundational delta smelt abundance indexing programs.

Use of cultured delta smelt for scientific research purposes	On December 7, 2018, the Service issued a framework programmatic biological opinion on our issuance of a section 10(a)(1)(A) permit to the Fish Conservation and Culture Laboratory for providing cultured delta smelt for scientific studies in the Delta. These studies are designed to help answer questions about how delta smelt that were spawned and reared in captivity may fare upon being released into the wild for population augmentation purposes.

5.2 Effects to Delta Smelt from the Proposed Action

This section analyzes components of the Proposed Action that are likely to affect delta smelt as denoted in Table 2-1: Components of the Proposed Action within the *Description of the Proposed Action* section. Most action elements occur within the Delta and are discussed below. The remaining action components not discussed in this section occur upstream of the Delta, where the operations have effects on delta smelt that are not realized until the flow reaches the Delta. The analyses below fully account for those upstream operational effects.

The analysis that follows is generally qualitative. Knowledge of currently available scientific information can provide basic information but may not enable prediction of how a species will respond to changes in its environment, particularly aggregate effects of multiple factors because aggregate and cumulative impacts are difficult to predict. This is because aggregate and cumulative impacts usually require a time component such as sequential exposure to a stressor. The cumulative nature of change in the Bay-Delta involving many pathways and decades of water operations layered on top of other stressors makes it difficult to distinguish the long-term effects of water operations from the effects that may arise from implementation of the PA. The Service acknowledges these interpretive limitations of this effects analysis.

The following CVP and SWP action elements are listed in Table 2-1: Components of the Proposed Action and included in the modeling results (except where indicated that the modeling does not reflect the PA): (1) Divert and store water consistent with the obligations under water rights and decisions by the State Water Resources Control Board, (2) Shasta critical determinations and allocations to water service and water repayment contractors and agreements with settlement and exchange contractors, and (3) Minimum export rate. The effects of these action elements are consistent with and included in the analysis for "Seasonal Operations of Banks and Jones" below; therefore, the effects of these project elements are not separately discussed in this effects analysis.

5.2.1 Seasonal Operations of Banks and Jones

Effects of entrainment from seasonal operations and OMR management

Overview

Effects that typically result from the operation of large water diversions are entrainment or injury of delta smelt that come in contact with the fish facility as water is being diverted (i.e., salvage). Other impacts are those associated with the actual diversion of large quantities of water from the river, which can affect flow patterns, hydrodynamics, and resulting habitat features and ecological processes that vary with changes in river flows into the estuary.

Entrainment

Entrainment is used to assess direct injury or loss of delta smelt from the diversion of water. Entrainment can occur whenever delta smelt are present in river (or estuary) water that is diverted (or exported), creating the opportunity for delta smelt and/or their food supply to follow the flow of diverted water and become entrained (i.e., lost from the Bay-Delta ecosystem). The entrainment footprint in the south Delta extends beyond the CVP and SWP facilities into adjacent waterbodies (Kimmerer and Nobriga 2008; Andrews *et al.* 2016; Hutton *et al.* 2019).

The entrainment of delta smelt into the south Delta, the CVP and SWP fish facilities, and the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. Salvage has historically been used as an index of entrainment resulting from CVP and SWP exports from the south Delta. However, because salvage has decreased with the decline in delta smelt abundance and shrinking populations become more difficult to detect, salvage may no longer accurately reflect the relative number of fish that become entrained in the south Delta or enter the fish facilities (Figure 5-25, Table 5-5). Because of this, salvage is no longer considered to be a reliable index of entrainment. Salvage is an extrapolated estimate of the number of fish at each fish facility and subsequently returned to the Delta through a truck and release operation. For a description of fish salvage operations, see Brown *et al.* (1996) and Morinaka (2013a,b) for a discussion of the Skinner Fish Facility.

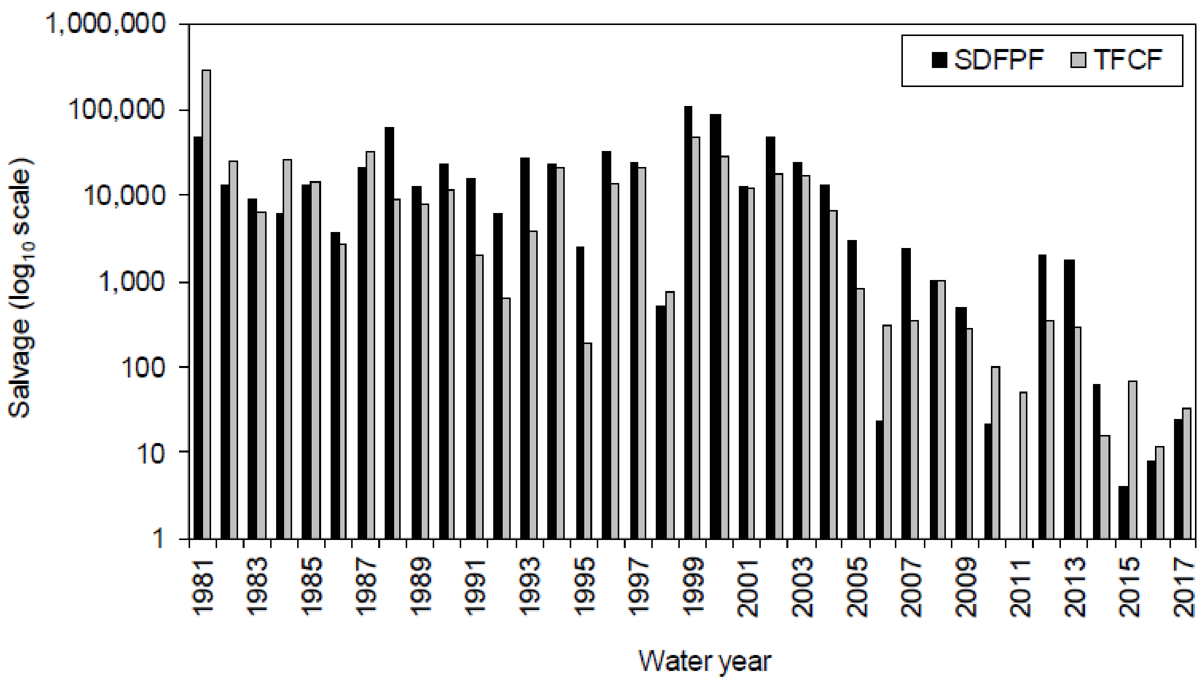


Figure 5-25. Annual salvage of delta smelt (all life stages) at the Skinner Fish Facility (SDFPF) and the Tracy Fish Collection Facility (TFCF). (Aasen and Morinaka 2018).

Under ideal conditions, salvage estimates are indices of entrainment because most entrained fish are not observed in salvage (Table 5-5). Pre-screen loss, defined as fish mortality occurring prior to fish reaching the facilities, is believed to be high and as a result, most entrained fish do not survive to be observed at the fish facilities (Castillo *et al.* 2012). Bennett (2005) suggested that many, if not most, of the delta smelt that reach the fish facilities likely die due to handling stress and predation; however, recent studies suggest there may be relatively high survival of adult delta smelt during collection, handling, transport, and release when they are salvaged during cool temperature conditions (Morinaka 2013b). There is no data on the survival of these fish post-release. Pre-screen loss due to predation near and within the CVP and SWP fish facilities is an additional cause of mortality for delta smelt. In one study, pre-screen loss of captive-reared delta smelt released into CCF ranged from about 90% to 100% for adults and nearly 100% in one trial using juveniles (Castillo *et al.* 2012). Please see the *Tracy Fish Collection Facility (TFCF) and Skinner Fish Facility* section below for a discussion of the effects of the fish facilities on delta smelt.

Table 5-5. Factors affecting delta smelt entrainment and salvage.

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% (n=1)	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), SWP: (Castillo *et al.* 2012)
Holding tank collection screens efficiency	~100%	SWP: unknown; CVP: 60% for larvae 10-20 mm, 9% for larvae <10mm	SWP: <100% until at least 30 mm; CVP: 82% for larvae 20-30 mm	CVP: (Reyes *et. al*. 2012, Wu and Bridges 2014)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Identified, not expanded	Identified from subsamples, then expanded in salvage estimates	
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 2013b)
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 2013b)

Presently, the Service considers delta smelt to almost always be entrained (and therefore lost to the population) if they enter Old or Middle rivers except under extremely wet San Joaquin Basin conditions. Because salvage numbers have dropped to record lows and pre-screen losses are high at the facilities, the salvage process does not return meaningful numbers of delta smelt back into the Delta (Table 5-5). Thus, the particular source of mortality of delta smelt in the south Delta is not especially important like it is for fish species that are more effectively salvaged (*e.g.,* Chinook salmon and steelhead). Most delta smelt that enter the southern Delta via Old and Middle rivers are assumed to be eaten by predators before they reach the fish facilities. If not managed carefully, the more negative modeled OMR flows under the PA could increase the entrainment of delta smelt into Old and Middle rivers without that change being reflected in salvage. Generally speaking, increases in entrainment translate into higher mortality of individuals from predation and entrainment into canal systems in which they will not survive.

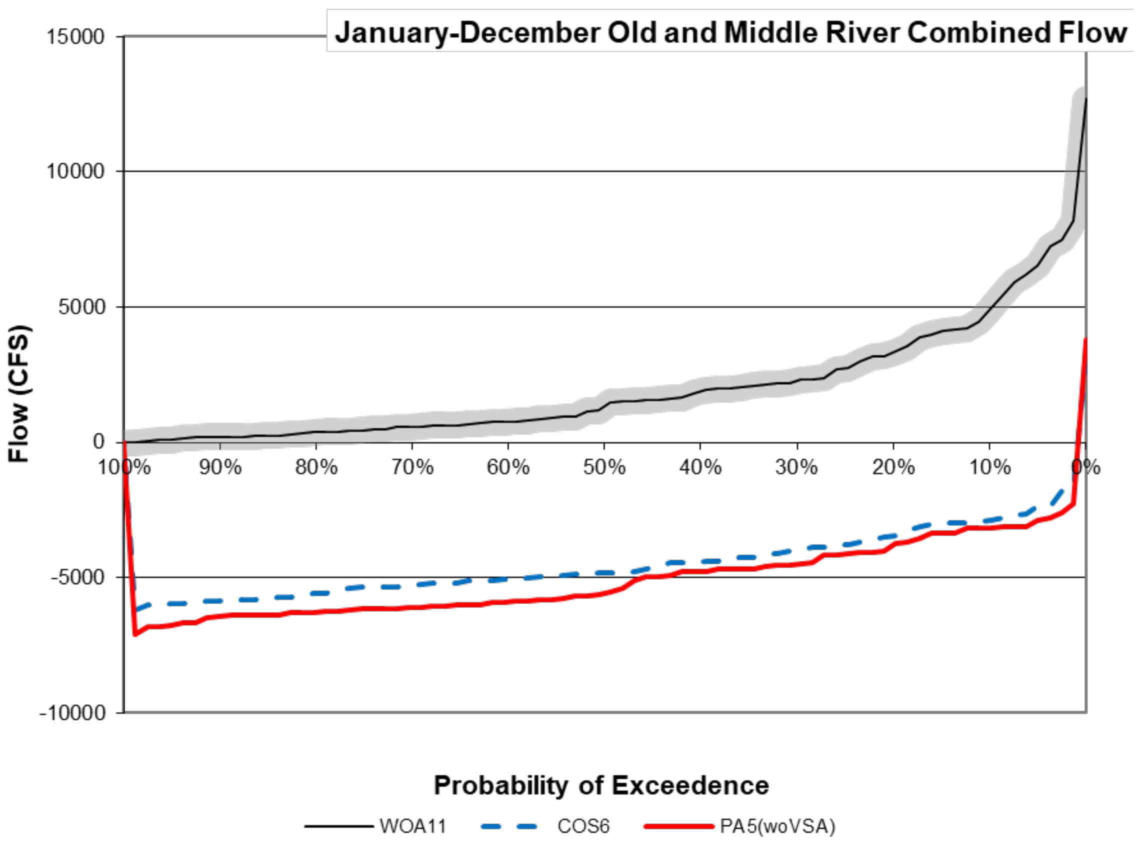


Figure 5-26. Modeled OMR flow from January to December. (Source: ROC BA 2019).

Larval, juvenile, and adult delta smelt are entrained into the south Delta during the migration, spawning, and transport periods of their life cycle (Kimmerer 2008; 2011; Grimaldo *et al.* 2009; Sommer *et al.* 2011). Delta smelt have been previously considered semi-anadromous and assumed to make a somewhat coordinated and generally eastward spawning migration into the Delta (Service 1993; Bennett 2005; Sommer *et al.* 2011). Newer research suggests that rather than a “migration”, the fish disperse in multiple directions during winter storms (Murphy and Hamilton 2013; Polansky *et al.* 2018). This BiOp uses the term “dispersal” to describe the wintertime movement toward spawning areas that appear to be fairly similar among years. Adult delta smelt show up in fish salvage counts typically during the winter dispersal period. Salvage of adults has mainly occurred from December through March (Kimmerer 2008; Grimaldo *et al.* 2009).

For adults, the risk of entrainment is influenced by net negative flow (stronger flood tides than ebb tides) and turbidity in the south Delta (Grimaldo *et al.* 2009; Figure 5-26). Project pumping (*i.e.,* the export of water from the Delta) can cause the tidally filtered or "net" flows in Old and Middle rivers and other south Delta channels to move "upstream" toward the facilities. This occurs when water removed by Banks and Jones, along with other diversions in the area, is back-filled by tidal and Sacramento River flows. This phenomenon is mathematically depicted as negative flow. The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. More net negative OMR flows and higher turbidity are often associated with adult delta smelt entrainment, but no particular OMR flow assures entrainment will or will not occur. Net flows themselves could be the mechanism that increases entrainment risk for young delta smelt that have poor swimming ability. However, high exports can also lead to strong tidal asymmetry in Old and Middle rivers where flood tides toward the pumps become much stronger than the ebb tides away from the pumps (Service 2008), so altered tidal flows are a second, covarying, mechanism that could increase risk of entrainment particularly of adult delta smelt if they are using tide-surfing behaviors to move (Sommer *et al.* 2011; Bennett and Burau 2015). The real-time management of adult delta smelt entrainment risk proposed in the PA is based on OMR flow and turbidity management.

Since 2008, turbidity management has become a widely accepted concept for reducing adult delta smelt salvage and proportional entrainment losses, following the concept that delta smelt population distribution expands in response to winter flow pulses that often coincide with higher turbidity (Sommer *et al.* 2011).

Given there are demonstrated relationships between delta smelt entrainment and salvage with OMR flows (Kimmerer 2008; Grimaldo *et al.* 2009), this effects analysis evaluates the differences between the PA and the current operations scenario (COS) as they are modeled using CalSim II. To analyze entrainment effects, we will examine the modeled OMR flows by each month during which delta smelt protections may be in place, from December through June. Important assumptions that were used in the CalSim II model that differ from what is described in the PA are depicted in the Table 5-6. The subsequent sections will describe how these differences were resolved for each specific time period in question. For the purposes of this analysis, the OMR index is an index of the combined flow in Old and Middle rivers calculated by DWR using a combination of data sources, including modeled data. Reclamation and DWR propose to use the OMR index as a management tool for real-time operations of the projects.

Table 5-6: Key differences between PA modeling assumptions and PA implementation language.

OMR Management Action	CalSim II Modeling Assumptions for PA Scenario	PA Implementation Language
Integrated Early Winter Pulse Protection (for delta smelt)	After December 1, when the 3-day average turbidity is assumed to be 12 NTU or greater at Old River at Bacon Island (OBI), Prisoner's Point (PPT) and Victoria Canal (VCU) based on Sacramento River Index (sum of monthly flow at four stations on the Sacramento, Feather, Yuba and American Rivers, from 2003 to 2006) greater than or equal to 20,000 cfs, projects will operate to an OMR index of -2,000 cfs for 14 days.	From December 1 through January 31, 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, projects will reduce exports for 14 consecutive days to maintain a 14-day average OMR flow no more negative than -2,000 cfs (once per water year).
Turbidity Bridge Avoidance (for adult delta smelt)	If the Sacramento River Index is greater than or equal to 20,000 cfs, projects will operate to an OMR index of -2,000 cfs for five days in January and February of any water year type. For March through June of Wet and Above Normal years, it is assumed that there will be one event of turbidity bridge avoidance in each month (-2,000 cfs OMR for 5 days).	Projects will operate to maintain daily average turbidity at Old River at Bacon Island (OBI) to less than 12 NTU. If daily average turbidity cannot be maintained less than 12 NTU, the OMR index shall not be more negative than -2,000 cfs until the daily average turbidity at OBI drops below 12 NTU. After 5 days of operation to -2,000 cfs without OBI dropping below 12 NTU, projects will assess whether continued Additional Real-Time OMR Restrictions are necessary or effective for species protection.
Storm-Related OMR Flexibility	In Above Normal and Below Normal years, there will be one opportunity in January and one opportunity in February to operate to a monthly average OMR flow of -6,000 cfs when increased pumping due to a storm is possible. In Dry years, only one opportunity in January or February is modeled. In Wet years, no flexibility is modeled.	The maximum (otherwise-permitted) export rate of 14,900 cfs may be taken, if turbidity at Bacon Island does not exceed 12 NTU. This could result in a range of OMR flow values. A duration of action is not specified.

Species-specific single-year loss thresholds (for salmonid species)	In Above Normal and Below Normal years, OMR during April and May will be -3,500 cfs.	Projects will operate OMR to -3,500 cfs when 50% of the annual salmonid loss threshold is reached, and will operate OMR to -2,500 when 75% annual salmonid loss threshold is reached (unless Reclamation determines action no longer warranted).

OMR flow can be modeled from CalSim II, but turbidity cannot. Because turbidity is an important factor influencing entrainment, the expected entrainment resulting from the PA cannot be estimated accurately and conditions have to be evaluated in real-time. The differences between modeling assumptions and how OMR management are described in the PA and the COS are important when considering the bounds of potential OMR flow scenarios during real-time implementation of the PA. For these four elements highlighted in Table 5-6, the PA modeling depicts a scenario that is different than the PA as written. Particularly, the Storm-Related OMR Flexibility and Single-Year Loss Threshold actions may be more protective than the PA modeling reflects. The technical working groups described in the PA will assist Reclamation and DWR in their assessment of the appropriate real-time OMR management response to these variables. Ultimately, implementation of the PA may fall closer to the PA as written, or closer to that depicted in the modeling, depending on real-time conditions. We have attempted throughout this effects analysis to provide context around the modeling results, particularly where we anticipate the modeling results to be less reflective of likely operations.

The analyses of the potential effects of the PA on different life stages of delta smelt that are presented in the sections below address direct effects of water exports (such as entrainment) and indirect effects (such as predation).

<u>*Adult Entrainment*</u>

According to the BA, the without action conditions of no south Delta exports would not entrain adult delta smelt into the facilities, but some delta smelt would still disperse into the south Delta and be subject to higher mortality rates associated with predation in habitats dominated by SAV. The lack of south Delta export pumping is reflected in OMR flows under the without action scenario generally being positive (BA Figures 5.16-41, 5.16-42, 5.16-43, 5.16-44).

In December, OMR flows described in the PA will be similar to current operational conditions (ROC BA 2019; Figure 5-27). OMR flow under current conditions is almost always more negative than -4,000 cfs in December, during which it is typical to see high rates of pumping. Under the PA, unless conditions trigger the Integrated Early Winter Pulse Protection of the OMR Management actions, OMR flows will be similar to current conditions, though the PA modeling does not reflect this action precisely.

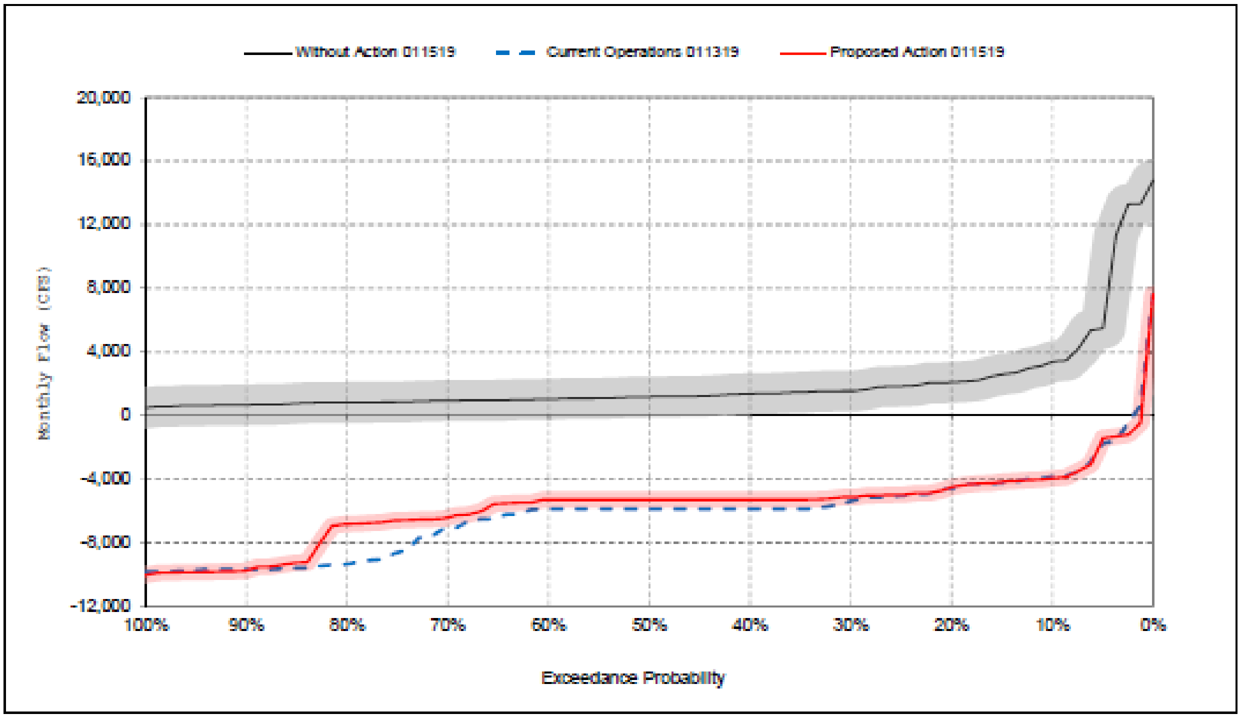


Figure 5-27. Mean Modeled Old and Middle River Flows, December (ROC BA 2019)

Under the PA, average OMR flows may be slightly more negative than current operations in January, February, and March, but generally will not exceed -5,000 cfs due to the Additional Real-Time OMR Restrictions. As noted in Table 5-6, Storm-Related OMR Flexibility actions may be taken that were modeled in CalSim II at a monthly averaged OMR flow of -6,000 cfs, but described in the PA as potentially much more negative OMR flows than -6,000 cfs. During the adult delta smelt's winter dispersal, OMR flows in the PA are expected to be slightly more negative than the COS but generally bounded at -5,000 cfs by the implementation language in Table 5-6 (ROC BA 2019; Figures 5-28, 5-29, and 5-30).

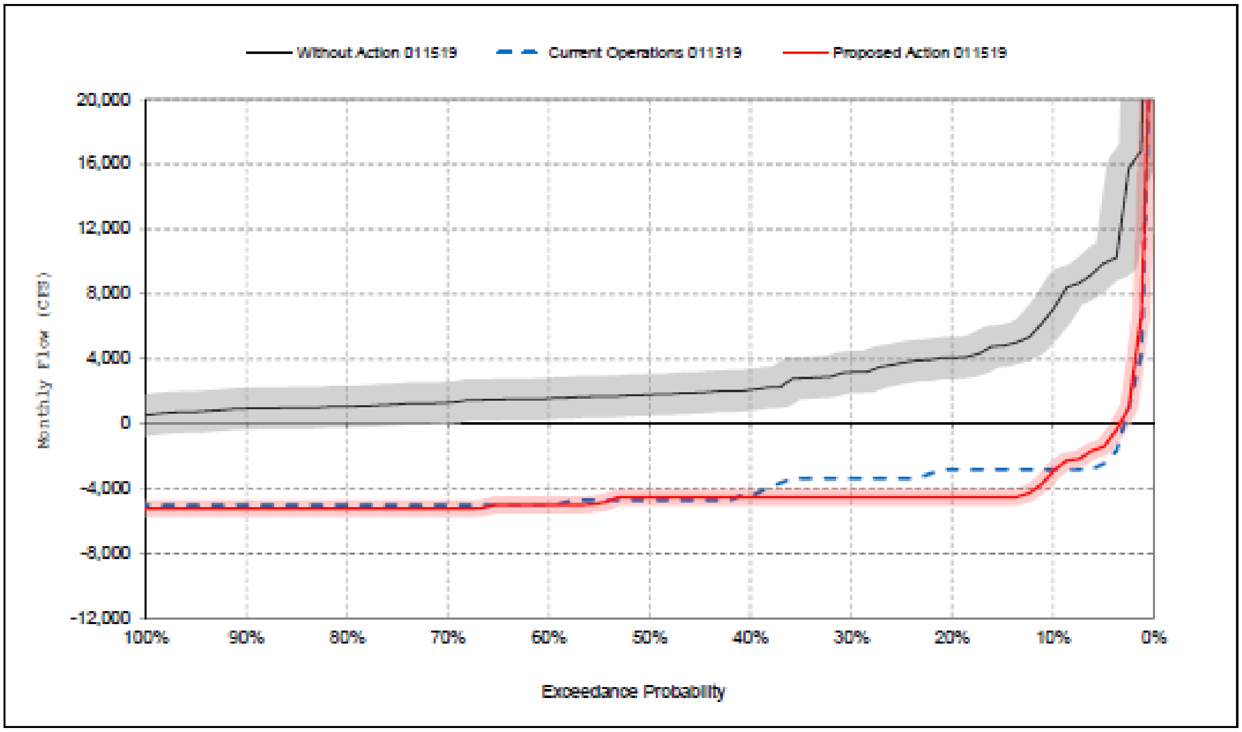


Figure 5-28. Mean Modeled Old and Middle River Flows, January. (ROC BA 2019)

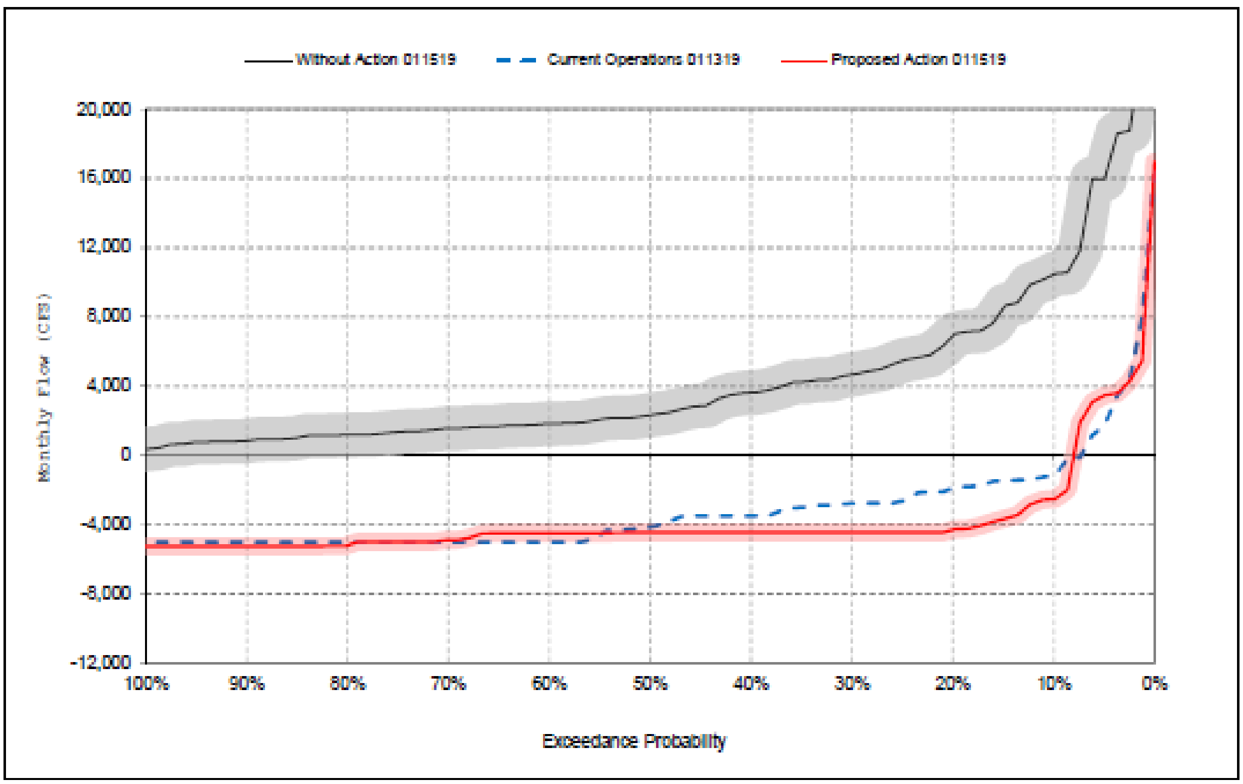


Figure 5-29. Mean Modeled Old and Middle River Flows, February. (ROC BA 2019)

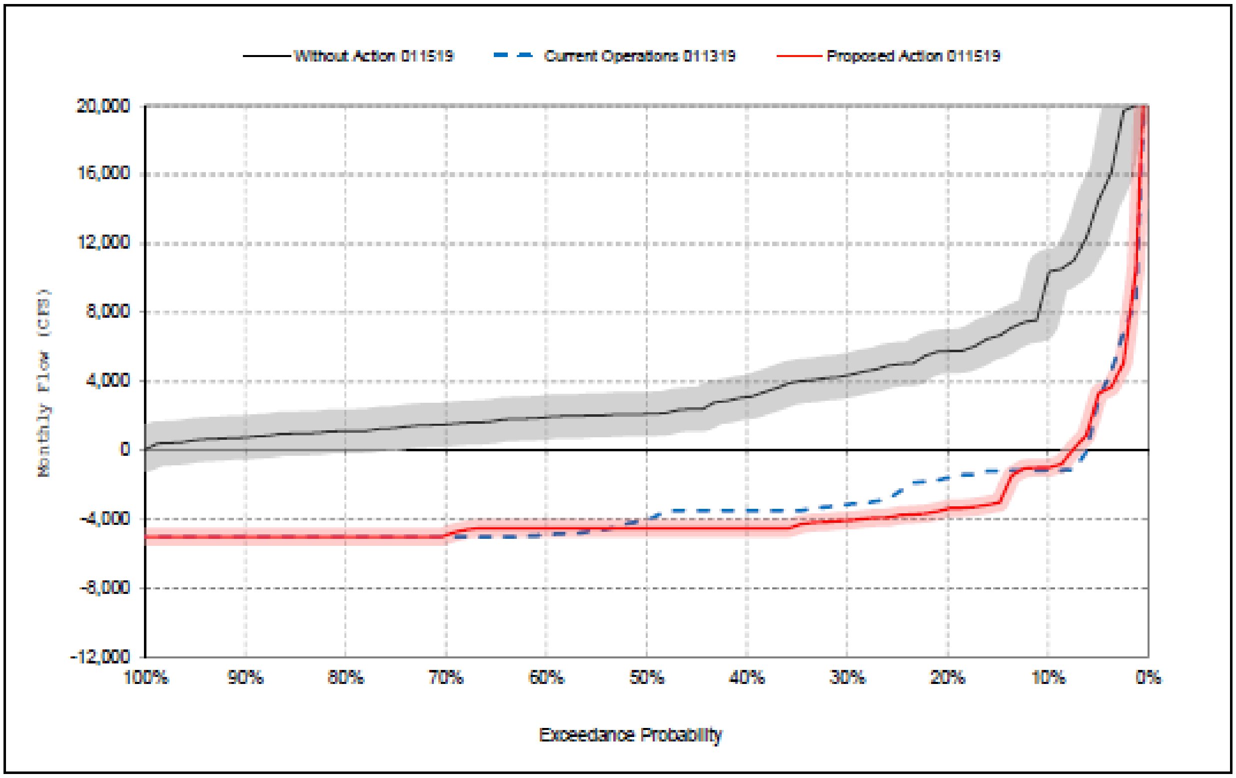


Figure 5-30. Mean Modeled Old and Middle River Flows, March. (ROC BA 2019)

Given that projected OMR flow conditions overall are expected to become slightly more negative than current conditions while maturing adult fish are dispersing from January through March under the PA, it is important to consider entrainment risk during this time in the context of OMR and turbidity. While there is no OMR flow value that guarantees entrainment of delta smelt, the exploration of the effects of turbidity management actions since 2008 have shown promising results for reducing entrainment when initiated early.

The CalSim II modeling indicates that monthly average OMR flows may be more negative in the PA relative to the COS. This is consistent with the likelihood of storm-related increases in exports that could result in short-term OMR flow more negative than -5,000 cfs. However, the PA proposes to use a suite of protective actions, identified in the PA as “Additional Real-Time OMR Restrictions”, to manage entrainment risk of delta smelt in real-time by managing OMR and turbidity together (see below). Entrainment risk may increase if the Directors of NMFS and the Service choose to authorize Reclamation and DWR to operate to a more negative OMR than what is specified in “Additional Real-Time OMR Restrictions”, but even if they do, the projects have proposed to operate to no more negative than -5,000 cfs during these Director-guided periods of time.

A suite of OMR Management actions are proposed and described in Table 5-6. The Integrated Early Winter Pulse Protection action is meant to replace RPA Action 1 of the 2008 BiOp, which called for the projects to reduce negative OMR flows to -2,000 cfs for 14 consecutive days if a turbidity trigger was met; the 2008 trigger was based on three-day averages being greater than or equal to 12 NTU at three separate stations in the south Delta. The Integrated Early Winter Pulse Protection action uses the Freeport station on the Sacramento River as an early indicator of turbidity dispersal into the Delta. The Freeport station is used because most of the sediment that enters the Delta is delivered by the Sacramento River (including the Yolo Bypass), and can provide advance warning that operational changes may be needed. If the Freeport inflow and turbidity triggers are met, the facilities would modify operations, including reducing exports if necessary, in order to reduce negative OMR flows to -2,000 cfs for 14 consecutive days.

As described in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area* sections, based on current information, the Service has determined that adult delta smelt disperse during early winter storms. The storms increase river inflows to the Delta, and therefore, net westward flows. When inflows increase enough, they can bring large quantities of sediment into the Delta and increase water turbidity. The tides and net flows then interact to disperse that turbidity. Delta smelt appear to respond to this seasonal change in their environment by spreading out (increasing their spatial distribution; Sommer *et al.* 2011; Murphy and Hamilton 2013). Not all of the delta smelt's movements during this seasonal dispersal are upstream. However, some individuals do move upstream and it is believed that net upstream movement against net downstream flow is facilitated by fish changing their distribution in the channel in response to tidal flows (Bennett and Burau 2015; Polansky *et al.* 2018).

Some of the delta smelt that disperse upstream move up the Sacramento River and some move up the San Joaquin River. Suitable spawning habitat is believed to be available in both primary channels. This seasonal re-distribution of adult delta smelt makes it clear that they can resist net flow directions and, therefore, modeling tools like DSM-2 PTM that provide information about tidal flow directions, which when evaluated over longer time frames provide information about net flows, will not be able to predict adult delta smelt movements. However, PTM modeling can provide information about the hydrodynamic influence of the Banks and Jones pumping plants on net water movement in the Delta (e.g., Kimmerer and Nobriga 2008) enabling an evaluation of how different OMR flows draw water off of potential spawning locations like the main stem of the San Joaquin River.

Under the Integrated Early Winter Pulse Protection action, the OMR flow target remains at -2,000 cfs, consistent with RPA Action 1 of the 2008 BiOp. Therefore, the effect of the operational change will remain largely the same between the COS and the PA scenarios to protect pre-spawning adult delta smelt from being entrained during the first major flush of the rainy season. Reclamation proposes to implement this protective action when specific Freeport flow and turbidity parameters are met, rather than relying on turbidity stations in the south Delta (Table 5-6). The Freeport station was selected to serve as an earlier, upstream indicator of high flow and turbid conditions that would likely reach the south Delta, ensuring the projects will have enough time to make the operational change to avoid an entrainment event. This new location trigger was recommended based on best professional judgment of biologists from Reclamation, DWR, the Service, and CDFW. No data was provided in the ROC BA to compare the historical frequencies of the trigger parameters being met and what, if any, differences there would be from the frequency of the 2008 RPA trigger parameter.

Our cursory analysis of available data from water years 2014-2019 indicates that the PA's Freeport flow and turbidity criteria were met in 4 out of 6 years, whereas the triggers under RPA Action 1 of the 2008 BiOp were not met in the same time period. The period of this analysis was limited by the availability of turbidity (NTU) information at Freeport, which only dates to 2014. This is a very limited comparative dataset of hydrological conditions, but it suggests that the Integrated Early Winter Pulse Protection action under the PA may be triggered more often than the previous RPA Action 1 under the COS. If the frequency of the Integrated Early Winter Pulse Protection action is greater than the RPA Action 1, we expect the projects will meet a 14-day -2,000 cfs OMR target more often than under the COS. Therefore, the PA, including the proposed Additional Real-Time OMR Restrictions, has the potential to provide protection more frequently for adult delta smelt dispersing in the early winter months than the COS condition.

Adult delta smelt are expected to disperse in general proportion to how they have in the recent past (Polansky *et al*. 2018). These seasonal movements are believed to be in response to increasing inflows and turbidity, but facilitated by selective use of tidal currents as discussed above. The Service has summarized available DSM-2 PTM data to demonstrate that project operations will have limited influence on San Joaquin River hydrodynamics at the OMR flows proposed under turbid conditions (Figure 5-31). This contrasts the results for particles released into Old and Middle rivers, which have a high likelihood of being entrained even at -2,000 cfs OMR. This analysis shows that the projects should have minimal influence on the winter movements of delta smelt, affecting only individuals that swim into Old and Middle rivers.

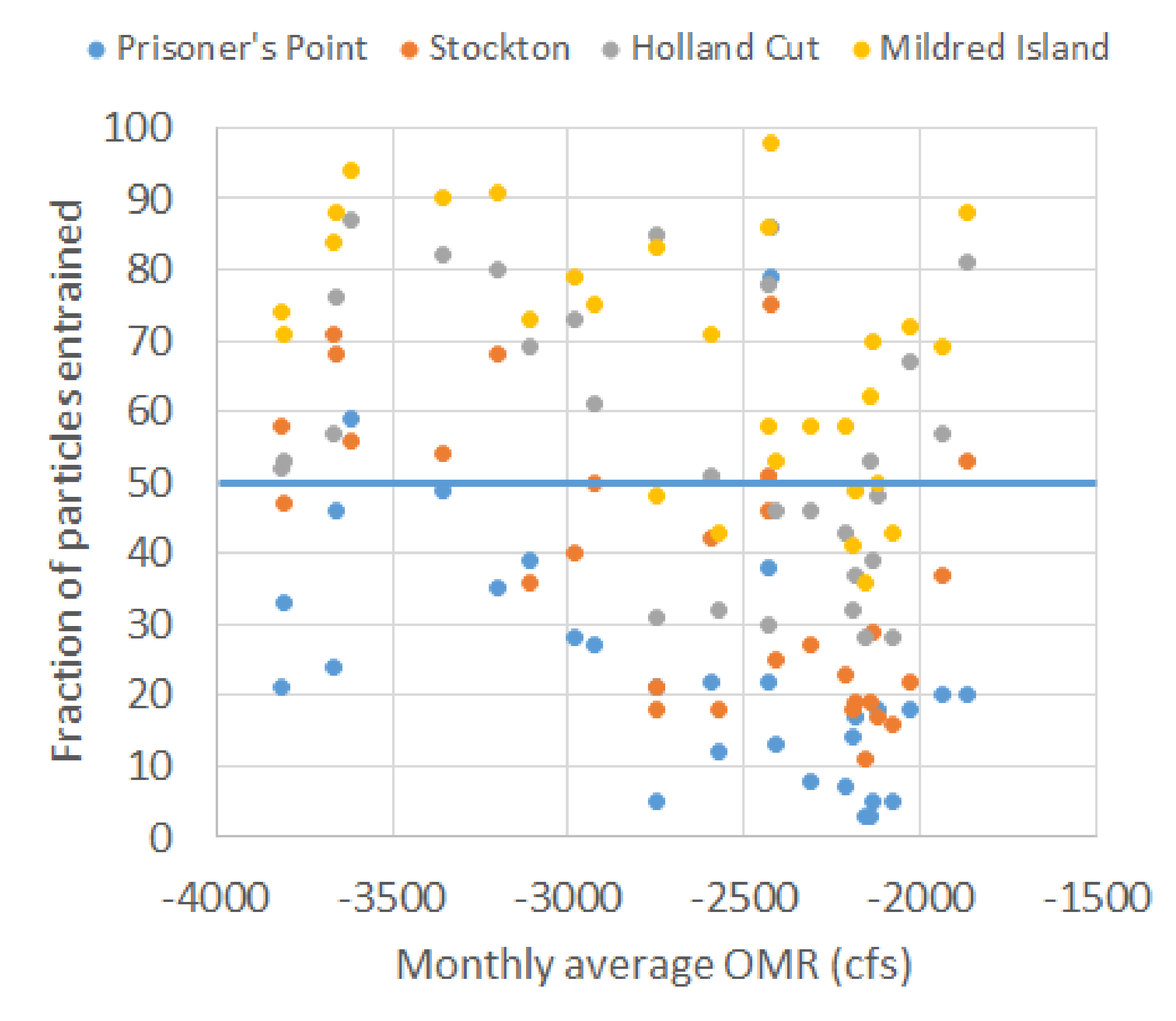


Figure 5-31. Scatterplot of monthly average OMR flow versus predicted particle entrainment 30 days after release from the four locations listed in the legend. Prisoner's Point and Stockton represent particle release sites on the main stem of the San Joaquin River. Holland Cut and Mildred Island represent particle release sites in Old and Middle rivers, respectively. Data points above the solid blue line reflect model runs in which particles were more likely than not to be entrained into the Banks and Jones pumping plants, whereas data points below the line reflect model runs in which particles were more likely than not to avoid being entrained. Data source: Service unpublished summary of data provided by CH2M Hill. Service staff queried the results from a comprehensive database of DSM-2 PTM runs for month-year combinations that bracketed an OMR range of -2,000 to -3,500 cfs; the -2,000 cfs trigger was proposed as a threshold in the ROC on LTO BA as part of the winter pulse protection action (see Table 5-6). For each release site, results are presented for 31 month-year combinations.

Reclamation proposes to implement the Additional Real-Time OMR Restrictions identified in the PA by February 1 to manage OMR to more positive than -5,000 cfs based on the suite of actions. The first of these actions is Turbidity Bridge Avoidance. Under this action, the projects will manage OMR to no more negative than -5,000 cfs beginning on February 1 even if turbidity in the south Delta remains low, with the exception of storm-related OMR flexibility actions. If the Integrated Early Winter Pulse Protection is triggered, Turbidity Bridge Avoidance would be implemented immediately following the end of the 14-day action. The objective of Turbidity Bridge Avoidance is to maintain OMR flow no more negative than -2,000 cfs if daily average turbidity at Old River at Bacon Island (OBI) station reaches 12 NTU. OBI was selected by the five agencies as the best available station to assess the formation of a turbidity bridge based on experience from the last 11 years of operations. It is located about halfway down the Old River corridor and Reclamation has proposed to redundantly telemeter this station to prevent lapses in data due to vandalism or malfunction. OMR flow of -2,000 cfs may prevent increases in proportional entrainment of adults under clear water conditions.

The Integrated Early Winter Pulse Protection and Turbidity Bridge Avoidance actions will both contribute to adult delta smelt protections during the dispersal and spawning periods by targeting a -2,000 cfs OMR flow. This is because more positive OMR flows will result in lower turbidity intrusion into the south Delta and subsequently reduce the likelihood of delta smelt moving towards the pumps.

Additionally, the single year loss thresholds for winter-run Chinook salmon and Central Valley steelhead are in place from December to March, overlapping with larval delta smelt emergence through the end of March. Single year loss thresholds for Central Valley steelhead are in place April 1 to June 15, overlapping with a significant portion of the larval/juvenile life stage. The single year loss thresholds could require OMR flow to be maintained at a 14-day moving average of -3500 cfs to -2500 cfs if a threshold is exceeded. These thresholds have not been included in the PA modeling run.

Overall, because Reclamation and DWR will manage to an OMR of -5,000 cfs or more positive based on Additional Real-Time OMR Restrictions described above, effects to adult delta smelt will be similar to the COS.

In the 2008 BiOp RPA, two actions were included to reduce adult entrainment. These were Action 1 (First Flush) and Action 2 (Adult Migration and Entrainment). Both actions were intended to reduce entrainment of adults, and help distribute spawning adults in areas where their progeny would not be subject to entrainment. Action 1 was intended to provide protection for pre-spawning delta smelt dispersing in the estuary associated with the first storm in the watershed providing a pulse of turbidity through the system. Action 1 had two parts for implementation, December 1 through 20 and for post December 20. The post December 20 action provided for automatic implementation of OMR at -2000 cfs for 14 days if turbidity at 3 selected monitoring stations was over a specific threshold.

Over time, we have determined that the three stations identified in the 2008 BiOp were not the best indicators of turbidity-linked entrainment associated with the first flush in the system. Newer stations that did not exist at the time the BiOp was written provide a better indication of when the first flush is occurring. As stated above, biologists from the Service, Reclamation, CDFW, and DWR worked collaboratively to develop new triggers to identify when a first flush of turbidity is moving through the watershed. These new triggers are incorporated into the

Integrated Early Winter Pulse Protection action proposed by Reclamation in the PA. When the action is triggered, OMR will be maintained at -2000 cfs for 14 days, equivalent to the action in the 2008 RPA. In addition, once OMR management begins, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of -5000 cfs, unless a storm event occurs, until that point in which OMR management ends in a season (when temperatures in south Delta become lethal or June 30, whichever is earlier). As stated above, based on analysis of available data collected at newer stations, we anticipate this action may occur more frequently than Action 1 in the 2008 RPA. For these reasons, we expect this action will provide equivalent or greater protection for adult delta smelt and their progeny as compared to Action 1 in the 2008 RPA.

Action 2 in the 2008 RPA either followed directly after Action 1, or in years when Action 1 was not triggered, when the Service determined there was entrainment risk to pre-spawning and spawning adults. When triggered, the Service made a determination setting OMR between -1250 cfs and -5000 cfs.

During the period of operation under the 2008 RPA, the CVP and SWP operators have gotten significantly better at reducing entrainment by managing turbidity, particularly in the Old and Middle River corridors. Those lessons learned demonstrate that when turbidities in Old and Middle rivers are higher, entrainment increases, while when turbidities in Old and Middle rivers are lower, entrainment decreases. The Turbidity Bridge Avoidance action in the PA is structured to manage Old and Middle River turbidity in a way that is protective of adults during the spawning period, and is also protective of larvae and juveniles, by reducing the likelihood of spawning in areas that will not contribute to the population. This action provides that OMR will be held at no more negative than -2000 cfs for up to 5 consecutive days to reduce turbidity in Old and Middle rivers, and longer should Reclamation and DWR determine it appropriate. Otherwise, OMR will be operated at no more negative than -5000 cfs. For these reasons, we expect this action will provide equivalent or greater protection for adult delta smelt and their progeny as compared to Action 2 in the 2008 RPA.

Larval and Early Juvenile Entrainment

According to the BA, 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.

Because larval fish begin to emerge in late March, we consider late March to have overlap in effects to adults and the larval/early juvenile life stages. Thus, this section also addresses effects to larvae emerging at the end of March. The PA provides for OMR flow to be no more negative than -5,000 cfs on a 14-day moving average once OMR Management has begun until the End of OMR Management offramps have occurred. Additionally, during this period, single year thresholds for protection of wild and hatchery winter-run Chinook salmon and wild Central Valley steelhead may be implemented to provide more positive OMR flow. The single year thresholds for winter-run Chinook salmon and Central Valley steelhead are in place from December to March, overlapping with larval delta smelt emergence through the end of March. Single year thresholds for Central Valley steelhead are in place April 1 to June 15, overlapping with a significant portion of the larval/juvenile life stage. The single year loss thresholds could require OMR flow to be maintained at a 14-day moving average of -3500 cfs to -2500 cfs if a threshold is exceeded. These thresholds have not been included in the PA modeling run. In years that the loss threshold is triggered in March, March OMR flows may be more positive than those modeled in the PA.

Reclamation and DWR are proposing to use results produced by Service-approved life cycle models to manage annual entrainment levels of larval/juvenile delta smelt. The Service life cycle models will be peer reviewed and publicly vetted prior to March 15, 2020. The Service will coordinate with the Delta Fish Monitoring Working Group to identify a delta smelt recruitment level that Reclamation and DWR can use in OMR management. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. In this context, recruitment is defined as the estimated number of post-larval delta smelt in June per number of spawning adults in the prior February-March.

We believe the life cycle models will provide a scientifically robust measure for maintaining OMR flow at a level appropriate to support recruitment. Reclamation and DWR, in coordination with the Service, will operationalize the life cycle model results through the use of real-time monitoring for the spatial distribution of delta smelt.

On or after March 15 of each year, if QWEST is negative, and larval or juvenile delta smelt are within the entrainment zone of the export pumps based on real-time sampling of spawning adults or young-of-year life stages, Reclamation and/or DWR will run hydrodynamic models and forecasts of entrainment informed by the EDSM or other relevant sampling information to estimate the percentage of larval and juvenile smelt that could be entrained. If necessary, Reclamation will manage exports to limit entrainment to be protective based on the modeled recruitment levels. Reclamation and DWR will re-run hydrodynamic models when operational changes or new sampling data indicate a potential change in entrainment risk. This process will continue until the offramp criteria have been met as described in the “End of OMR Management” section of the PA. In the event the life cycle results cannot be operationalized in a manner that can be used to inform real-time operations, Reclamation and DWR will work with the Service to develop an alternative plan to provide operational actions protective of this life stage.

Exports in all water year types will increase under the PA in comparison to the COS in April and May, as demonstrated in the exceedance plots from the modeling provided in the BA (Figures 5-32 and 5-33). This conclusion is more certain than the winter operations (December – March) model results because the PA does not include the San Joaquin River I:E ratio limits from the NMFS 2009 biological opinion. The PA modeling scenario includes the assumption of OMR flow of -3500 cfs during Above Normal and Below Normal years. For the purposes of this analysis, we assume that the PA as modeled will roughly represent the actions described above, as the larval/juvenile entrainment action and single-year loss thresholds may result in OMR flow more positive than -5000 cfs in years that it is triggered. The model predicts that exports and OMR conditions in June will be similar between the PA and COS.

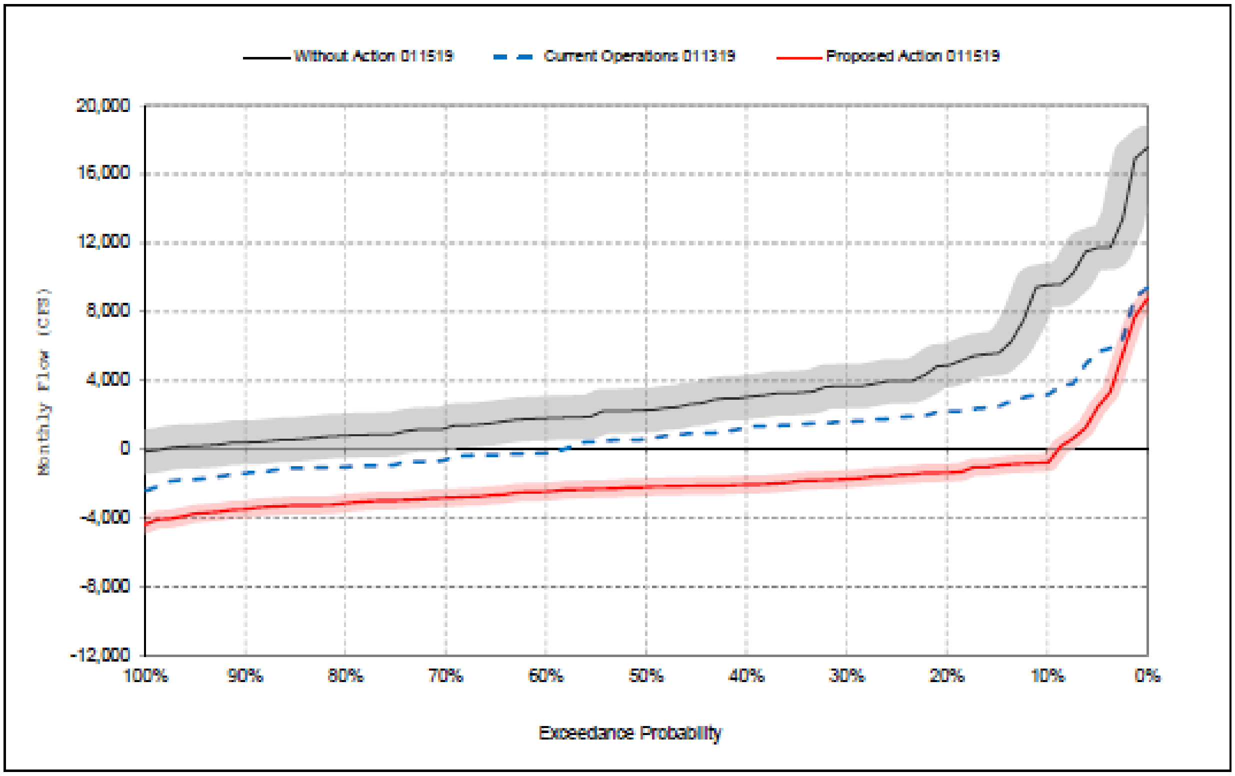


Figure 5-32. Mean Modeled Old and Middle River Flows, April. (ROC BA 2019)

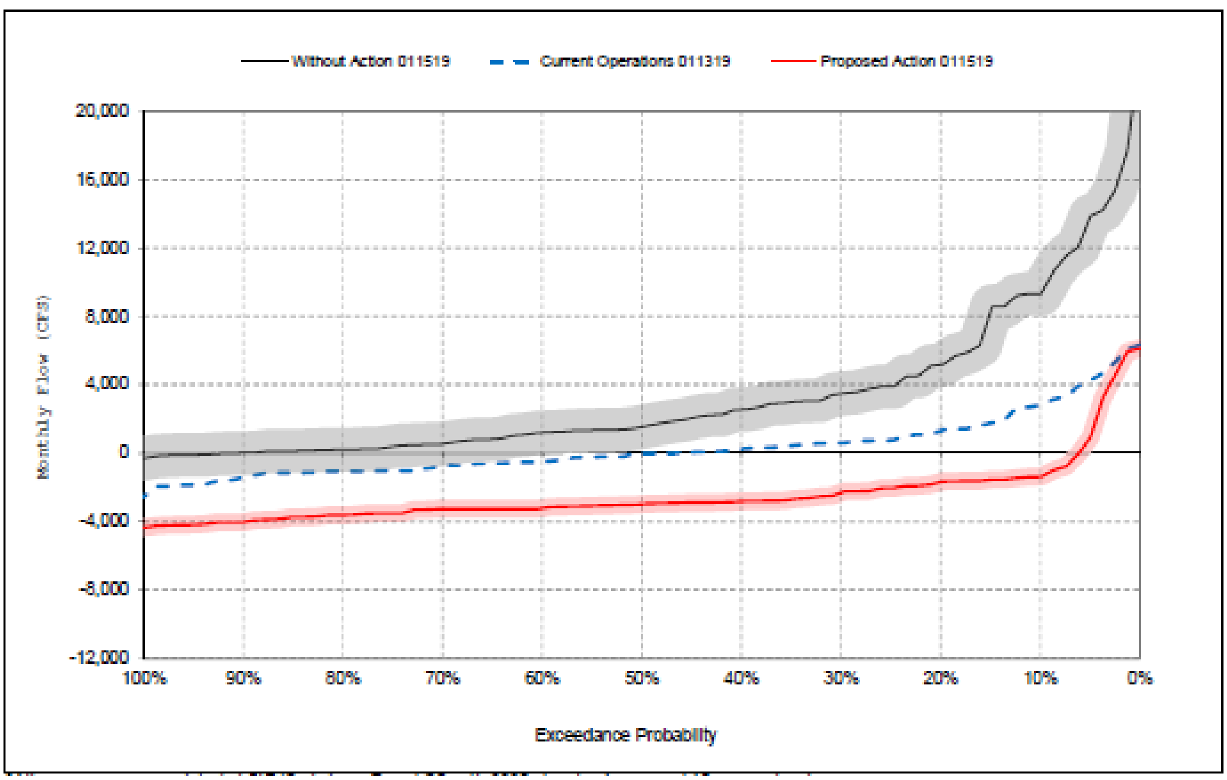


Figure 5-33. Mean Modeled Old and Middle River Flows, May. (ROC BA 2019)

As discussed in the *Adult Entrainment* section above, more negative flows modeled under the PA from the COS may result in greater entrainment into Old and Middle rivers. This remains the case for larval and early juvenile delta smelt during the months of April and May. Fish of these life stages are small, making them weak swimmers that tend to move along with transport flows within the Delta (Kimmerer 2008). PTM runs suggest that larvae hatching in the mainstem of the San Joaquin River just outside of the south Delta may be entrained at flows proposed under the PA modeling. With more negative OMR flows under the PA than the COS, any larvae hatching in the south Delta are more likely to be pulled south by net negative flows; however, the loss may be reduced if more positive flow than predicted in the PA scenario are realized. More positive OMR flow could be realized when the single-year loss threshold is triggered, or when provided for by the larval/juvenile protection action. Without a downstream flow mechanism to reach suitable rearing habitat, most larvae hatched in the south Delta are presumed to be lost to the population (Figure 5-31). In Appendix 2, we estimated the percentage of adult delta smelt spawning in the south Delta to be approximately 1-2.5 % of the population. This would correspond to an equivalent percentage loss of larval delta smelt to entrainment.

Based on the findings of Polansky *et al.* (2018), the adult spawner distribution remains much the same from year to year, but as shown in Appendix 2, even very modest differences in the assumption about spawning distribution can have a large effect on predictions of proportional entrainment. Given the uncertainty around spawning distribution in any given year, Reclamation should monitor and re-evaluate as needed as part of Reclamation's adaptive implementation of its water operations and to stay within the effects analyzed in this opinion.

In addition to the larval entrainment action described above and the commitment to operate at OMR of -5000 cfs or more positive throughout the time that larval and juvenile delta smelt may be subject to entrainment, unless a Storm-Related OMR Flexibility action is taken, Reclamation and DWR are proposing to limit adult entrainment through OMR limitations described in the adult entrainment section. These actions to reduce entrainment risk to adults reduces the likelihood of adults spawning in areas that would make their progeny subject to entrainment. These operational actions are anticipated to keep larval and juvenile entrainment losses low.

Other PA elements that may help reduce overall entrainment effects to the population at all life stages include increasing cultured smelt production at the Fish Conservation and Culture Laboratory (FCCL). Supplementation is intended to create a more robust delta smelt population that can better tolerate stressors. These efforts to begin near-term supplementation of delta smelt in the wild will come prior to the construction of the Delta Fish Species Conservation Hatchery designed to facilitate increased supplementation over time, boosting the number of delta smelt in the wild. These PA elements are discussed in depth below, under Non-Operational Actions.

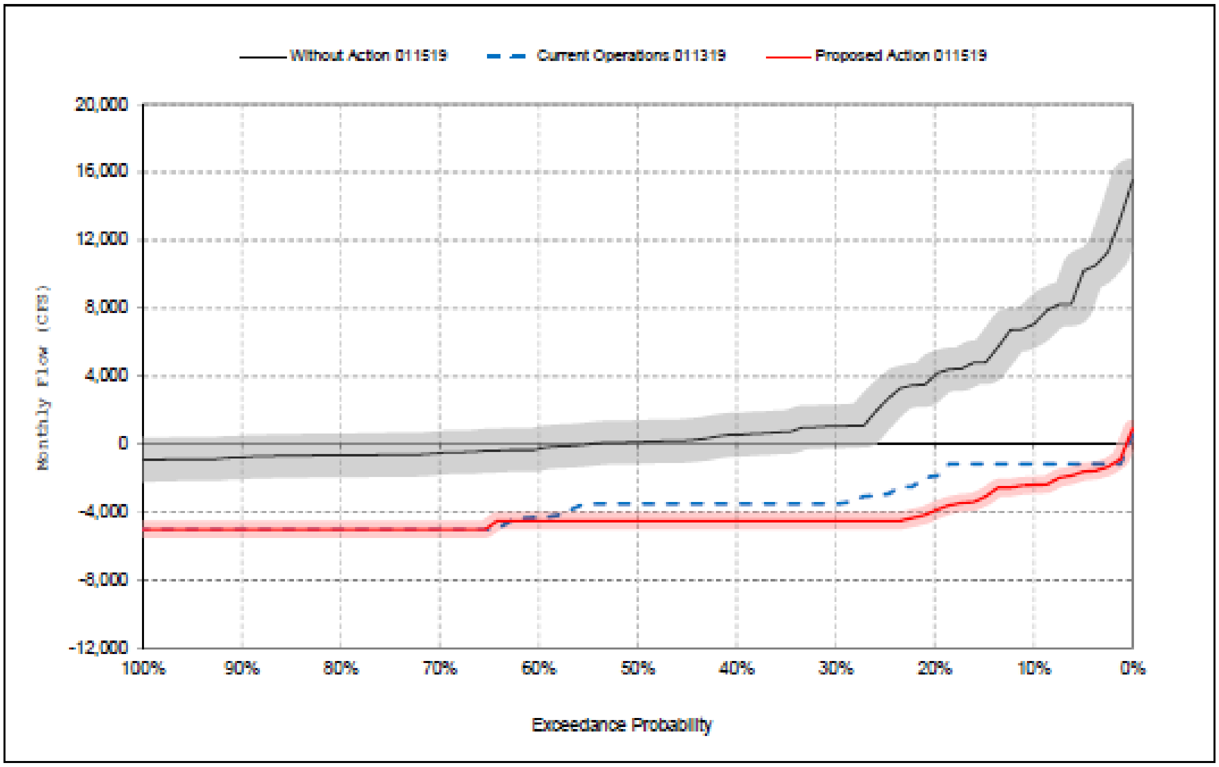


Figure 5-34. Mean Modeled Old and Middle River Flows, June. (ROC BA 2019)

Modeled flows in June are largely similar between the PA and the COS (Figure 5-34). Warming temperatures in the south Delta, typically beginning in June, create inhospitable conditions for hatched larvae and early juveniles and encourage their downstream movement to the LSZ (Moyle 2002; Kimmerer 2008). Based on similar modeled conditions, delta smelt larvae and early juveniles are not expected to experience greater rates of entrainment under the PA than from the COS in June.

Action 3 of the 2008 RPA, Entrainment Protection of Larval Smelt, begins with evidence of spawning and a Service determination that the action had been triggered. When triggered, the Service made a determination, setting OMR between -1250 cfs and -5000 cfs.

Under the PA, Reclamation and DWR will operate during this time period at no more negative than -5000 cfs. Additionally, Reclamation and DWR will use results produced by Service life cycle models to manage annual entrainment levels of larval/juvenile delta smelt. The Service will work with Reclamation and DWR to determine how best to operationalize the life cycle model results, taking into account consideration of real-time spatial distribution of delta smelt and operational actions described in the PA. During the period of larval/juvenile protection, Reclamation and DWR will also be implementing operations consistent with the single year loss thresholds to protect salmonids described in the PA. These protections are expected to provide equivalent or better protection than Action 3 in the 2008 RPA.

Predation of Delta Smelt

According to the BA, turbidity could be affected by the PA relative to the without action scenario. Potentially less sediment supply under the PA during the winter/spring could give less sediment for resuspension during the fall subadult period. With greater (more upstream) X2 under the PA (Figures 5.16-33, 5.16-34, 5.16-35 of the BA), the LSZ potentially could overlap areas with much higher channel to shoal ratios that support less wind-wave sediment resuspension (IEP 2015), which could then translate into greater predation risk for delta smelt. Thus, the eastward shift of location of the LSZ caused by the PA has the potential to cause mortality of delta smelt associated with increased predation risk.

Delta smelt entrained by negative OMR flow are subject to a greater likelihood of predation in the south Delta. This is because the channelized habitats and clearer water conditions in the south Delta provide favorable conditions for non-native fishes that prey on delta smelt (Moyle *et al.* 2016). These conditions are exacerbated by the presence of SAV in the south Delta, which functions to slow water movement and reduce turbidity, reducing the cover that helps mask delta smelt from likely predators like young largemouth bass (see Ferrari *et al.* 2014). As stated in the BA, available estimates of sediment removal by the south Delta export facilities are low, i.e., approximately 2% of sediment entering the Delta at Freeport in 1999–2002 under similar assumptions for south Delta export rates modeled under the PA (Wright and Schoellhamer 2004). While modeled OMR flow in the south Delta is expected to become slightly more negative under the PA than under the COS, turbidity levels are expected to remain similar to the COS in the south Delta due to the relatively small amount of sediment movement discussed above. Therefore, turbidity conditions are not expected to differ enough from the COS to provide an improvement or degradation in turbidity conditions for delta smelt. However, more negative OMR flow under the PA during April and May has the potential to entrain a greater fraction of the delta smelt population into the south Delta than has been occurring since 2009 (Appendix 2). The suite of OMR management actions previously discussed will help to minimize increases in proportional entrainment over the COS caused by the PA. Mortality associated with higher predation risk caused by entrainment is considered as part of the overall effects caused by entrainment due to operation of the CVP and SWP under the PA.

Other Considerations

Delta smelt abundance during the timeframe of this consultation could change due to a number of factors including, but not limited to, hydrological or weather conditions. Increases in abundance could result in higher levels of salvage.

One example of how delta smelt abundance could be affected is through supplementation. As discussed in more detail in the Non-Operational Actions section below, Reclamation proposes to support the FCCL supplementation efforts to develop necessary information to begin a supplementation program, focusing on capturing existing genetic diversity and expansion of FCCL to produce maximum numbers of delta smelt. The intent of this program is to begin supplementation of delta smelt in the wild with fish captively produced by FCCL within 3-5 years from the issuance of the BiOp. Reclamation also proposes to partner with DWR to construct and operate the Delta Fish Species Conservation Hatchery by 2030. The supplementation action is expected to benefit delta smelt by augmenting a wild population so that it is more resilient to withstanding the effects of entrainment.

5.2.2 South Delta Fish Facilities and Clifton Court Forebay Activities

This section addresses elements of the PA that would be encountered after entrainment of individuals. Under the without action scenario, these PA elements would not affect delta smelt because the projects would not be operating. The entrainment of delta smelt into the south Delta by the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. The only mechanism through which delta smelt could potentially survive the poor habitat conditions of the south Delta is through salvage at the fish facilities, but the reasons why few if any delta smelt survive the process under current conditions and operations protocol are discussed above. Therefore, the Service considers the effects of the elements of the PA that are encountered post-entrainment to have already been analyzed under entrainment effects in Section 5.2.1 in this BiOp including injury or mortality as a result of entrainment. If the delta smelt abundance increases in the future under the PA, including from expanding production at the FCCL to begin supplementation in the wild and associated development of the supplementation strategy, as well as from future operation of the Delta Fish Species Conservation Hatchery, it will lead to potential additional post-entrainment effects. Higher abundance is not expected to increase proportional entrainment, but may affect overall entrainment. The following is a brief discussion of activities under which delta smelt may be encountered after entrainment into the south Delta.

Tracy Fish Collection Facility (TFCF) and Skinner Fish Facility

Each of the pumping plants has a respective fish facility to manage fish salvage. The Tracy Fish Collection Facility screens fish before they reach the Jones Pumping Plant (CVP) and the Skinner Fish Facility screens fish before they reach the Banks Pumping Plant (SWP). The efficiency of each facility is described in Table 5-5. Each of these facilities uses behavioral barriers (louvers) to guide entrained fish into holding tanks from which they are loaded into trucks and transported to release sites in the Delta. The proposed salvage process for the fish facilities includes regular fish sampling of exported water for 30 minutes out of every 120 pumping minutes, though this sampling rate may vary based on debris load, mechanical failure, or other factors (ROC BA 2019). Using the subsampling rate at the time of collection, the facilities will apply the appropriate multiplier to estimate the total number of delta smelt salvaged during that time.

Due to low population numbers, it is likely that the 25% subsampling rate may not accurately depict the number of delta smelt that pass through the fish facilities. Especially under conditions when fish arrive at the fish screens along with large masses of aquatic weeds and debris that hinder operations and clog fish screens and other machinery, the sampling rate and efficiency may decrease significantly depending on the debris load and the effort required to clean the louvers. In some instances, exports continue without fish sampling due to mechanical issues and any fish present are not recorded. Salvage of delta smelt of any life stage has become increasingly rare in recent years, mirroring the overall decline of the population discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area*. Total salvage for water year 2018 for both facilities was four delta smelt, a historic record low. Given delta smelt's current degraded status, salvage is no longer a suitable indicator for entrainment.

The salvage of delta smelt does not return meaningful numbers of delta smelt back into the Delta and current TFCF and Skinner Fish Facility protocols dictate that delta smelt that are subsampled for fish counts are euthanized and retained in order to determine gender and sexual maturation of each individual. The information provided by these analyses can offer additional evidence of delta smelt spawning activity to supplement regular surveys designed to monitor the status of delta smelt. Additionally, most delta smelt that enter the south Delta via Old and Middle rivers are assumed to be eaten before they reach the fish facilities. Therefore, there are no additional effects to delta smelt of any life stage beyond what was described above in Section 5.2.1 from the operation of the salvage facilities.

Clifton Court Forebay Aquatic Weed Program

According to the BA, in the without action scenario, CCF gates are not operated and Banks Pumping Plant is not run and there would be no removal of aquatic weeds from CCF. Under the PA, DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Extensive weed build-up in CCF can provide predator ambush habitat and reduce efficiency of fish salvage. Herbicides may include Komeen®, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique®, a copper carbonate compound. These products are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of toxins. Because delta smelt within CCF are already entrained and have a nearly 100% mortality rate (Castillo *et al.* 2012), the application of herbicides does not change the overall impact of the PA on the species, though it could increase salvage if the herbicide treatments reduce predation losses across the forebay, or decrease observed salvage if the fish receive acutely toxic doses of these chemicals.

Clifton Court Forebay Predator Removal

Predator control efforts under the Proposed Action to reduce predation on listed fish species following entrainment into CCF could reduce pre-screen loss of delta smelt. Depending on the gear type used, predator control efforts may also catch or injure delta smelt. Because delta smelt within CCF are already entrained and have a nearly 100% mortality rate (Castillo *et al.* 2012), predator removal activities would not change the overall impact of the PA on delta smelt discussed in Section 5.2.1 above.

5.2.3 Other Delta and Suisun Marsh Operations

Water Transfers

Sometimes water rights holders in northern California sell some of their water to users south of the Delta. When extra pumping capacity is available, Reclamation and DWR will deliver these purchased water allotments to the purchaser through the South Delta pumping facilities. Reclamation's PA proposes to expand the transfer window from July 1-September 30 to July 1-

November 30, which could result in additional pumping of approximately 50 TAF per year in most water year types (ROC BA 2019).

From July to November, most delta smelt are rearing juveniles and are no longer distributed in habitats from which they can be entrained in exported water (Nobriga *et al*. 2008). The Service believes this is due to a combination of better OMR management in the spring and changing habitat conditions in the south Delta associated with SAV infestation, and possibly toxic impacts of *Microcystis* blooms. Salvage of delta smelt has not been observed in July since 2008, and salvage has not been reported during the months of August-November since 2000 (CDFW unpublished data). Thus, delta smelt are not anticipated to be present in the San Joaquin River east of Antioch or the OMR corridor during this expanded water transfer season. In addition, water transfers are associated with 'carriage water' which is small quantities of freshwater in addition to the transfer amount that are delivered to the Delta to help insure that salinity standards continue to be met as the water is moved through the system. Thus, the export of transfer water in this particular action should also not impact habitat suitability by lowering Delta outflow or changing the location of X2. Typically, movement back into the San Joaquin River and associated channels does not begin until December or January after the proposed transfer window will have ended. Thus, effects to the sub-adult life stage are also not anticipated.

Delta Cross Channel

Reclamation uses the DCC to divert Sacramento River water into the south Delta via the north and south forks of the Mokelumne River. Historical operation of the DCC was shown to route juvenile Chinook salmon smolts into the interior Delta, which lowered their survival (Newman and Rice 2002; Newman and Brandes 2010). In response to this research, SWRCB D-1641 required DCC gate closures that were expanded upon by NMFS (2009).

According to the BA, under without action conditions, DCC gates are permanently closed. Under the Proposed Action, the DCC gates would usually be closed during delta smelt's reproductive season; however, Reclamation has proposed to open the DCC gates during low inflow conditions to help meet D-1641 salinity requirements. Reclamation would use modeling to predict when D-1641 salinity standards would be exceeded and open the DCC to avoid the exceedances.

Adult delta smelt and their progeny have occasionally been collected in the vicinity of the DCC (Merz *et al*. 2011), but the Service considers this a transiently used area. Opening or closing the DCC gates may change the dispersal path of some delta smelt, but it is not known whether there is a consequence, such as a change in predation risk or likelihood of successful spawning. Given that Reclamation does not propose to operate the DCC gates very frequently and the Service does not have information indicating DCC operation impacts delta smelt, effects to the species are not anticipated for any life stage.

Agricultural Barriers

DWR will continue to install three agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year when necessary for water quality purposes. The barriers are installed between April and July and removed in November. The effects of installation of these three barriers are covered under a separate biological opinion with the Corps, where they are referred to as the Temporary Barrier Program (TBP) (Service file number: 08FBDT00-2018-F-0041). Installation activities under the TBP biological opinion are covered for a period of 5 years and expire after 2022. If section 7 coverage for the installation of the TBP lapses, reinitiation of consultation may be necessary to continue installing TBP facilities.

Under the Proposed Action, the operation of the TBP would not include the Head of Old River Barrier and the three remaining barriers would be operated at their respective locations. After TBP installation, adult delta smelt that have already been entrained into Old and Middle rivers may be trapped between the barriers and the fish facilities. The placement of the barriers would prevent these individuals from moving back downstream and they and any progeny spawned that far south would very likely not survive the summer. Given that the barriers are in poor habitat, delta smelt that have dispersed or been drawn this far south are already assumed not to survive per the description of entrainment above. As discussed in the TBP installation biological opinion, delta smelt occurring in the vicinity of the barriers could be subjected to predation because of predator species congregating by the barriers. However, because very few delta smelt can successfully reproduce as far into the south Delta as the location of these barriers, any effects of TBP operations above and beyond the entrainment effects related to the export of water from the Banks and Jones pumping plants are minimal.

Contra Costa Water District Rock Slough Intake

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. All CCWD facilities are subject to no-fill and no-diversion periods identified as March 15 through May 31 and April 1 through April 30, respectively, for fisheries protection. The no-fill and no-diversion periods may be modified with approval from the Service, NMFS, and CDFW. On average, CCWD diverts approximately 127 TAF per year. Approximately 110 TAF is CVP contract supply. No changes in operation criteria are proposed for the facilities. CCWD's operation of the diversion, storage, and conveyance facilities are covered under a separate biological opinion (Service file number: 1-1-93-F-35 and 1-1-07-F-0179). CCWD's operations in the PA are consistent with the separate biological opinions and remain unchanged from current operations; CCWD's average annual diversions are not expected to increase under the PA.

The intakes at Old River and Middle River have a maximum pumping capacity of 250 cfs each and are screened in accordance with delta smelt fish screening criteria (approach velocity of 0.2 ft/second). The Rock Slough intake, which has a maximum pumping capacity of 350 cfs, is screened to the same specifications. The Old and Middle rivers are poor habitat for delta smelt and as described above, they are assumed to already have been entrained once they enter Old and Middle rivers. Rock Slough is a dead-end slough off of Old River that is also poor habitat for delta smelt. The Service considers the effects of the Rock Slough Intake to delta smelt to have already been analyzed under entrainment effects in Section 5.2.1 in this BiOp including injury or mortality as a result of entrainment. Numbers of delta smelt collected at Rock Slough during sampling at the intake have been extremely low (only one larval delta smelt and one adult delta smelt were collected in 20 years of monitoring). Except when flows are very high, few if any delta smelt can successfully reproduce as far into the south Delta as the Rock Slough intake. As discussed in the BA, the effects of Rock Slough diversions on velocity in the San Joaquin River are minimal and unlikely to affect the movement of delta smelt into the south Delta.

North Bay Aqueduct (NBA)

According to the BA, under the without action scenario, there would be no pumping at the Barker Slough Pumping Plant. Under the PA, the maximum annual diversion through the NBA would increase to 125 TAF. Operations will continue subject to existing regulatory requirements. Based on the CalSim II modeling period of record, the maximum total amount of water that the NBA has diverted in March through May is about 30 TAF.

The Barker Slough Pumping Plant diverts water from the Cache Slough Complex, which is one of several key delta smelt spawning and rearing regions. Adult and larval delta smelt densities in the greater Cache Slough Complex are among the highest observed, but historical catch data indicate that delta smelt numbers in Barker Slough are very low, indicating that a relatively small portion of the delta smelt population in this region is susceptible to historical levels of NBA diversions. Each of the ten Barker Slough Pumping Plant pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish approximately one inch or larger from being entrained. The bays tied to the two smaller units have an approach velocity of 0.2 ft/second. The larger units were designed for a 0.5 ft/second approach velocity, but actual approach velocity is about 0.44 ft/second. The fish screens should preclude 100% of adult delta smelt and juvenile delta smelt larger than 25 mm in length from being entrained, but it is not known how well they protect individuals < 25 mm in length.

The NBA diversions do not appear to have had a substantial effect on delta smelt (Service 2008). However, an increase in diversions, particularly if taken during the spring, may increase the entrainment of larval individuals less than 25 mm in length. Reclamation and DWR propose to work with the Service to develop NBA minimization measures by the end of the 2019 calendar year. These minimization measures will aim to protect larval delta smelt from entrainment to the NBA and will consider reduction in diversion through the NBA during the spring for appropriate water year types, when larval delta smelt begin to hatch and emerge. Along with the implementation of these measures to protect larval delta smelt, it is expected that the effects to delta smelt will continue to be minimal under the PA on an individual and population level. However, delta smelt <25mm in length that reach the fish screens are likely to be killed as a result of passing through the screens and into the pumping plant and/or aqueduct where they will not survive.

Suisun Marsh Salinity Control Gates (SMSCG)

The SMSCG are generally operated, as needed, from October through May to meet the SWRCB's D-1641 salinity standards in the Suisun Marsh. The number of days the SMSCG are operated in any given year varies depending on hydrology (*i.e.*, more days of SMSCG operation are generally required in drought years, and in wetter years. The SMSCG have historically been operated for 60-120 days between October and May. The Delta Smelt Summer-Fall Habitat Action includes gate operations in June through September in addition to the historic October through May operation, and effects of this action are analyzed separately from the October through May operations.

Under current operations, delta smelt could be entrained into Montezuma Slough when the SMSCG is opened and then closed especially during the late summer and fall when the gates are most likely to be used. The degree to which movement of delta smelt around the LSZ is constrained by opening and closing the SMSCG and whether or not this harms delta smelt are unknown. Striped bass may aggregate near the SMSCG, which could elevate predation rates. Additionally, delta smelt may experience an increased risk of entrainment into the managed marshes where they would be unlikely to survive (Culberson *et al.* 2004; Service 2008). However a recent study found that the body condition of delta smelt collected from Suisun Marsh was better than at other locations (Hammock *et al.* 2015). The freshening of Montezuma Slough through gate operations could provide additional low salinity habitat for delta smelt to forage, spawn and rear.

Roaring River Distribution System (RRDS)

According to the BA, under the without action scenario, DWR would not operate the Roaring River Distribution System. Under the PA, the Roaring River Distribution System (RRDS) will maintain a maximum approach velocity of 0.2 ft/second at the intake fish screens. During mid-September through mid-October, water diversions into RRDS increase to support a fall flood-up of wetlands to ready them for the arrival of winter waterfowl. During this one-month period, DWR proposes to divert water into RRDS at rates that result in approach velocities up to 0.7 ft/second. The RRDS intakes are screened (3/32-inch opening, or 2.4 mm) and physically exclude fish greater than 30 mm in length from being entrained. Therefore operation of RRDS can entrain larvae and small juveniles in the spring and early summer. Once delta smelt grow to lengths greater than 30 mm, RRDS can only result in take if individuals are impinged onto the screens. It is not known whether this occurs. During March-June when delta smelt < 30 mm are present, any effects on delta smelt would be expected to be similar between the COS and PA.

The proposed maximum approach velocity of 0.7 ft/second operation during the fall flood up in mid-September through mid-October exceeds the CDFW-recommended design criterion of 0.2 ft/second, but has been approved on an annual basis to support fall flood up since 2009 through a variance of the 2008 BiOp. During September and October nearly all delta smelt exceed 30 mm in length and would therefore be very unlikely to be entrained and lost to the population. Impingement is a more likely take mechanism for these juvenile fish. The 0.7 ft/second approach velocity may result in greater impingement on the screens than the 0.2 ft/second approach velocity. However, the Service considers higher entrainment or impingement mortality to be unlikely because the RRDS intakes are positioned in a part of Montezuma Slough where the channel is about 300 to 350 feet wide and delta smelt would need to be within a few feet of the fish screens to have any vulnerability to variation in approach velocities through the screens. The information that we have available indicates that delta smelt generally avoid in-water structures and would therefore have little tendency to be in close proximity to the RRDS intakes, particularly given the substantial width of the adjacent channel.

Morrow Island Distribution System (MIDS)

According to the BA, under the without action scenario, DWR would not operate the Morrow Island Distribution System. Under the PA, the Morrow Island Distribution System (MIDS) will continue to operate as identified in the 2008 Service BiOp. No changes in operations are proposed.

Individual delta smelt could be entrained by the three unscreened 48-inch intakes that form the MIDS intake. However, Enos *et al*. (2007) noted that this would generally only occur in wet years, per Hobbs *et al*. (2005). Enos *et al*. (2007) noted that under normal operations, MIDS is often closed or diversions are limited during spring, which may provide some protection of fish that spawn or disperse at that time, particularly open-water fish like delta smelt that do not congregate around in-stream structures such as diversions. Enos *et al.* (2007) did not collect any delta smelt during sampling of the MIDS intake in 2004-2006, although they did capture adult delta smelt with purse seines during sampling in the adjacent Goodyear Slough. Based on this empirical research, it is expected that the effects to delta smelt for all life stages will continue to be minimal under the PA on an individual and population level. The Service expects that mortality is likely to occur when individual delta smelt enter the intakes.

5.2.4 Delta Smelt Summer-Fall Habitat

Availability of suitable habitat throughout the year is important for delta smelt to complete its life cycle. During the larval through sub-adult life stages, suitable habitat attributes to support delta smelt rearing include the combination of landscape, turbidity, salinity, temperature, and food co-occurring in the same area (Feyrer *et al*. 2007; 2011; Nobriga *et al*. 2008; Sommer and Mejia 2013; Bever *et al*. 2016; Simonis and Merz 2019). When these habitat attributes do not occur together delta smelt can suffer harm through physiological stress and contaminant exposures (Hammock *et al*. 2015; Komoroske *et al*. 2015; Hasenbein *et al*. 2016b), injury and/or mortality due to inadequate foraging and shelter habitat that together result in poor fish health (Hammock *et al*. 2015) and elevated vulnerability to predators (Ferrari *et al*. 2014; Schreier *et al*. 2016).

Most delta smelt use the LSZ at some point in their life cycle and the population distribution tracks the movement of the LSZ somewhat (Moyle *et al.* 1992; Dege and Brown 2004; Feyrer *et al.* 2007; 2011; Nobriga *et al.* 2008; Sommer *et al.* 2011; Bever *et al.* 2016; Manly *et al.* 2015; Polansky *et al.* 2018; Simonis and Merz 2019). The LSZ is frequently defined as waters with a salinity range of about 0.5 to 6 ppt. The LSZ generally expands and moves downstream as river flows into the estuary increase, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under lower flow conditions (Jassby *et al*. 1995; MacWilliams *et al*. 2015). This expanded LSZ at higher outflow adds to habitat available in the Cache Slough Complex that is not affected by variation in Delta outflow (Sommer and Mejia 2013). Appropriate water quality conditions need to overlap an underwater landscape featuring variation in depth, tidal current velocities, edge habitats, and food production (Hobbs *et al*. 2006; Bever *et al*. 2016; Hammock *et al*. 2017; 2019). The LSZ and other adjacent tidally-influenced freshwater habitats described in the Environmental Baseline section help to ensure that suitable habitat attributes listed above are present and available to delta smelt.

The influence of freshwater flow inputs on delta smelt distribution could in turn influence mechanisms that affect the species' population dynamics when those mechanisms are linked to where the fish reside or how they are distributed in the estuary (Moyle *et al*. 1992; Bennett 2005; Hobbs *et al*. 2006; Hammock *et al*. 2015; 2017; Bush 2017). Delta smelt seldom occur in the estuary at salinities that begin to cause physiological stress (Komoroske *et al*. 2016) and salinity increases linked to changes in Delta outflow tend to be associated with an eastward shift in the spatial distribution of the delta smelt population (Moyle *et al.* 1992; Dege and Brown 2004; Feyrer *et al.* 2007; 2011; Nobriga *et al.* 2008; Sommer *et al.* 2011; Bever *et al.* 2016; Manly *et al.* 2015; Polansky *et al.* 2018; Simonis and Merz 2019). We note that water temperature, turbidity, water diversion rates, prey availability, and possibly other factors would also affect these complex and inter-related spatial recruitment and survival mechanisms.

It is reasonable to deduce that these factors also affect delta smelt at the scale of individual fish. Delta smelt, particularly individuals at the edges of the population spatial distribution, may experience habitat conditions that are missing one or more of the habitat attributes that were described above (see Table 5-3). When these habitat attributes do not occur together, delta smelt can suffer harm through physiological stress and contaminant exposures, and mortality due to inadequate foraging and shelter habitat that together result in poor fish health (Hammock *et al*. 2015) and elevated vulnerability to predators (Ferrari *et al*. 2014; Schreier *et al*. 2016). One factor that can affect the habitat suitability experienced by individual fish is water operations, which by influencing the magnitude and net direction of freshwater flow in the Delta (Hutton *et al*. 2018), can affect the overlap of several of delta smelt's physical habitat attributes (Bever *et al*. 2016). Unfavorable conditions may include reduced prey production, which could affect how much biomass of key prey such as *P. forbesi* is available to be transported into the turbid water refuge of the LSZ during the summer and fall (Kimmerer *et al*. 2018a,b). Low outflow can also increase delta smelt's reliance on the Cache Slough Complex which can expose more fish to stressful water temperatures (Bush 2017). Summer water temperatures are typically 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). Thus, during summer, many parts of the estuary are energetically costly and physiologically stressful to delta smelt (Komoroske *et al*. 2015), underscoring the need for larger areas of low-salinity habitat to avoid or minimize localized habitat-based effects to delta smelt.

Delta Smelt Summer-Fall Habitat Action

According to the BA, under the without action scenario, DWR would not operate the SMSCG or Goodyear Slough Outfall, leading to a saltier Suisun Marsh and decreased delta smelt habitat suitability in the fall and early winter of drier water year types. However, during some fall seasons and most winter-spring seasons, the without action scenario would also result in higher Delta outflow than the PA and COS, resulting in overall increases in delta smelt habitat. In the without action scenario, X2 is at 86 km on average in September and 84 km on average in October. Under the current operations scenario, X2 is at 86 km on average in September and 87 km on average in October. In contrast, under the modeling provided for the PA, X2 was predicted to be at 92 km on average in September and October. However, Reclamation has proposed the following Summer-Fall Habitat Action that is not reflected in the modeling and will move the average X2 westward of the model-predicted values.

The Delta Smelt Summer- Fall Habitat Action proposed in the PA is intended to improve delta smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of delta smelt. Reclamation and DWR propose to use structured decision making to implement delta smelt habitat actions. The Summer-Fall Habitat Action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline at 80 km from the Golden Gate in above normal and wet water years in September and October. Reclamation and DWR will also implement additional measures that are expected to achieve additional benefits. These measures include operation of SMSCG for up to 60 additional days (not necessarily consecutive) from June 1 through October 31 of below normal and above normal years. SMSCG operation may also be implemented in wet years if preliminary analysis shows expected benefits. Food enhancement actions, e.g., those included in the Delta Smelt Resiliency Strategy to enhance food supply would also be implemented. These food enhancement actions include the North Delta food-web project, Sacramento River Deepwater Ship Channel lock reoperation, and Roaring River distribution system reoperation. Reclamation and DWR will monitor dissolved oxygen at Roaring River distribution system drain location(s) during delta smelt food distribution actions to ensure compliance with Water Quality Objectives established in the San Francisco Bay Basin Plan.

Reclamation has included considerations for implementation and has identified the potential for implementation of other actions that will be more fully defined and developed through the structured decision making or other review process. The annual process is described more fully in the PA. The process will involve a Delta Coordination Group that will make annual determinations on the actions to be implemented each year.

Reclamation has stated its intent to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action will depend on the hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases may be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood-control limitations are expected. In these scenarios, Reclamation will make releases in a manner that minimizes redd dewatering where possible. In the event that Reclamation determines the Delta outflow augmentation necessary to meet 2 ppt isohaline at 80 km from the Golden Gate as described above cannot be met through primarily export reductions and is expected to have a high storage cost, Reclamation will still implement the rest of this action, and will meet with NMFS and the Service to discuss alternate potential approaches that improve habitat conditions.

SMSCG Operation and Outflow Action

We described in Table 5-3 how the status of delta smelt critical habitat has limited overlap of the needed PCEs in many locations. Table 5-7 describes the operations Reclamation and DWR have proposed through a Summer-Fall Habitat Action to increase the spatial overlap of delta smelt habitat attributes with a focus on Suisun Marsh. Reclamation and DWR propose to operate to a monthly average X2 location at 80 km in September and October in Above Normal and Wet years. The rationale for doing so is to lower the salinity of Montezuma Slough and the larger embayments of eastern Suisun Bay to improve the overlap of low-salinity water with the bay and marsh's turbid shoals and connecting channels. Reclamation and DWR propose to continue October – May SMSCG operations as necessary to meet D-1641 water quality requirements that protect the management of waterfowl habitats in Suisun Marsh's wetlands. The SMSCG can be opened on ebb tides to divert Sacramento River water into Montezuma Slough, which is subsequently diverted onto numerous hunting clubs and other managed wetlands in the marsh to grow freshwater and low salinity forage for various waterfowl species. The SMSCG are closed on flood tides to limit the influx of saltier water. Reclamation and DWR have proposed new operations of SMSCG for up to 60 additional days (may be non-consecutive) for portions of the June-October period in Below Normal and Above Normal years. This new action may also help wetlands but is intended to increase the use of Suisun Marsh by delta smelt where a recent study found the smelt had relatively high feeding success and relatively low contaminant exposure (Hammock *et al*. 2015). This new SMSCG action may also be implemented in Wet years if research indicates delta smelt receive benefits from doing so. This action continues a recent experimental approach to managing delta smelt habitat quality within the Suisun Marsh, where prey density is generally higher than in Suisun Bay, and turbidity is usually higher than it is in the Delta east of the Sacramento-San Joaquin river confluence.

Table 5-7. Proposed management for the Delta Smelt Summer-Fall Habitat Action by Water Year Type (WYT).

Water Year Type	SMSCG action	Delta outflow operation
Below Normal	Operate up to 60 additional days June-October	D-1641 compliance
Above Normal	Operate up to 60 additional days June-October	D-1641 compliance plus meeting a monthly average X2 at 80 km during September and October.
Wet	Potential to operate up to 60 additional days June-October if preliminary analysis shows expected benefits	D-1641 compliance plus meeting a monthly average X2 at 80 km during September and October.

Because the specific actions of this project element are to be determined annually by a Delta Coordination Group through a structured decision-making process, the specific actions taken in each water year may be unique based on evaluation of outcomes of prior actions and conditions for that year. The Delta Coordination Group will be comprised of representatives from the Service, Reclamation, DWR, CDFW, NMFS, and stakeholders. If implementation of this action cannot meet the goals and objectives of this program then reinitiation of consultation will be necessary.

Under current operations, the SMSCG is nearly always open so delta smelt can usually enter and leave Montezuma Slough whenever conditions compel them to. In lower flow conditions when Suisun Marsh needs to be freshened to meet D-1641 salinity standards, the gates can be operated tidally. This usually occurs rather sporadically, but when it does, it may impede movement of delta smelt for a few hours or redirect some fish further into the marsh. The degree to which movement of delta smelt around the LSZ is constrained by opening and closing the SMSCG is unknown. It is also unknown whether this harms those individual delta smelt. Operation of the SMSCG may cause individual delta smelt to face an increased risk of entrainment into the managed marshes where they would be unlikely to survive (Culberson *et al.* 2004; Service 2008). However, one recent study found that the body condition of delta smelt collected from Suisun Marsh was better than at other locations (Hammock *et al.* 2015), suggesting that there may be a net benefit to delta smelt through occupying larger channels of Suisun Marsh.

As noted above, the modeling conducted for the BA did not reflect the Delta outflow that accompanies this action in Wet and Above Normal years; rather it only estimated what may be needed to meet D-1641 salinity standards in the western Delta during the summer and fall. Thus, this effects analysis is largely qualitative because the BA modeling does not reflect the PA or the adaptive nature of the actions that will be implemented. The analysis focuses on effects to individuals and the population using available data from a 2018 SMSCG pilot study, BA modeling, and the modeling presented to the Service during reinitiation of the 2008 Fall X2 action in 2017 and 2019.

In the context of the PA, Figure 5-35 shows the predicted difference between the PA and the COS during the summer months at Belden's Landing in Montezuma Slough, which was identified as one potential compliance point for the Summer-Fall Habitat Action.

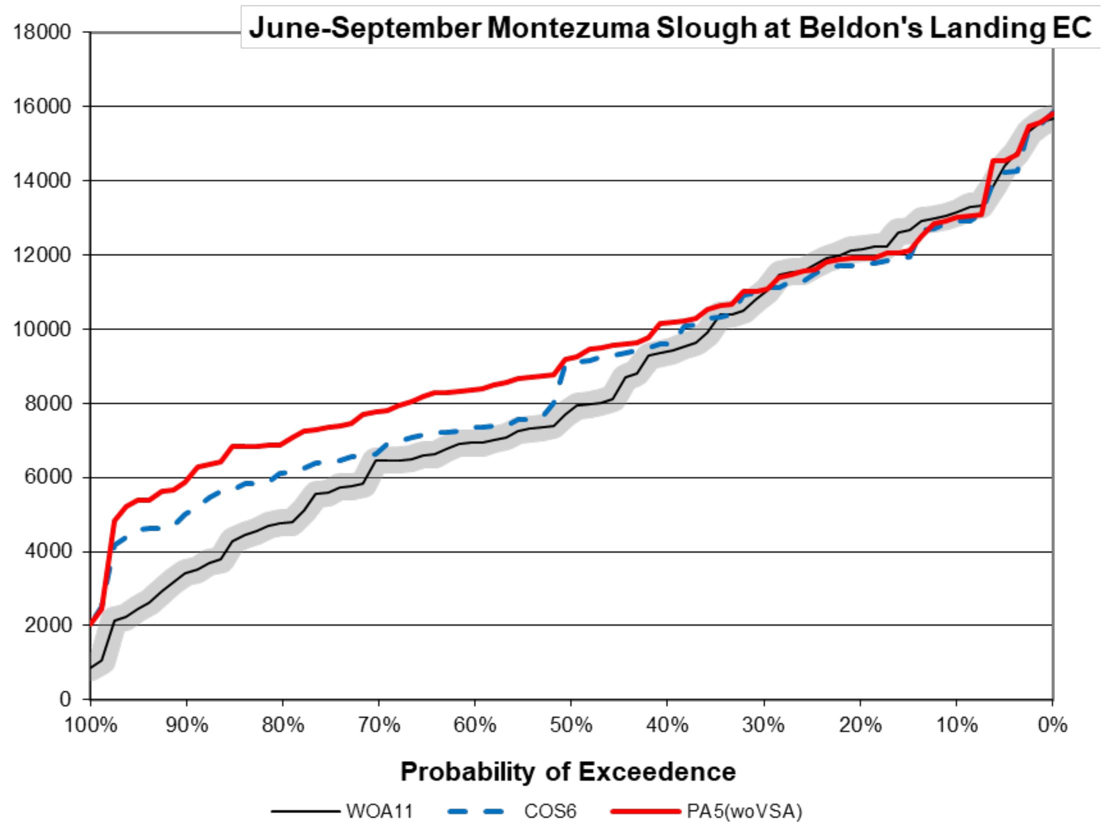


Figure 5-35. Summer Electrical Conductivity at Belden's Landing. Electrical conductance (EC) on the Y-Axis is show µS/cm).(Source: ROC BA 2019)

Generally, in Suisun Marsh, higher summer salinities were predicted to occur in about half of the water years compared with COS (Figure 5-35). However, the Delta Smelt Summer-Fall Habitat Action was not included in the modeling because the action was developed after the modeling was produced. The Summer-Fall Habitat Action will bring the salinity distribution at Belden's Landing closer to what was modeled under the COS. In Below Normal years, no additional outflow beyond that which is required to meet D-1641 water quality standards is proposed. However, it is the drier half of water year types where PA and COS modeling converge with regard to predicted salinity at Belden's Landing, so the model predictions are likely more accurate for these lower flow years. The proposed use of the SMSCG could reduce salinity at Belden's Landing in Below Normal water years. This means that the PA modeling overestimates the salinities in Suisun Marsh that will result from implementation of the PA.

A 2018 SMSCG pilot study, which occurred during a Below Normal year, showed potential benefits for delta smelt including lower salinity, higher (overall) habitat suitability in Suisun Marsh and a slight improvement in habitat suitability in Grizzly Bay - even with X2 as high as 84 km (Sommer *et al.* 2019). The EDSM survey had not been collecting delta smelt in Suisun Marsh prior to the experiment, but observed modest numbers in Montezuma Slough during the 30-day study period; however based on historical TNS results (CDFW 2019), it is not unusual to observe delta smelt in the marsh during the summer. It was posited that the 2018 SMSCG operations would generate habitat conditions that were similar to Wet year conditions and allow delta smelt to access habitat within the marsh (ROC BA 2019). Preliminary results were mixed with regard to this hypothesis. Further results are forthcoming and may be able to guide the Delta Coordination Group in crafting future habitat actions.

In Above Normal and Wet water year types, the PA modeling does not reflect the proposed location of X2 at 80 km from the Golden Gate Bridge in September and October. Maintaining X2 at a monthly average 80 km in September and October would be expected to lower the salinity of Suisun Marsh and parts of Suisun Bay (MacWilliams *et al*. 2015; Reclamation 2017; 2019), which in turn could improve habitat for delta smelt because the low-salinity zone would more frequently occur in association with the comparatively turbid, low-velocity shoals of Grizzly and Honker bays, as well as Montezuma Slough in Suisun Marsh.

In 2017 and 2019 (the two most recent Wet water years), Reclamation reinitiated consultation proposing to modify the Fall X2 action from the Reasonable and Prudent Alternative of the 2008 BiOp. The 2008 RPA required X2 to be maintained at 74 km in Wet years for the months of September and October. In 2017, Reclamation proposed to maintain X2 at 74 km in September, but at 81 km in October. In 2019, Reclamation proposed to maintain X2 at 80 km in both months. To support each reinitiation, Reclamation provided an analysis of the effects on delta smelt habitat suitability and delta smelt next-year recruitment predicted to result from moving X2 to different locations bounded by 74 and 81 km. Reclamation concluded from its modeling that turbidity assumptions played a larger role in estimated habitat suitability than the salinity change in Suisun Bay that resulted from an X2 at 80 km in place of 74 km (Reclamation 2017). Reclamation noted that a large habitat suitability inflection point occurred if X2 averaged 80 versus 81 km because the salinity change associated with this particular 1-km X2 shift resulted in much higher frequencies of > 6 psu salinity waters occurring in Montezuma Slough and overlapping the turbid shoals of eastern Suisun Bay. Based on this finding, Reclamation amended its request to maintain X2 at 80 km in October 2017. The Service amended the 2008 BiOp to allow Reclamation to operate its facilities to achieve an average X2 location of no greater than 80 km in the month of October 2017 (Service 2017). The Service also modified the 2008 BiOp to allow operations consistent with Reclamation's 2019 proposal (Service 2019); however, Reclamation ultimately decided to operate consistent with Action 4 of the 2008 RPA in 2019.

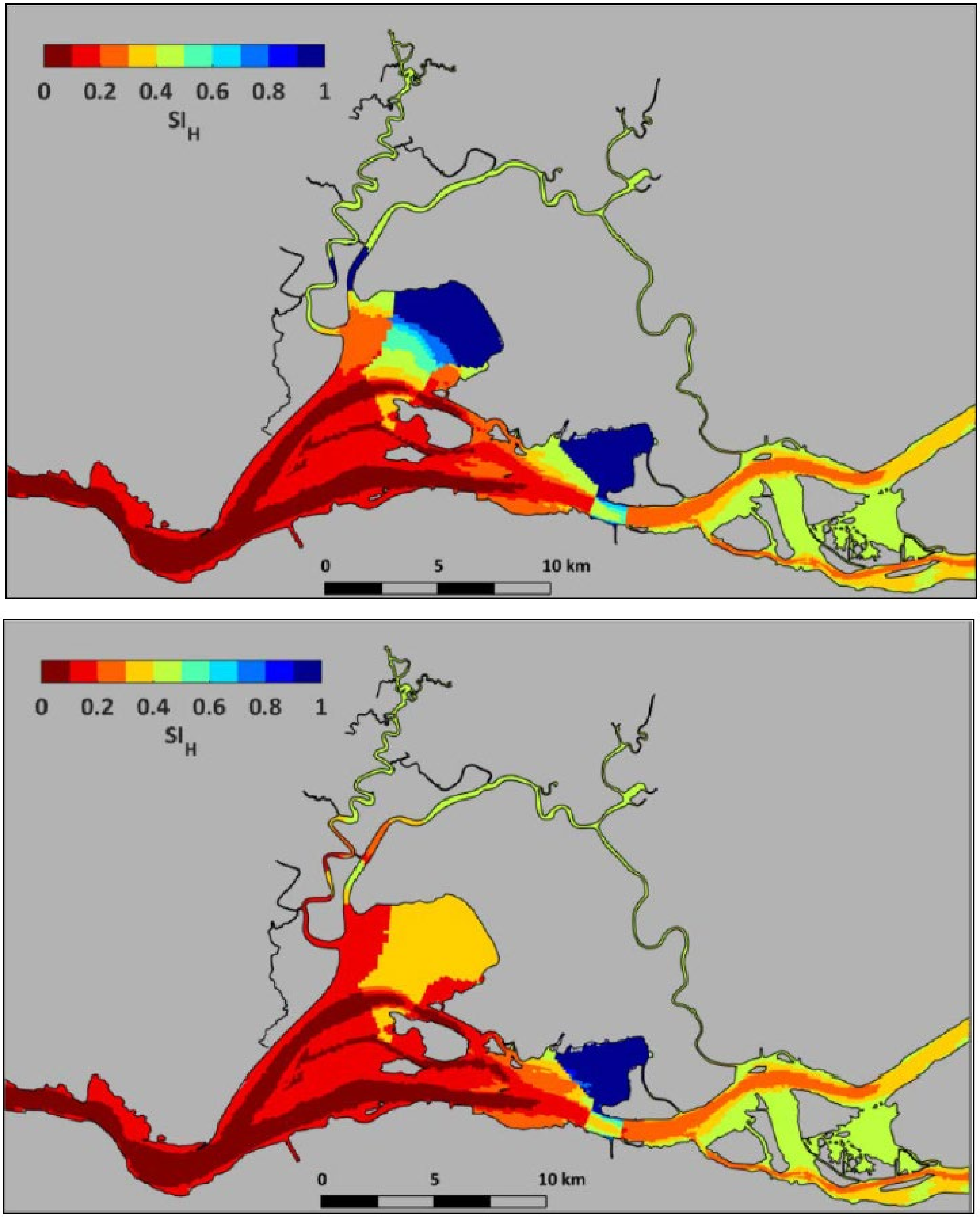


Figure 5-36. The delta smelt station-based habitat index proposed by Bever *et al.* (2016) in the Suisun Bay region at an X2 of 80 km (top panel) and at 81 km (bottom panel). Source: Effects Analysis in support of 2017 Fall X2 modification request (Reclamation 2017).

Food Enhancement Actions

No food enhancement actions would occur under the without action scenario, but prey densities might be elevated due to higher spring and early summer outflow and the lack of water exports. Reclamation proposes to implement several food subsidy projects in conjunction with the Delta Smelt Summer-Fall Habitat Action because food limitation is a common conclusion of quantitative empirical and modeling studies of delta smelt (Kimmerer 2008; Maunder and Deriso 2011; Miller *et al*. 2012; Hammock *et al*. 2015; Hamilton and Murphy 2018; Kimmerer and Rose 2018). Reclamation's proposed coupling of an X2 action, new SMSCG actions and several food subsidy actions may improve the spatial overlap of delta smelt suitable habitat attributes in two locations where conditions can be managed with a comparatively lower water cost (Suisun Marsh and the Cache Slough complex). The Service acknowledges that it remains an untested assumption that food resources can be distributed to benefit delta smelt; superior competitors may benefit as well or more so, and there is a risk of redistributing contaminants with these actions in a manner that could offset benefits. The integrated timing of food enhancement projects involving re-operation of the RRDS is expected to provide food benefits to delta smelt that may be attracted to the fresher and more turbid conditions generated in the vicinity of Suisun Marsh. Other actions will attempt to augment prey resources in the turbid waterways of the North Delta. These actions are addressed programmatically in this consultation (see *Food Enhancement Actions* in Section 5.2.5 below*)*, so further detail about how these actions will be implemented and expected benefits will be addressed in subsequent consultation prior to implementation.

Delta Smelt Summer-Fall Habitat Action Summary

The 2008 BiOp recognized that due to high levels of exports in the fall over the 10-year period prior to the BiOp issuance, the fall months in the estuary resembled Critical years, regardless of year type. In fall of Critical years, the LSZ is located further upstream then in wetter years, resulting in changes to the composition of other habitat attributes co-occurring with the LSZ. In order to address this loss of co-occurring habitat attributes, the 2008 RPA called for Reclamation and DWR to operate to an X2 position of 74 km in September and October of Wet years and 81 in Above Normal years. In November, the action specified that the projects were to release any gained storage to allow the estuary benefit from any November storms. The Service used X2 position as a surrogate for the location of the LSZ.

Altogether, the spatial extent of high suitability rearing habitat will be somewhat lower under the PA in Wet years, and somewhat higher in Above Normal and Below Normal years than what it would be anticipated under the COS. This statement is largely limited to the months of September and October of Wet and Above Normal water years due to the explicit differences in operations rules between the PA and COS. The suite of management interventions in the Summer-Fall Habitat Action is intended to focus benefits into places like the Cache Slough Complex and Suisun Marsh where outcomes can be controlled and observed fairly carefully, and it will add actions to Below Normal water years, potentially increasing the frequency of years that the delta smelt population receives some helpful management intervention. The effects to individuals and to the population of this adaptive set of actions cannot be quantified at this time. However, the Service anticipates that the actions identified would continue to provide low-salinity habitat in Honker and Grizzly Bays and Suisun Marsh in Above Normal and Wet years and increase its frequency in Suisun Marsh in Below Normal years. Additionally food enhancement actions, described at a programmatic level at this time, may provide better feeding conditions for delta smelt in Suisun Marsh and the Cache Slough Complex. The structured decision making process called for under this action will incorporate new results each year to help refine the potential benefits that may be realized.

5.2.5 Non-Operational Actions

Under the without action scenario, the non-operational actions proposed by Reclamation and DWR in the PA, and listed below, would not occur.

Cultured Smelt Production from Fish Conservation and Culture Laboratory (FCCL)

As discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area*, the delta smelt faces a high risk of continued decline if the population is not supplemented. Reclamation proposes to fund a two-phase process that would lead to annual supplementation of the wild delta smelt population with propagated fish within 3-5 years from issuance of the biological opinion. The first step in this process will be the development of a supplementation strategy within one year of the issuance of the BiOp that will describe the capacity needed at hatchery facilities to accommodate the delta smelt production needed to meet genetic and other hatchery considerations with a goal of increasing production to a number and the life stages necessary to effectively augment the population. The Service will be the lead on the development of this supplementation strategy.

The FCCL has closed the life cycle of delta smelt, meaning that they can produce new generations of fish at their facility without the addition of new wild spawners and keep enough progeny alive to repeat the process for multiple generations. Annually, the FCCL provides approximately 33,000 fish of different life stages for use in research. Additionally, approximately 32,000 adults are reared in the refuge population. To achieve these production levels, the FCCL frequently removes fish at the egg and juvenile stages. Additional funding will support expansion of facilities to maintain these fish and increase rearing capacity to provide up to approximately 125,000 adults within 3 years.

The Service will work with partners to use this expanded delta smelt production at the FCCL to determine how a successful reintroduction program can be developed. This work will focus on production from FCCL in the near term, but the Service recognizes that expansion of the refugial population and propagation of additional fish for supplementation will require a new facility. The Service, with support from Reclamation, has been pursuing and will continue to pursue a Delta Fish Technology Center, which could house the Delta Fish Species Conservation Hatchery discussed below, to address these needs. The Service has already completed a BiOp for construction of the Delta Fish Technology Center (Service file number 08FBDT00-2017-F-0101). The effects of scientific research activities for use of cultured delta smelt in contained environments are addressed in the framework programmatic biological opinion on our issuance of a section 10(a)(1)(A) permit to FCCL (Service file number 08FBDT00-2018-F-0360).

Supplementation through the FCCL will increase the likelihood that the population of delta smelt will be sustained in the wild by achieving a robust, genetically diverse captive population. This will increase the likelihood of their ability to survive and reproduce in the wild to boost population numbers and maintain distribution throughout the species range and to be able to withstand the multiple factors that have led to its decline, including entrainment and associated predation resulting from seasonal operations of the Banks and Jones facilities.

No effects to delta smelt are anticipated from any construction associated with the expansion of FCCL because the expansion is not expected to be in delta smelt habitat. Fish hatcheries, including conservation-oriented hatcheries, can positively and negatively impact the populations being supplemented. The Service's desired positive impact is to provide delta smelt with insurance against extinction. We believe this is necessary because the species' recent abundance trends strongly suggest it is in the midst of demographic collapse and likely will require supplementation to persist (Moyle *et al*. 2016; Hobbs *et al*. 2017; Lessard *et al*. 2018). Negative impacts can occur when hatchery practices result in the loss of genetic variation that is adventitious for wild fish or when behavioral adaptation to captive conditions is maladaptive when fish are returned to the wild. The Service has considerable experience with fish propagation and will work to ensure that best practices are employed in the production and supplementation of delta smelt back into the estuary.

Delta Fish Species Conservation Hatchery

To support and expand supplementation into the future, Reclamation proposes to partner with DWR to construct and operate the Delta Fish Species Conservation Hatchery by 2030. The Delta Fish Species Conservation Hatchery would breed and propagate delta smelt with equivalent genetic resources as the contemporary stock and with the goal of raising delta smelt in sufficient numbers to effectively augment the existing wild population. Potential negative effects of releasing hatchery produced fish into the wild could include reduced fitness through domestication of hatchery fish that may breed with wild delta smelt. The agencies intend to address potential negative impacts through development of the hatchery program for delta smelt.

With increased populations from active supplementation of delta smelt through the FCCL program and the Delta Fish Conservation Hatchery, entrainment of supplemented delta smelt is reasonably certain to occur; however, the entrainment protection actions in the PA will reduce entrainment losses of supplemented delta smelt to numbers lower than the population increases associated with supplementation. The supplementation action is expected to benefit delta smelt by augmenting a wild population so that it is more resilient to withstanding the effects of entrainment. We do not expect supplemented delta smelt to be released into the south Delta. The net effect is a higher proportion of the overall population will be protected from being entrained, particularly with the Integrated Early Winter Pulse Protection and Turbidity Bridge Avoidance measures in place to avoid drawing delta smelt further south.

Since development of the Delta Fish Species Conservation Hatchery is being addressed programmatically in this consultation, further detail about adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

Tidal Habitat Restoration (8,000 acres)

Reclamation and DWR propose to complete construction of the remainder of the 8,000 acres of intertidal and associated subtidal habitat restoration in the Delta and Suisun Marsh by 2030. The objective of this activity as stated is to "improve habitat conditions for delta smelt by enhancing food production and availability" (Service 2008).

Primary production in tidal wetlands within the Bay Delta estuary have been shown to support high zooplankton growth (Mueller-Solger *et al*. 2002). These proposed restoration actions are therefore expected to enhance the food web on which delta smelt depend. Restoration will be designed to increase high quality primary and secondary production in the Delta and Suisun Marsh through increasing the quality and quantity of tidal wetlands on the landscape. Exchange of water between tidal wetlands and surrounding channels is expected to distribute primary and secondary production from the wetlands to adjacent pelagic habitats where delta smelt occur. Tidal exchange will be optimized through the intertidal habitat restoration design by incorporating extensive tidal channels supported by appropriately sized vegetative marsh plains. Data suggest that freshwater tidal wetlands can be an important habitat type to delta smelt with proper design and location.

Tidal restoration projects in the estuary have generally created fish feeding benefits very quickly (Cohen and Bollens 2008; Howe and Simenstad 2011). Following Herbold *et al*. (2014), the restoration projects that will be credited to this action in the coming decade will be sited and designed to locally increase food web production in a location that delta smelt should be able to access it. Reclamation and DWR commit to funding and ensuring that monitoring, operation, maintenance, and permanent protection occur on these restored lands. An overall monitoring program developed to focus on the effectiveness of the restoration actions will inform future actions undertaken for the intended food web benefit of delta smelt.

In 2010, DWR established the Fish Restoration Program (FRP), a coordinated effort between DWR and CDFW, which focuses on the planning, design, and permitting of individual restoration projects. Additionally, the Tidal Wetlands Monitoring Program (TWMP) was established in 2014 by DWR with assistance from CDFW to focus on the effectiveness of the restoration actions. The FAST, which includes Reclamation, CDFW, NMFS, and the Service, coordinates on the design and crediting of proposed restoration projects to ensure they meet the objective stated above. A MOA was signed in 2011 where these signatory agencies committed to collaborate in planning habitat projects (Reclamation *et al.* 2011). This process has facilitated streamlining and efficiencies in the planning and approval of these restoration projects. The FRP has made significant progress in overcoming hurdles which has created momentum in acquiring lands, designing, and constructing projects. Restoration projects that have broken ground on construction include Tule Red, Yolo Flyway Farms, and Decker Island. This momentum is expected to continue in the coming years in order to complete the remaining restoration acreage.

As described in the *Consultation Approach* section of this BiOp, subsequent consultations will occur for each tidal habitat restoration project, which will address effects at the site-specific level and will include Incidental Take Statements, as appropriate. Tidal restoration projects within the Suisun Marsh Plan Programmatic Biological Opinion coverage area could tier to this BiOp.

Based on consultations on previous tidal habitat restoration projects, we expect that the following types of activities are likely to affect delta smelt, but this list does not include all possible effect mechanisms: vegetation removal for site preparation, access routes, construction staging, earthwork, breaching of berms or levees, new berm construction, tidal network creation, pond creation, in-water construction activities, dredging, water quality and biological monitoring, and long-term management activities. The nature and magnitude of adverse effects of tidal habitat restoration will vary depending on project design, site location, and construction timing, magnitude, and duration.

Reclamation and DWR are proposing to complete the habitat restoration action called for in the 2008 BiOp. This action identifies restoration of 8000 acres of tidal and subtidal habitat. The intent of this action was to address losses due to entrainment in the south Delta and to create additional food to replace impacts to food supply by operation of the SWP.

This restoration was slow to be implemented given the need to find and procure appropriate restoration sites, and develop a crediting model to ensure projects could achieve desired benefits. The California EcoRestore program has been steadily implementing this RPA action and is beginning to move projects towards completion. This action is being analyzed at a programmatic level, with additional consultation necessary for individual projects. This action will provide the benefits that were indented to be achieved in the 2008 BiOp.

Predator Hotspot Removal

Available conceptual models suggest that predation on delta smelt is related to macroscopic drivers like water temperature (Nobriga *et al*. 2013), water turbidity (Ferrari *et al*. 2014; Schreier *et al*. 2016), and the degree of SAV infestation (Ferrari *et al*. 2014; IEP 2015). Under this model, predation losses of delta smelt are not likely to be greatly changed by removing predator hot spots as described in the PA because there will still be expansive beds of SAV, clearer waterways, and stressful summer water temperatures that affect how delta smelt can use available habitat. Widespread SAV in the south Delta stills the movement of water, which in turn decreases turbid–water cover for delta smelt, while providing ambush habitats for species like largemouth bass (Ferrari *et al*. 2014). Predator hot spot removal under the PA is primarily focused on providing positive effects to juvenile salmonids. The PA did not provide details about when, where, and how predator hotspot removal will be implemented. This project element is programmatic and will be addressed under future consultation when Reclamation identifies specific actions to be taken to reduce predator hot spots. Actions may include removal of structures and minimization of lighting near fish screens, bridges, and other infrastructure where predators congregate. While not expected to negatively impact delta smelt habitat, predator hot spot removal is not expected to have an appreciable positive effect on delta smelt of any life stage. The hot spots identified in Grossman *et al.* 2016 are mostly located in the south Delta, where the macroscopic conditions mentioned above contribute to high rates of pre-screen loss. The scale of implementation for this project element would likely make little difference on predation rates of delta smelt and effects are expected to be minimal. Subsequent consultation will address effects at the site-specific level.

Food Enhancement Actions

Reclamation proposes to pursue a series of food enhancement actions that may lead to overall increases in prey availability for delta smelt. These are intended to address the concept that limited food supply is negatively impacting delta smelt population numbers, which has been a common finding in quantitative studies of delta smelt population dynamics (Mac Nally *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Rose *et al.* 2013b; Hamilton and Murphy 2018; Kimmerer and Rose 2018). While there are no details on timing or frequency, an increase in food supply may be able to benefit rearing juvenile delta smelt and sub-adult delta smelt. Based on the locations of these projects, the influx of food would occur in desirable locations where delta smelt are typically found. Any actions to benefit the food web may also benefit competitors and predators of delta smelt. The magnitude of benefits cannot be estimated at this time without additional details. Since these activities are being addressed programmatically in this consultation, further detail about adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

Suisun Marsh and Roaring River Distribution System Food Subsidies Study

Infrastructure in the RRDS will drain water potentially containing zooplankton from the canal into Grizzly Bay to augment delta smelt food supplies in that area. In addition, managed wetland flood and drain operations can potentially promote food export from the managed wetlands to adjacent tidal sloughs and bays where delta smelt may be able to access it.

Sacramento Deepwater Ship Channel Study

Reclamation proposes to reconnect the Deepwater Ship Channel to the Sacramento River. The reconnected Sacramento Deepwater Ship Channel has the potential to transport nutrients and zooplankton from the Sacramento River and Ship Channel into the north Delta. An increase in food supply has the potential to benefit delta smelt and their habitat in the Cache Slough complex. There is also the potential that experimental changes to the water volume and velocity down the Ship Channel would alter existing flow conditions and prey availability, conditions which are believed to already be favorable to delta smelt. The question of whether conditions in the Ship Channel can be improved are the topics of an in-progress study of phyto- and zooplankton production in the Ship Channel.

North Delta Food Subsidies/Colusa Basin Drain Study

DWR, Reclamation, and water users propose to increase food in the north Delta by routing nutrient-rich water from the Colusa Basin into the Yolo Bypass and north Delta where it can stimulate phytoplankton blooms (Frantzich *et al*. 2018) that in turn can stimulate zooplankton blooms. The additional inflow also helps disperse the blooms into the north Delta. DWR, Reclamation, and water users would work with partners to route agricultural drain water (i.e., nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut into the Tule Canal (Yolo Bypass Toe Drain) and from there it would flow into to Cache Slough, potentially supplementing the aquatic food web in the north

Delta for fish species. Reclamation would work with DWR and partners to use this mechanism to augment flow in the Yolo Bypass in July and/or September.

Sediment Supplementation Feasibility Study

The role of turbid water in improving delta smelt's ability to find prey and evade predators was discussed in section 5.1.2, *Status of Critical Habitat Within the Action Area*. Several factors have reduced the inflow of sediment into the estuary, which has lowered habitat suitability for delta smelt. Reclamation proposes to conduct a sediment supplementation feasibility study to determine whether there are actions they and DWR can take that would increase the turbidity of water in the Delta. There may be significant logistic and legal hurdles to implementing major sediment supplementation efforts, but a careful evaluation of this topic is warranted. This action proposes to conduct a study and therefore will not result in take of delta smelt.

5.3 Effects to Delta Smelt Critical Habitat from the Proposed Action

5.3.1 Background

The Service's 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. The intended conservation value of delta smelt critical habitat is to consistently provide all of the needed habitat attributes corresponding to where delta smelt reside during their life cycle. These habitat attributes often operate synergistically; that is, they need to overlap in order to provide suitable habitat for delta smelt to survive and successfully reproduce. In addition, the area of overlapping habitat attributes must be of a sufficient quantity and quality to support the population.

As described in the Environmental Baseline section, critical habitat is currently not serving its intended conservation role and function for all life stages. The Service's review indicates it is rearing habitat that remains most impacted by ecological changes in the estuary, both before and since the delta smelt's listing under the Act. Those changes have stemmed from chronic low outflow, changes in the seasonal timing of Delta inflow, lower flow variability, species invasions and associated changes in how the upper estuary food web functions, declining prey availability, high water temperatures, declining water turbidity, and localized contaminant exposure and accumulation by delta smelt.

The following are the delta smelt critical habitat Primary Constituent Elements (PCEs) as defined in the critical habitat rule (Service 1994):

Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat. As reviewed in the *Status of Critical Habitat Within the Action Area*, physical habitat in the Bay-Delta has been substantially changed with many of the changes having occurred decades ago (Andrews *et al.* 2017; Gross *et al.* 2018). Important physical habitat attributes include substrate, water depth variation and channel morphology for spawning adults, and potentially foraging habitat for rearing juveniles along marsh edges (Bever *et al.* 2016; Hammock *et al.* 2019a). Information on spawning habitat is incomplete. Eggs of delta smelt are demersal and adhesive and therefore could be attached to any number of substrates. It is difficult to protect spawning habitat without knowing what it is.

Primary Constituent Element 2: "Water" is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable habitat for delta smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat (Hammock *et al.* 2015).

Primary Constituent Element 3: "River flow" was originally believed to be critical as transport flow to facilitate an extended spawning migration by adult fish and the transport of offspring to low-salinity rearing habitats (Service 1994). However, it has since been shown that although some individual fish may embark on what could be considered a short spawning migration, there is no population-scale spawning migration *per se*, and most transport and retention mechanisms for delta smelt (and their prey) involve the selective use of tidal currents rather than net flows (Kimmerer *et al.* 1998; 2002; Bennett *et al.* 2002; Kimmerer *et al.* 2014a; Bennett and Burau 2015). River flow includes both inflow to and outflow from the Delta, both of which influence the net movements of water through the Delta and further into the estuary (Kimmerer and Nobriga 2008). As mentioned above, these variations in freshwater flow affect the spatial distribution of salinity including X2, which in turn exert some influence on the distribution of delta smelt (Sweetnam 1999; Dege and Brown 2004; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Sommer *et al.* 2011; Manly *et al.* 2015; Polansky *et al.* 2018; Simonis and Merz 2019).

Primary Constituent Element 4: "Salinity" is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5–6.0 ppt (Kimmerer 2004; MacWilliams *et al.* 2015). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. The 2 ppt isohaline (X2) is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 ppt (Jassby *et al.*1995). By local convention, the location of the LSZ is described in terms of the distance from X2 to the Golden Gate Bridge; X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.*1995; Kimmerer 2002b). During the past 40 years, the monthly average of the location of X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km), but as reviewed in the *Status of Critical Habitat Within the Action Area*, this is a smaller range than under pre-development conditions (Andrews *et al.* 2017; Gross *et al.* 2018). At all times of the year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete their life cycle. In general, the abiotic elements of delta smelt habitat quality and habitat surface area are greater when the LSZ is located in Suisun Bay than when it is located in the Delta (Feyrer *et al.* 2011; 2016; Bever *et al.* 2016). The density of delta smelt's primary prey is related to X2 in the spring (Kimmerer 2002b), but not in the summer and fall (Kimmerer 2002b; Kimmerer *et al.* 2018c). One recent study reported better metrics of delta smelt feeding success for fish within the Suisun Marsh (Hammock *et al.* 2015).

Due to the interrelationship between the PCEs and the intended conservation role they serve for different delta smelt life stages, some effects are similar and overlap across the PCEs. For instance, Delta outflow determines the extent and location of the LSZ and the areas of physical habitat delta smelt are able to utilize at all times of year. Therefore, many of the effects described below for the PCEs are difficult to separate so some effects are repeated for multiple PCEs.

As discussed in the *Status of the Critical Habitat Within the Action Area*, it was originally believed that delta smelt adults needed access to spawning habitat during the adult migration period from December through July (Service 1994). The current paradigm is that maturing adults do not migrate as much as disperse in response to winter storms which bring pulses of freshwater and turbidity into the estuary (Murphy and Hamilton 2013; Polansky *et al.* 2018). Thus, although the delta smelt critical habitat rule characterizes the spawning movement as a migration, we analyze the effects of the PA on critical habitat for "dispersing" adults instead of the original conceptual model of a west to east "spawning migration" described in the rule (Service 1994).

Effects to each PCE were evaluated qualitatively and, when appropriate, using CalSim II modeling. The CalSim II model is used by Reclamation and DWR to simulate the operation of the major CVP and SWP water facilities in the Central Valley and generates monthly estimates of river flows, exports, reservoir storage, deliveries, and other parameters (PA modeling). The following PA components are encompassed in the analysis below as part of water operations and are represented in the hydrologic modeling. No additional effects are anticipated from: minimum export rate, DCC operations, agricultural barriers, Contra Costa Water District (Rock Slough) diversions, North Bay Aqueduct diversions, and Water Transfers. Additionally, the Service qualitatively evaluated the effects of operational and non-operational components of the PA to delta smelt critical habitat which were not included in the modeling (e.g., the Summer-Fall Habitat Action and food web enhancement actions). Table 5-8 summarizes where the effects to critical habitat from the PA are expected to occur for each PCE.

5.3.2 Effects to Critical Habitat for All Life Stages of Delta Smelt to PCE 2-Water

According to the BA, with respect to PCE 2-Water, relative to the without action scenario, reduced winter-spring inflow to the Delta under the PA may 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 to the suitability of rearing habitats. The BA also indicates that the PA will cause small changes in several components of water quality (PCE 2) needed to support delta smelt in all life stages, but such changes will have small to negligible effects compared to the COS, either for the component alone, or in combination with actions proposed as part of the PA.

- *Sediment load*: Turbidity produced by sediment suspended from the erodible sediment pool in the estuary from wind, river flow and tidal forces can contribute to cover for delta smelt needed to avoid predators and to facilitate successful feeding and predator avoidance by the larvae (Ferrari *et al.* 2014; Baskerville-Bridges *et al.* 2004; Hasenbein *et al.* 2016a; Schreier *et al*. 2016; Sullivan *et al.* 2016). While suspended phytoplankton can also contribute to turbidity, the estuarine turbidity maximum can be influenced by the available sediment pool which is hypothesized to be depleted following increases due to hydrologic mining in the mid 1850's to 1880's and lax regulation on sediment input during post-war urbanization in the 1940's to 1970's (Schoellhamer 2011). Currently, available science does not permit us to extrapolate turbidity concentrations from sediment load.

  The majority of suspended sediment entering the estuary comes from the Sacramento River and Yolo Bypass during high flows with a smaller proportion coming from the San Joaquin River at Vernalis and the Eastside tributaries. Previous studies have estimated that about 2% of the sediment discharge at Freeport was exported via the SWP (Schoellhamer *et al.* 2012) (Figure 5-37). According to the PA modeling, total exports (including SWP, CVP, CCWD and NBA facilities) would increase by an annual average of 12.5% (592.4 TAF) relative to the COS with increases in exports occurring in all months except December and July. Comparison between the PA and COS shows small differences in exports during the months of January through March when precipitation-associated sediment loading would be the greatest. The highest increase in Delta exports occurs during April and May. OMR Management actions will work to prevent the draw of sediment-laden Sacramento River water into the central Delta thus minimizing the volume of sediment export. Based on our understanding of sediment transport timing and sources in the estuary, any changes resulting from the PA are expected to be negligible.

- *Food availability:* Primary production in the estuary varies annually due to several factors including consumption by the invasive overbite clam, a long-term decline in total suspended solids, nutrient inputs, and river flow (Jassby *et al.* 2002; Glibert *et al*. 2015). Water exports directly entrain phytoplankton and zooplankton (Arthur *et al.* 1996; Jassby and Cloern 2000). No estimates of food web loss to entrainment were provided in the BA. The PA proposes a 12.5% annual average increase in exports into the CVP and SWP as compared to the COS. Exports were modeled to increase in all months except December and July. Conceptually, we would expect a greater loss of food web organisms resulting from an increase in exports (Jassby and Cloern 2000) relative to the COS. However, modeling by Kimmerer *et al.* (2018b) suggests that exports do not affect the subsidy of the copepod, *P. forbesi*, to the LSZ in summer and fall during juvenile rearing. Thus, although zooplankton productivity might be higher if there were no exports, we do not expect that the rate that *P. forbesi* is exchanged between freshwater and the LSZ will be affected.

The PA includes several actions including habitat restoration, water management, and food enhancement actions which may provide information for food web management and/or augment delta smelt's food supply.

  - *Habitat Restoration:* Reclamation and DWR have proposed to complete construction of the remainder of the 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh by 2030 to increase estuary productivity including availability of delta smelt prey. Tidal restoration projects will be sited and designed to increase available food web production for delta smelt. Tidal marshes may act as nitrogen sources or sinks (Yang and Best 2015; Yang et al. 2015; Jasper *et al.* 2014; Lehman *et al.* 2010). Tidal habitat restoration of this magnitude, once complete, would be expected to improve the availability of food for delta smelt for all life stages. However, the magnitude of the effect of this component of the PA is unknown at this time. Reclamation and DWR commit to funding and ensuring that monitoring, operation, maintenance, and permanent protection occur on these restored lands. The monitoring program will evaluate the effectiveness of the restoration actions. DWR has established the Fish Restoration Program (FRP), a coordinated effort between DWR and CDFW, which focuses on the planning, design, and permitting of individual restoration projects. In addition, the FAST, which includes Reclamation, CDFW, NMFS, and the Service, coordinates on the design and crediting of proposed restoration projects to ensure they meet the objective stated above. The momentum that has been created in recent years to implement tidal marsh restoration is expected to continue in the coming years in order to complete the remaining restoration acreage. Since this activity is being addressed programmatically in this consultation, further detail about effects including benefits to delta smelt critical habitat will be addressed in subsequent consultation prior to implementation.

- *Delta Smelt Summer-Fall Habitat:* Reclamation and DWR have proposed a suite of operational and food web stimulation actions as a Summer-Fall Habitat Action (Table 5-7). The purpose of the Summer-Fall Habitat Action is to increase the overlap of delta smelt habitat attributes in two places that tend to be turbid and have somewhat elevated or manageable prey concentrations (Suisun Marsh and the Cache Slough Complex). The net direction and magnitude of the effect of this element of the PA is unknown at this time. If effective, the Summer-Fall Habitat Action will improve a suite of rearing habitat attributes for juvenile delta smelt from June through October in and adjacent to Suisun Marsh and the Cache Slough Complex.

  Overall, the scientific basis of the Summer-Fall Habitat Action is sound. Delta smelt are hypothesized to experience food limitation in summer and fall (Bennett and Moyle 1996) and summer-to-fall survival has been associated with zooplankton biomass (Kimmerer 2008). Kimmerer (2008) suggested that delta smelt management should include improved habitat or food supply. Reclamation and DWR may also operate the Roaring River Distribution System (RRDS) to distribute zooplankton by routing fresh water through the Distribution System where zooplankton can grow in the shallow wetlands and then move the water back into Montezuma Slough and Grizzly Bay where delta smelt can access it if updated science demonstrates benefits. The combined use of X2 management, SMSCG operation and RRDS water distribution would, in June through October, direct Sacramento River water and its accompanying food web into Montezuma Slough and its tributaries and direct organic carbon from the Marsh into Grizzly and Honker Bays. The PA posits that these actions will make more food available for rearing juvenile delta smelt in Suisun Marsh in 3 of 5 water year types (Below Normal, Above Normal, Wet).

- *Sacramento Deepwater Ship Channel Food Study:* The PA includes a partnership 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. The PA posits that the reconnected ship channel has the potential to transport phyto- and zooplankton growing in the channel into the north Delta to improve food availability in the Liberty Island/Cache Slough region. There is also the potential for transport of agriculture-associated contaminants (e.g. rice herbicides and fungicides) in Sacramento River water into the Ship Channel. Thus, the net direction and magnitude of the effect of this element of the PA is unknown at this time. All life stages of delta smelt are present at this location. The Service anticipates that changes in water quality parameters like turbidity will be monitored as part of the study. Since this activity is being addressed programmatically in this consultation, further detail about effects including benefits to delta smelt critical habitat will be addressed in subsequent consultation prior to implementation.

- *North Delta Food Subsidies/Colusa Basin Drain Study:* DWR, Reclamation, and water users have proposed to locally stimulate a planktonic food web in the north Delta by routing nutrient-rich water from the Colusa Basin Drain into the Yolo Bypass and north Delta (Frantzich *et al.* 2018) if updated science demonstrates benefits. They propose to move agricultural drain water (i.e., water high in nutrients and perhaps phytoplankton) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Yolo Bypass Tule Canal/Toe Drain into Cache Slough where the BA posits it will stimulate a local zooplankton bloom. Reclamation has proposed to 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 stimulate phyto- and zooplankton production. There is also the potential for the concomitant distribution of contaminants along with the agricultural drainage water. All life stages of delta smelt may be present at this location, but the net direction and magnitude of the effect of this element of the PA is unknown at this time since the ability of the action to produce the intended phytoplankton bloom has thus far been mixed and the hypothesized zooplankton response has not yet been shown conclusively. Since this activity is being addressed programmatically in this consultation, further detail about effects including benefits to delta smelt critical habitat will be addressed in subsequent consultation prior to implementation.

- *Suisun Marsh and Roaring River Distribution System Food Subsidies Study:* DWR and Reclamation and water users have proposed to study and potentially manage to add nutrients, phytoplankton and invertebrates to Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, RRDS food production, and reoperation of the Suisun Marsh Salinity Control Gates if updated science demonstrates benefits. The RRDS was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of CDFW-managed wetlands in Suisun Marsh. Because the RRDS intake is screened, adult delta smelt do not have access to the wetlands within the RRDS. However, the BA posits that this management action may attract delta smelt in greater numbers into adjacent parts of the marsh, specifically to the edge habitats where RRDS return flows are delivered. Reclamation believes this action can increase food availability for delta smelt occurring in Suisun Marsh and Bay. Discharges of water with high particulate and dissolved organic carbon may also contribute to depleted oxygen levels in the Marsh and Bay margins when water temperatures are high. Since this activity is being addressed programmatically in this consultation, further detail about effects including benefits to delta smelt critical habitat will be addressed in subsequent consultation prior to implementation.

The PA will cause small changes in several components of water quality (PCE 2) needed to support delta smelt in all life stages, but such changes will have small to negligible effects compared to the COS, either for the component alone, or in combination with actions proposed as part of the PA. The benefits to water quality of habitat restoration, implementation of the Summer-Fall Habitat Action, and the food enhancement actions may help provide the needed habitat attributes in appropriate areas where delta smelt reside, particularly for rearing juvenile delta smelt. These benefits will depend on how and when these actions are implemented, and if other necessary habitat attributes are also present and of sufficient quality to support completion of the life cycle. Effects of the programmatic components (habitat restoration and food enhancement actions), including how these components contribute to water quality, will be addressed in more detail in subsequent consultation on these components.

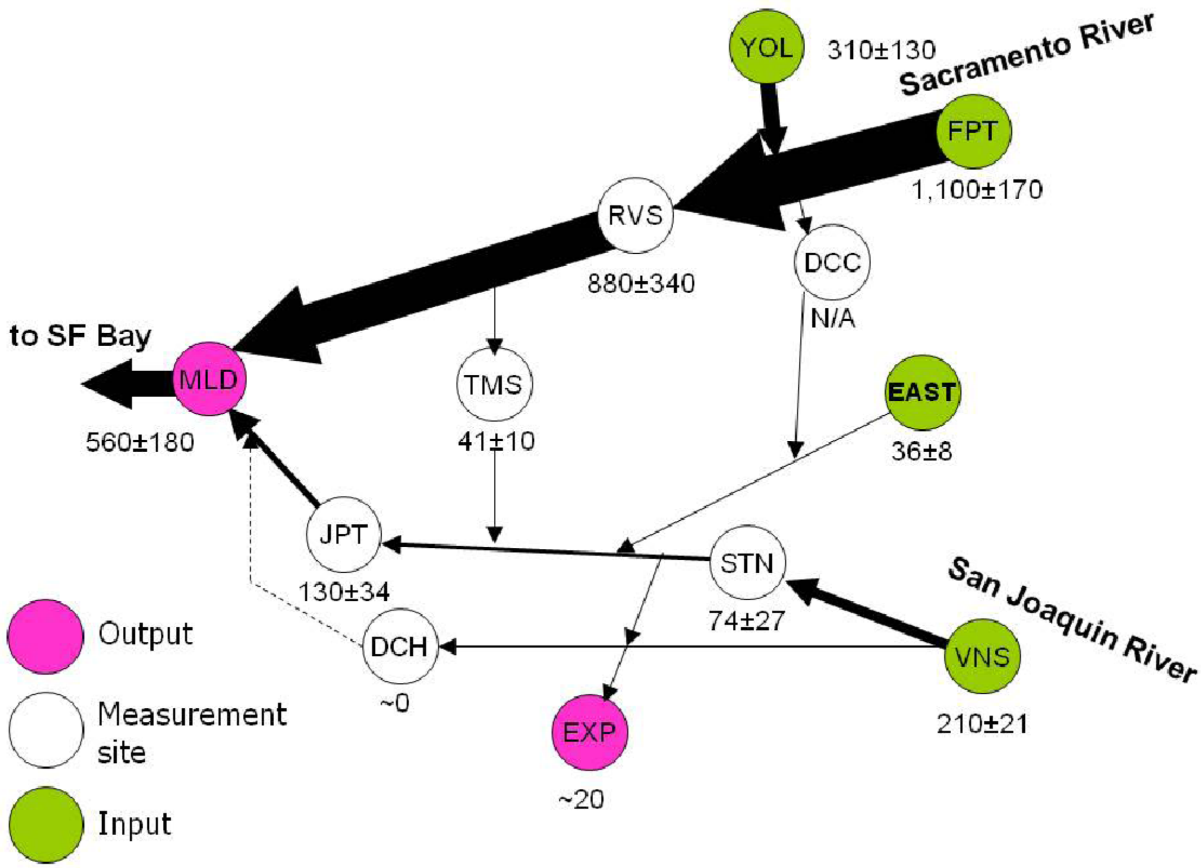


Figure 5-37. Average annual Delta sediment budget based on water years 1999–2002, except for Threemile Slough (TMS), which is based on water years 2001 and 2002 only. Numbers are the annual suspended-sediment flux and the estimated error in thousand metric tons. Arrow thickness indicates relative magnitude of the suspended-sediment flux. Sediment deposition accounts for the decreased sediment fluxes from east to west. Additional sites are Sacramento River at Freeport (FPT), Yolo Bypass (YOL), Delta Cross Channel (DCC), Sacramento River at Rio Vista (RVS), Mallard Island (MAL), Eastside tributaries (EAST), San Joaquin River at Vernalis (VNS), San Joaquin River at Stockton (STN), exports from the State and Federal water projects (EXP), Dutch Slough (DCH), and San Joaquin River at Jersey Point (JPT). Source: Wright and Schoellhamer 2004.

Table 5-8. Summary of effects of the PA on critical habitat by life stage as compared to the COS.

Life stage	*PCE 1: Physical habitat*	*PCE 2: Water [quality]*	*PCE 3: River flow*	*PCE 4: Salinity [LSZ]*
Dispersing adults ***(Dec-March)***	Not Applicable	Negligible loss of sediment due to exports. Small contributions to prey production from restoration in unknown locations in the Delta and Suisun Marsh.	Modeled PA OMR flows are more negative than COS. OMR management (Table 2-1) is expected to result in water operations that are similarly protective of this PCE as the COS.	No change in effect
Spawning adults ***(Feb-May)***	No change in effect	Negligible loss of sediment due to exports. Small contributions to food web from restoration in unknown locations in the Delta and Suisun.	Not Applicable	No change in effect
Dispersing larvae and juveniles ***(March-June)***	Not Applicable	Negligible loss of sediment due to exports. Small contributions to food web from restoration in unknown locations in the Delta and Suisun.	Modeled PA OMR flows are more negative than COS. OMR management (Table 2-1) is expected to result in water operations that are similarly protective of this PCE as the COS.	No change in effect.
Rearing larvae and juveniles ***(July-Dec)***	No change in water depth. Potential increase in marsh foraging from restoration and food enhancement in Suisun Marsh, Grizzly and Honker Bays.	Negligible loss of sediment due to exports. Small contributions to food web from restoration and potentially food web enhancement action in unknown locations in the Delta and Suisun.	The PA will lower river flow in some months and water years types. The lower river flow may contribute to lower habitat suitability of western parts of critical habitat by increasing the fraction of time in which the LSZ primarily encompasses deep channelized habitats. The Summer-Fall Habitat Action will seasonally improve conditions in Above Normal and Below Normal water years relative to the COS.	The PA will increase salinity in some months and water years types. The higher salinity will at times contribute to lower habitat suitability of western parts of critical habitat by increasing the fraction of time in which the LSZ primarily encompasses deep channelized habitats. The Summer-Fall Habitat Action will seasonally improve salinity conditions in Above Normal and Below Normal water years relative to the COS.

5.3.3 Effects to Delta Smelt Critical Habitat by Life Stage

Habitat conditions supporting larval and juvenile transport

PCE 3 – River Flow

The operation of the CVP and SWP involves the storage, release and diversion of freshwater. Stored water is delivered to the Delta where some of it is exported, often along with runoff from other sources. These actions directly influence river flows in the Delta and Suisun Bay, which in turn affects aspects of habitat quality within the critical habitat boundaries (Service 1994; Bever *et al.* 2016). The PA provides a quantitatively modeled base condition and qualitative descriptions of real-time and seasonal management strategies that will be used to modify the modeled base condition to various degrees. The PA is expected to result in changes to river flows and net flows into and out of the Delta as compared to the COS (ROC BA 2019), which will in turn affect PCE 3.

It was once thought that delta smelt needed to be transported from "upstream" spawning habitats to "downstream" rearing habitats from December through July (Service 1994). Now we recognize most of the larval transport occurs from March through June. Delta smelt can likely begin feeding where they are hatched, and often rear close to where they are believed to have hatched. It is also recognized that larval fishes, including delta smelt, use swimming behavior changes timed to the tidal cycle and local bathymetry to maintain themselves in low-salinity habitats that often have large seaward net flows (Bennett *et al.* 2002). The primary remaining mechanism related to a transport flow for larvae and juveniles that is thought to be both pertinent to the critical habitat function, and under substantial CVP and SWP control, is the varying magnitudes of flood and ebb tidal flows in Old and Middle rivers that are indexed by OMR. The more negative the OMR flow, the greater the flood tide volume and velocity toward the south Delta pumping plants are relative to the ebb tide, and the more Sacramento River water back-fills for the diverted San Joaquin/south Delta water. This tidal asymmetry indexed by OMR can be associated with net southward transport of larval delta smelt into unsuitable habitat and ultimately into water diversions where they may be salvaged and have an extremely low likelihood of survival (Kimmerer 2008; 2011).

The CalSim II modeling in support of the PA caps OMR flow at -5,000 cfs (14-day running moving average) during March-May. However, the modeling predicts that OMR flow would typically be a little less negative than -5,000 cfs most of the time. Although the CalSim II modeling indicates that the projects are not anticipated to operate in a way that causes monthly mean OMR flow to reach as negative as -5,000 cfs in April and May, negative OMR flows (any value) are modeled to occur more frequently in April and May relative to the COS. The frequency of negative OMR flows (any value) is modeled to be about the same in March and June as in the COS. Thus, the model results suggest that relative to the COS, the PA will have some impact on the larval transport flow. The PA includes OMR management actions to reduce entrainment of larval and juvenile delta smelt. Reclamation and DWR are proposing to use results produced by Service life cycle models with other best available scientific tools and information to determine an OMR threshold that will not negatively impact delta smelt recruitment. The Service expects that the actions in the PA will result in water operations with similar impact to the larval transport river flow PCE as those modeled in the COS.

Habitat conditions supporting rearing

<u>PCE 1-Physical habitat</u>

The PA will not result in changes to water depth beyond what results from habitat restoration. Habitat restoration will provide additional tidal wetland marsh edge which was suggested to be important foraging habitat by Hammock *et al.* 2019a. The magnitude of the effect of these activities are unknown at this time, but will be addressed in subsequent consultation. Since there will be no changes to water depth except what results from habitat restoration and habitat restoration is expected to provide additional physical habitat, the conservation value of this PCE to supporting successful completion of the life cycle of delta smelt is not likely to be diminished as a result of the PA.

<u>PCE 4 – Salinity</u>

The salinity of the estuary plays a key role in determining how delta smelt habitat attributes overlap (see 5.1.2, *Status of Critical Habitat Within the Action Area*). The LSZ expands and moves downstream when river flows are high (Jassby *et al.* 1995; Kimmerer *et al.* 2013; MacWilliams *et al.* 2015). By exporting river inflows (PCE 3), the PA can contribute to upstream movement and contraction of the LSZ (PCE 4) into the Delta shipping channels, which can in turn affect how PCE 4 interacts with the other three PCEs. Ideal rearing conditions for juvenile delta smelt occur when the location of the LSZ maximizes habitat quantity and quality by providing appropriate salinity, turbidity, water quality, temperature, and food availability. The location of the LSZ is important in determining the quality, both extent and suitability, of juvenile rearing habitat. When X2 is at 81 km or above, the upstream extent of the LSZ differs between the Sacramento and San Joaquin rivers. However, the portion of the LSZ that extends up the San Joaquin River in summer and fall is poor quality due to SAV, high water clarity and elevated temperature, thus the Service uses X2 on the Sacramento River (Hutton *et al.* 2015) as the habitat indicator. When X2 is located at or above 85 km, the entire LSZ is upstream of Chipps Island, east of the turbid shoals in Suisun Bay (i.e., Grizzly Bay and Honker Bay) and the more suitable habitat conditions that occur when the LSZ overlaps these embayments (Bever *et al.* 2016). Figure 5-38 shows the predicted difference in expanse and location of the LSZ under steady-state Delta outflow conditions when X2 is located at 84 km versus 85 km.

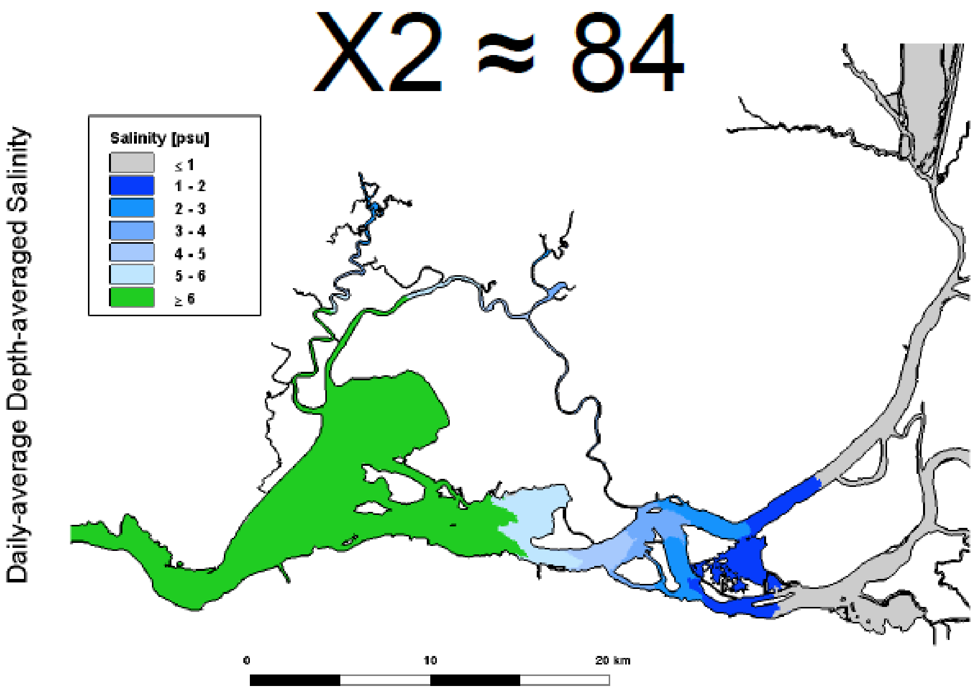
Figure 5-39 through Figure 5-45 show the difference between scenarios in kilometers over 82 years of modeling during each of the juvenile rearing months of June through December when, based on previous research, habitat suitability has declined over the past several decades and may limit the species' resilience (Feyrer *et al*. 2007; 2011; Nobriga *et al*. 2008; Bever *et al*. 2016; Castillo 2019). A positive difference indicates an X2 upstream or eastward of the location predicted by the CalSim II-modeled COS. For the summer months of June, July and August, PA conditions are similar to the COS (Figures 5-39 through 5-41). Historically, approximately half of years are classified as Wet or Above Normal. In Wet years and Above Normal years, the modeled X2 position in September and October are overestimated (more eastward) given revisions to the PA to maintain a monthly average X2 of 80 km in September and October of Wet and Above Normal years (Figure 5-42 and Figure 5-43).

The PA modeling also predicted that X2 position in Novembers and Decembers following Wet and Above Normal water years would move farther upstream than the equivalent COS X2 positions (Figure 5-44 and Figure 5-45). The PA includes water operations changes to increase the upstream storage of water during November and December to improve cold-water pool for salmonid fishes; therefore, we would anticipate X2 to be further upstream under the PA than under current operations in these months. All published papers that have evaluated fall habitat conditions for delta smelt and its potential effect on their viability have relied on four-month averages (September-December) of X2 and other habitat indices (see Feyrer *et al*. 2007; 2011; 2016; Mac Nally *et al*. 2010; Thomson *et al*. 2010; Bever *et al*. 2016; Castillo 2019). There are two reasons for this choice. The first is that the FMWT abundance index is also calculated using September-December catch data; the second is that it is not possible to evaluate delta smelt mortality or factors driving its variation one month at a time during the fall because the data are too variable (i.e., 'noisy'). It is apparent from physical modeling that a change in X2 will affect the salinity of the critical habitat in November and December (e.g., MacWilliams *et al*. 2015). However, it is not clear how much this change will affect the conservation value of the critical habitat in these late fall months as water temperatures cool and seasonal storms and windier weather often return to the Bay-Delta region which may improve the suitable habitat when X2 is located further east.

The SMSCG are used to lower the salinity within Montezuma Slough and Suisun Marsh. Under D-1641, DWR can operate the gates from October-May; the frequency of SMSCG operations is a function of outflow. When outflow is low in the fall through the spring, the gates are operated more frequently to pump fresh water into the marsh. In wetter years, operations can be limited to a few days during the driest parts of the year. Historical operation of the gates consistent with D-1641 only slightly overlaps with the proposed Delta Smelt Summer-Fall Habitat Action which includes up to an additional 60 days of gate operation during June-October. SMSCG operation moves low salinity water into Montezuma Slough which is in turn directed into Suisun Marsh via the RRDS and other intakes. The operation of the SMSCG is expected to improve salinity conditions experienced by delta smelt inhabiting Suisun Marsh and coax additional delta smelt into Montezuma Slough where turbidity and prey densities can be higher at times. Gate operation can also result in upstream movement of X2; however, the PA states that the projects will meet their D-1641 salinity requirements even if that requires additional Delta outflow to offset salinity changes at compliance points caused by SMSCG operation.

Reclamation and DWR have proposed to incorporate operations of the SMSCG for up to 60 additional days (may be non-consecutive) in Below Normal and Above Normal water year types. This action may also be implemented in Wet water year types if information suggests there are benefits of doing so. The purpose of the action is to direct more fresh water into the Suisun Marsh to create and maintain low salinity habitat there and in adjacent shoals in Grizzly Bay. The goals of the Summer-Fall Habitat Action relevant to critical habitat are to manage the overlap of low-salinity water with localized turbid areas and copepod production that may be less affected by the overbite clam (Hammock *et al.* 2017; Baumsteiger *et al.* 2017) and establish contiguous low salinity habitat from the Cache Slough Complex to the Suisun Marsh (Moyle *et* *al.* 2010; 2016). Specific actions will be informed each year by the use of structured decision making to achieve habitat goals which will try to overlap low salinity water (0 to 6 ppt at Belden's Landing from June to October), with turbid water (targeting at least 12 NTU) and highest available food supplies. The proposed management actions are described in Table 5-7.

The suite of management interventions in the Summer-Fall Habitat Action is intended to focus benefits into places like the Cache Slough Complex and Suisun Marsh where outcomes can be controlled and observed fairly carefully, and it will add actions to Below Normal water years, potentially increasing the frequency of years that the delta smelt population and critical habitat receives some helpful management intervention as compared to the COS. Altogether, the spatial extent of high suitability rearing habitat will be somewhat lower under the PA in Wet years, and somewhat higher in Above Normal and Below Normal years than what would be anticipated under the COS. This statement is largely limited to the months of September through October of Wet and Above Normal water years due to the explicit differences in operations rules between the PA and COS. The Service anticipates that the actions identified would continue to provide low-salinity habitat in Honker and Grizzly Bays and Suisun Marsh in Above Normal and Wet years and increase its frequency in Suisun Marsh in Below Normal years. Additionally food enhancement actions, described at a programmatic level at this time, may provide better feeding conditions for delta smelt in Suisun Marsh and the Cache Slough Complex. The structured decision making process called for under this action will incorporate new results each year to help refine the potential benefits that may be realized.



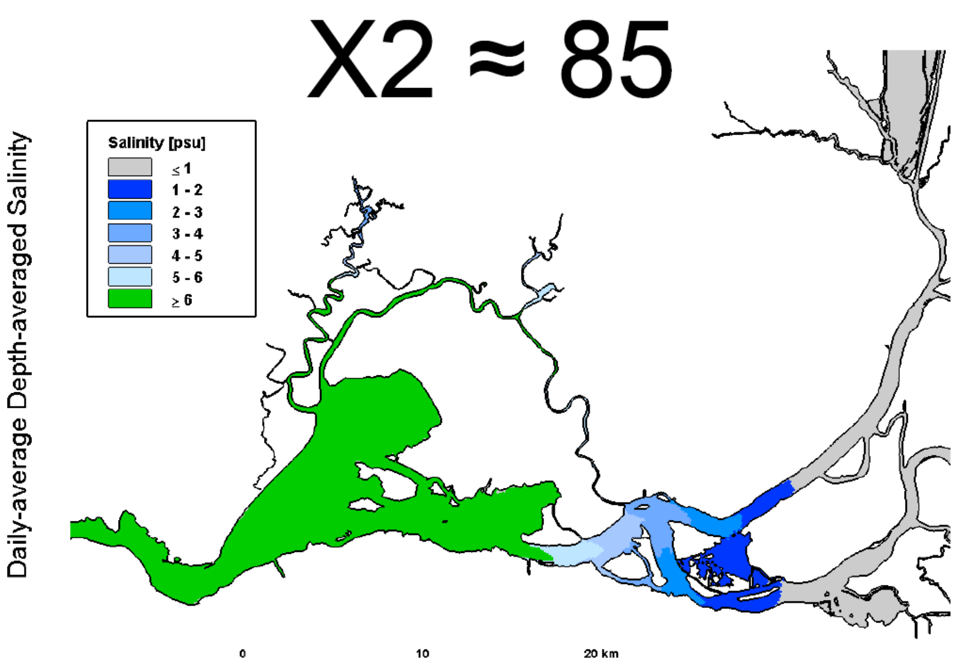


Figure 5-38. Daily-averaged depth-average salinity in psu (practical salinity units) between Carquinez Strait and the western Delta for X2 located at 84 and 85 km (Delta Modeling Associates 2012).

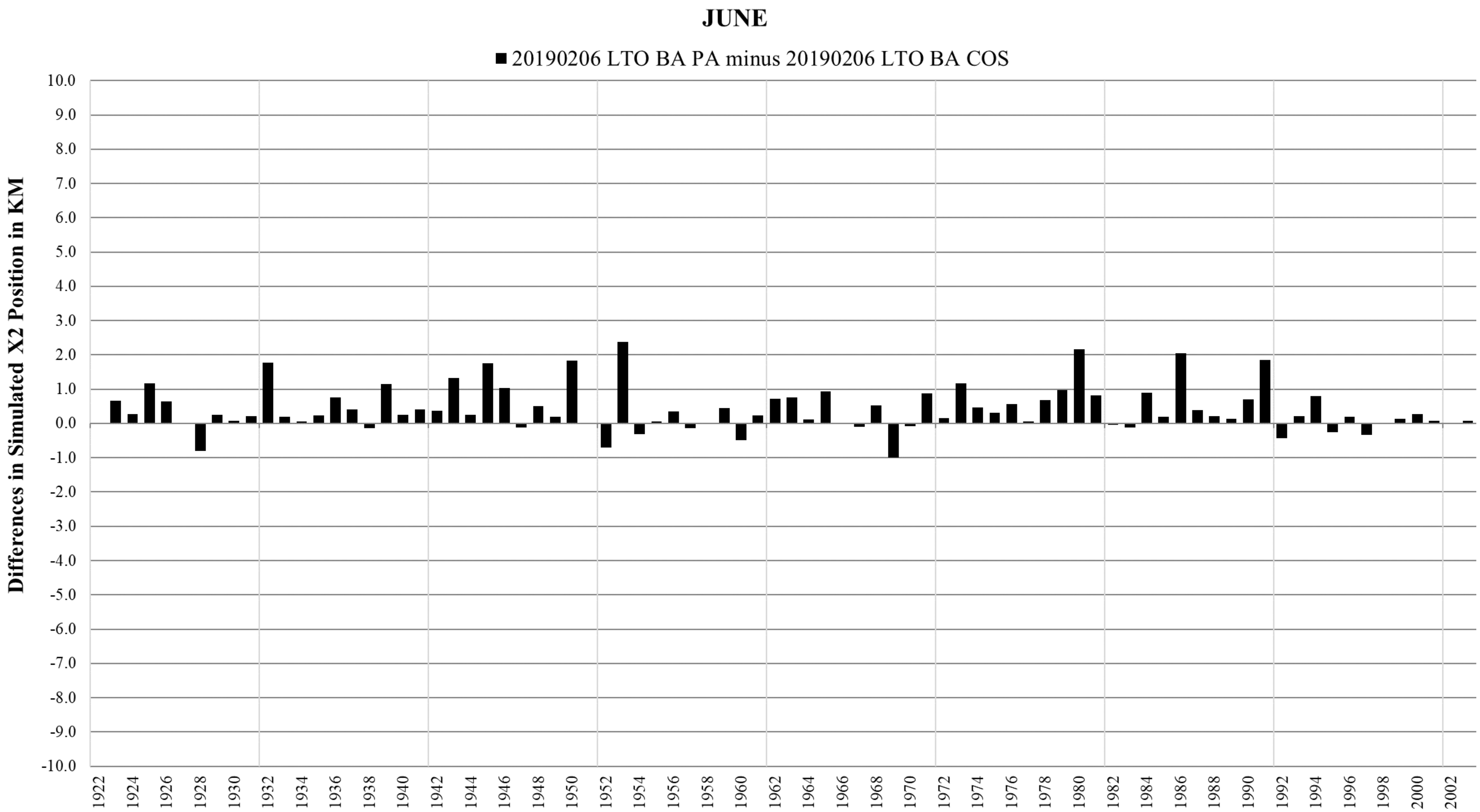


Figure 5-39. Difference in the position of X2 in kilometer between the PA and the COS for all Junes based on 82 years of CalSim II modeling.

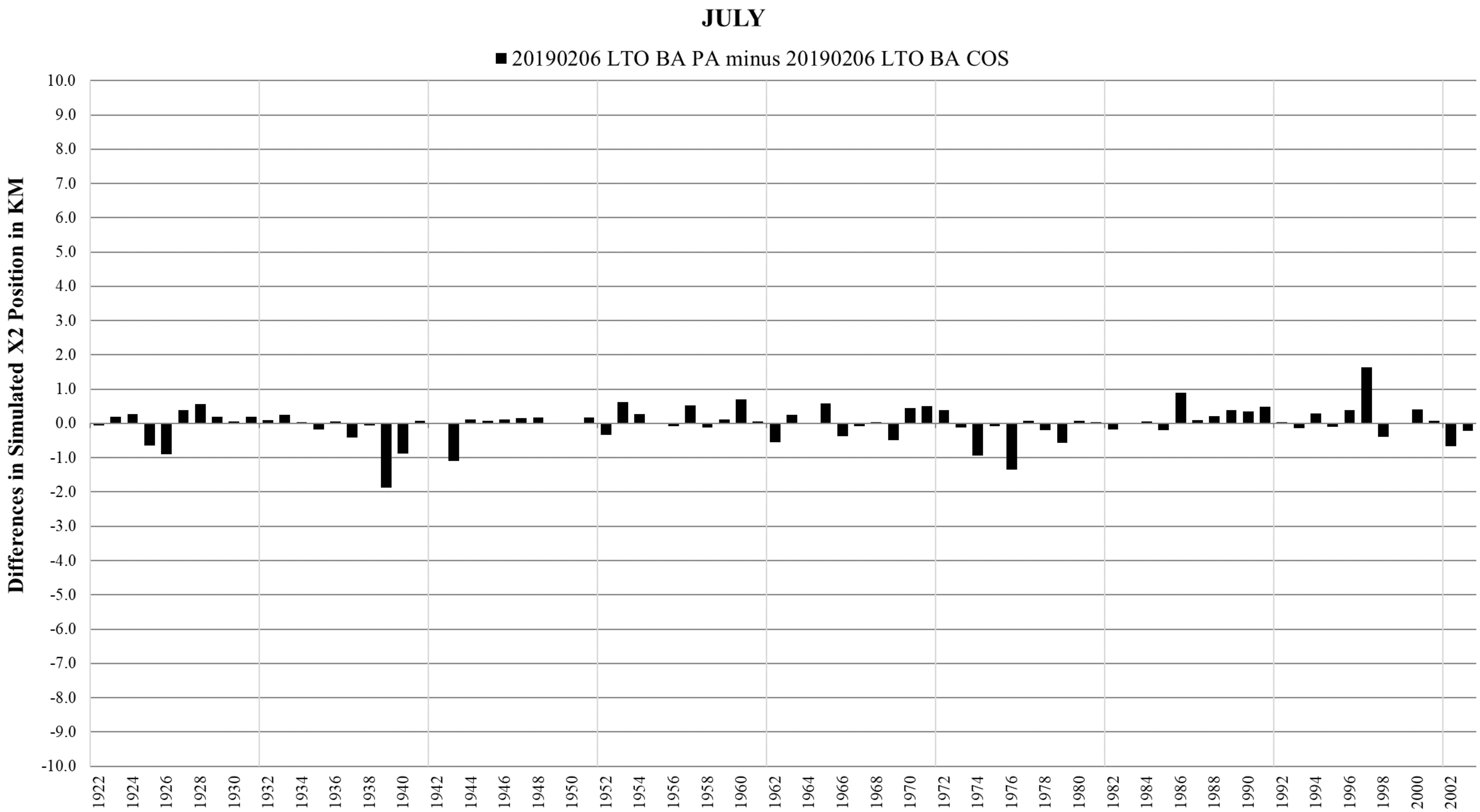


Figure 5-40. Difference in the position of X2 in kilometer between the PA and the COS for all Julys based on 82 years of CalSim II modeling.

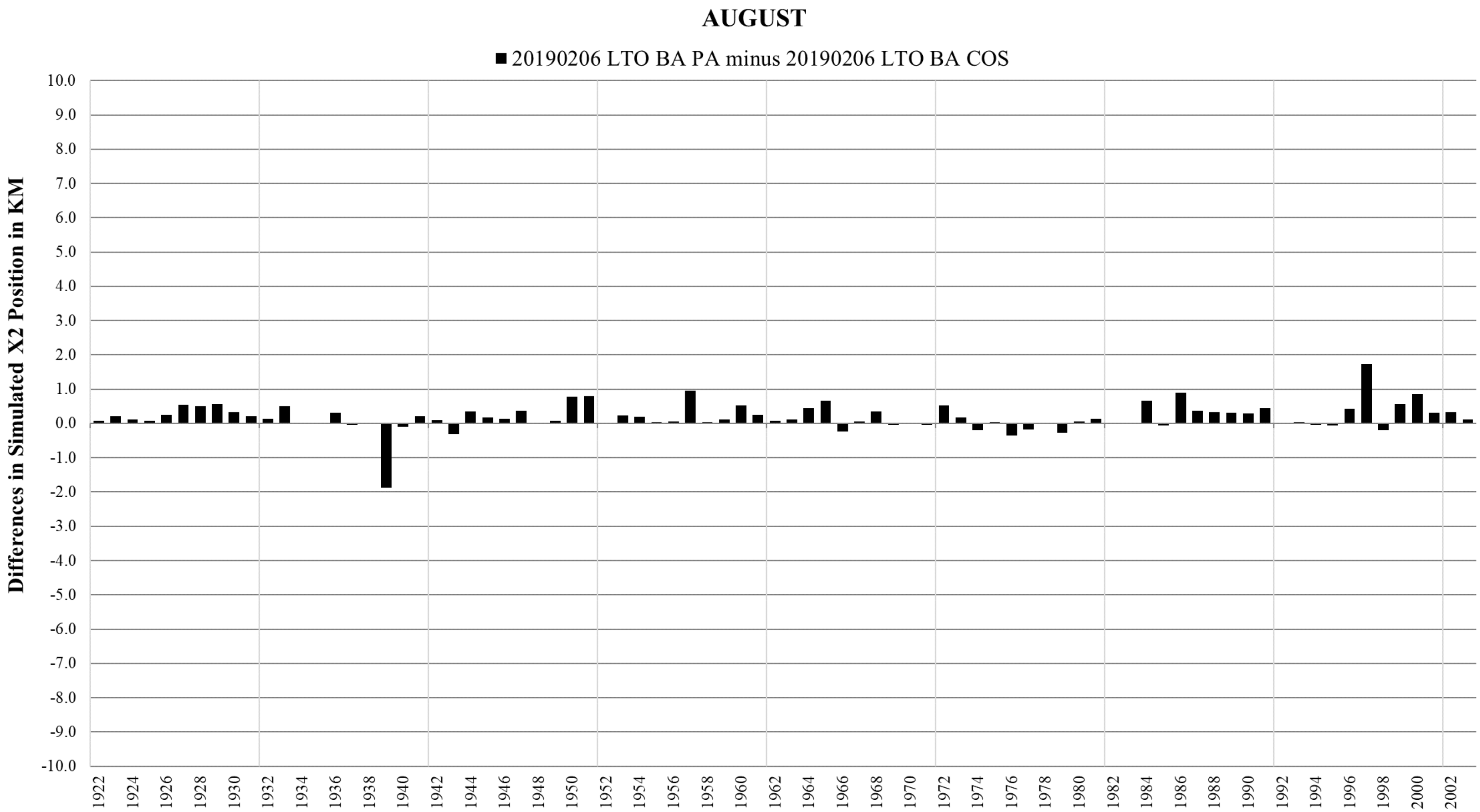


Figure 5-41. Difference in the position of X2 in kilometer between the PA and the COS for all Augusts based on 82 years of CalSim II modeling.

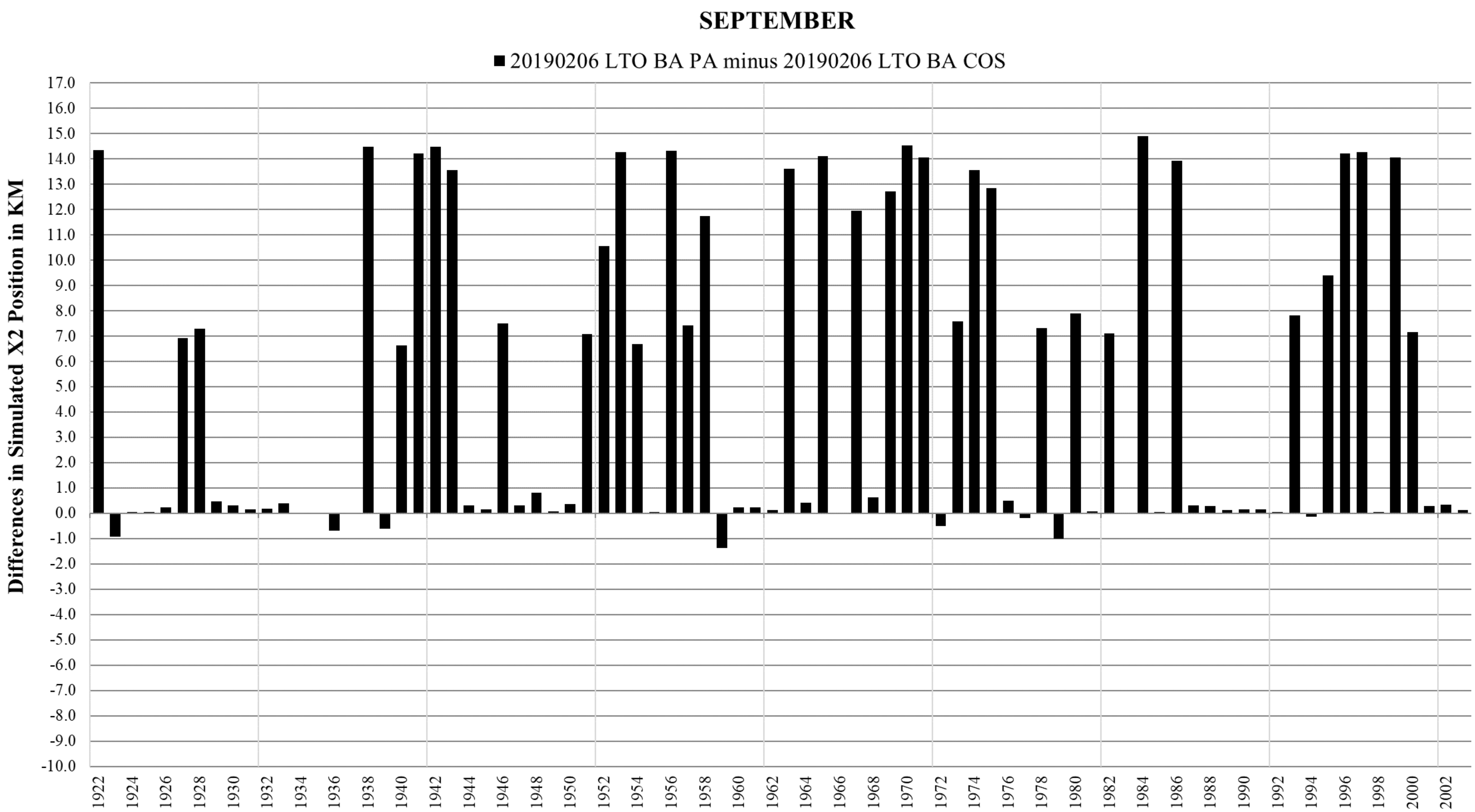


Figure 5-42. Difference in the position of X2 in kilometer between the PA and the COS for all Septembers based on 82 years of CalSim II modeling.

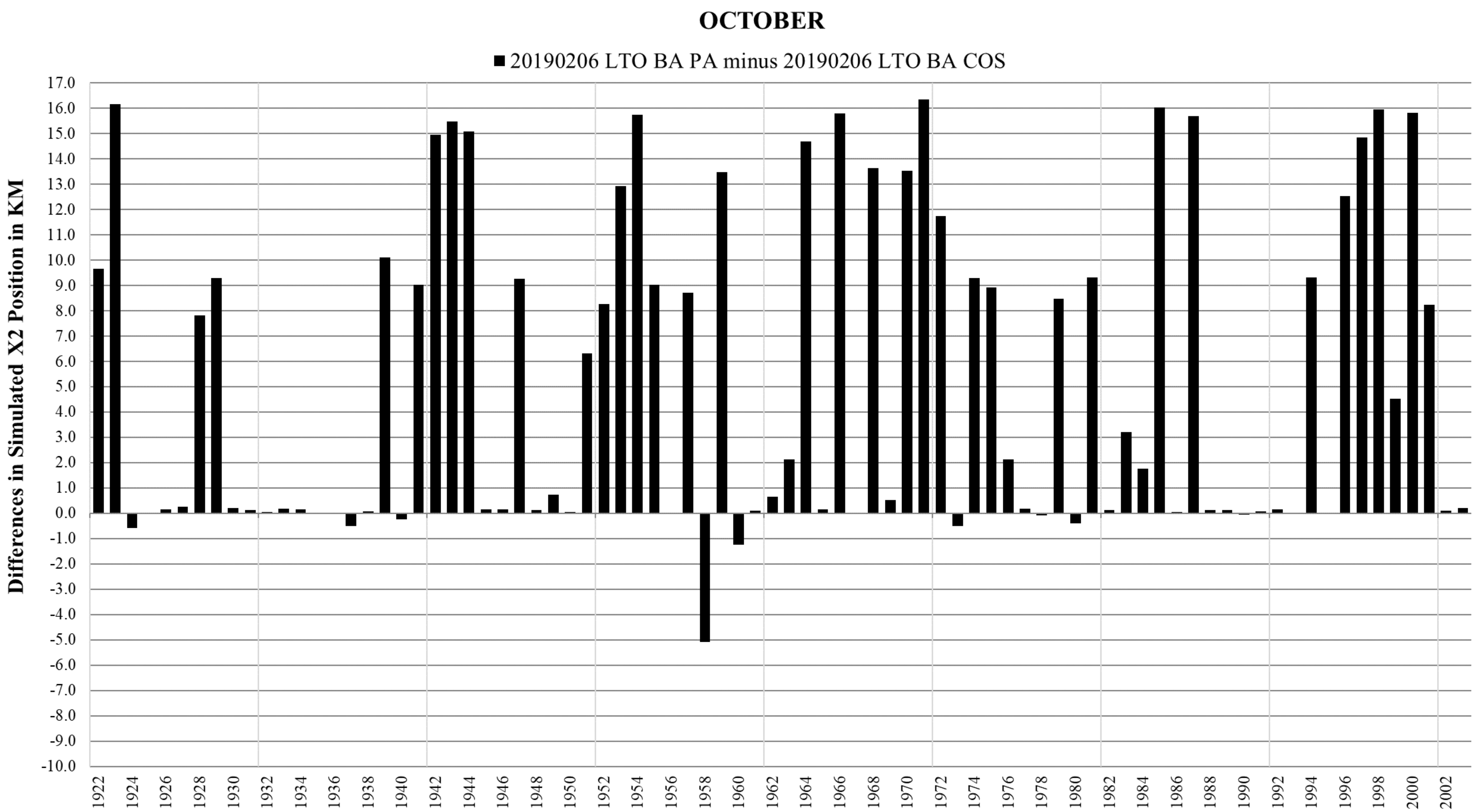


Figure 5-43 Difference in the position of X2 in kilometer between the PA and the COS for all Octobers based on 82 years of CalSim II modeling.

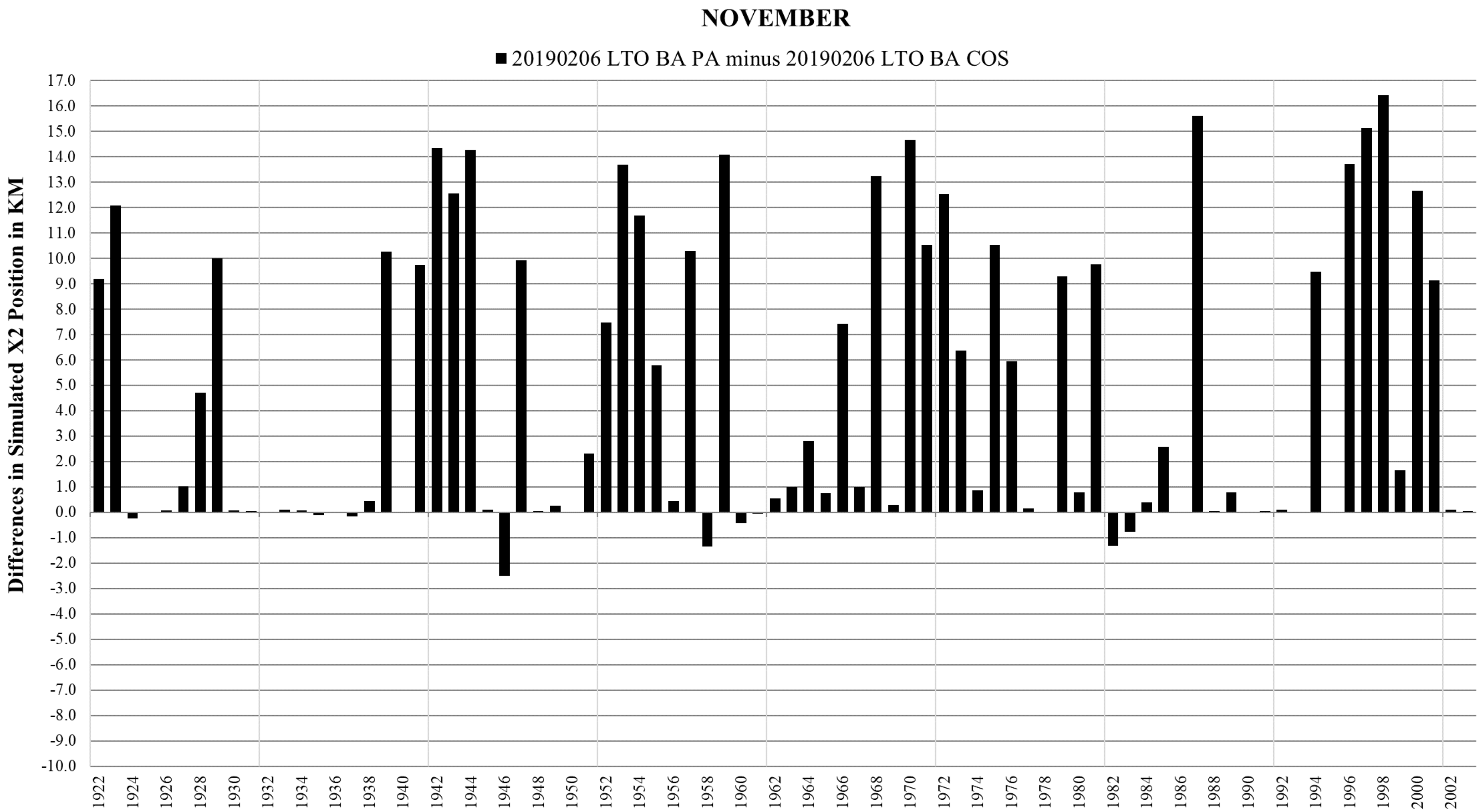


Figure 5-44. Difference in the position of X2 in kilometer between the PA and the COS for all Novembers based on 82 years of CalSim II modeling.

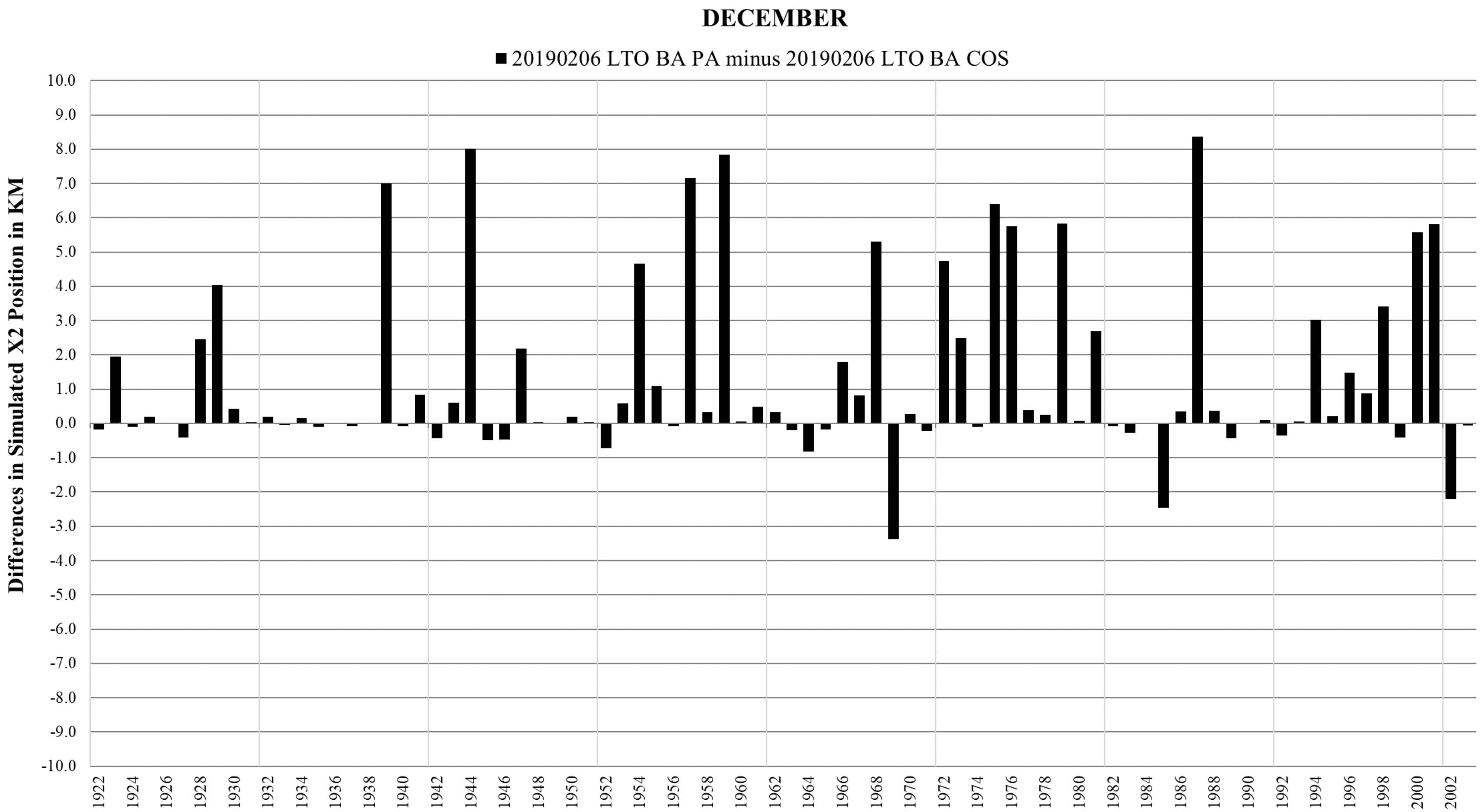


Figure 5-45. Difference in the position of X2 in kilometer between the PA and the COS for all Decembers based on 82 years of CalSim II modeling.

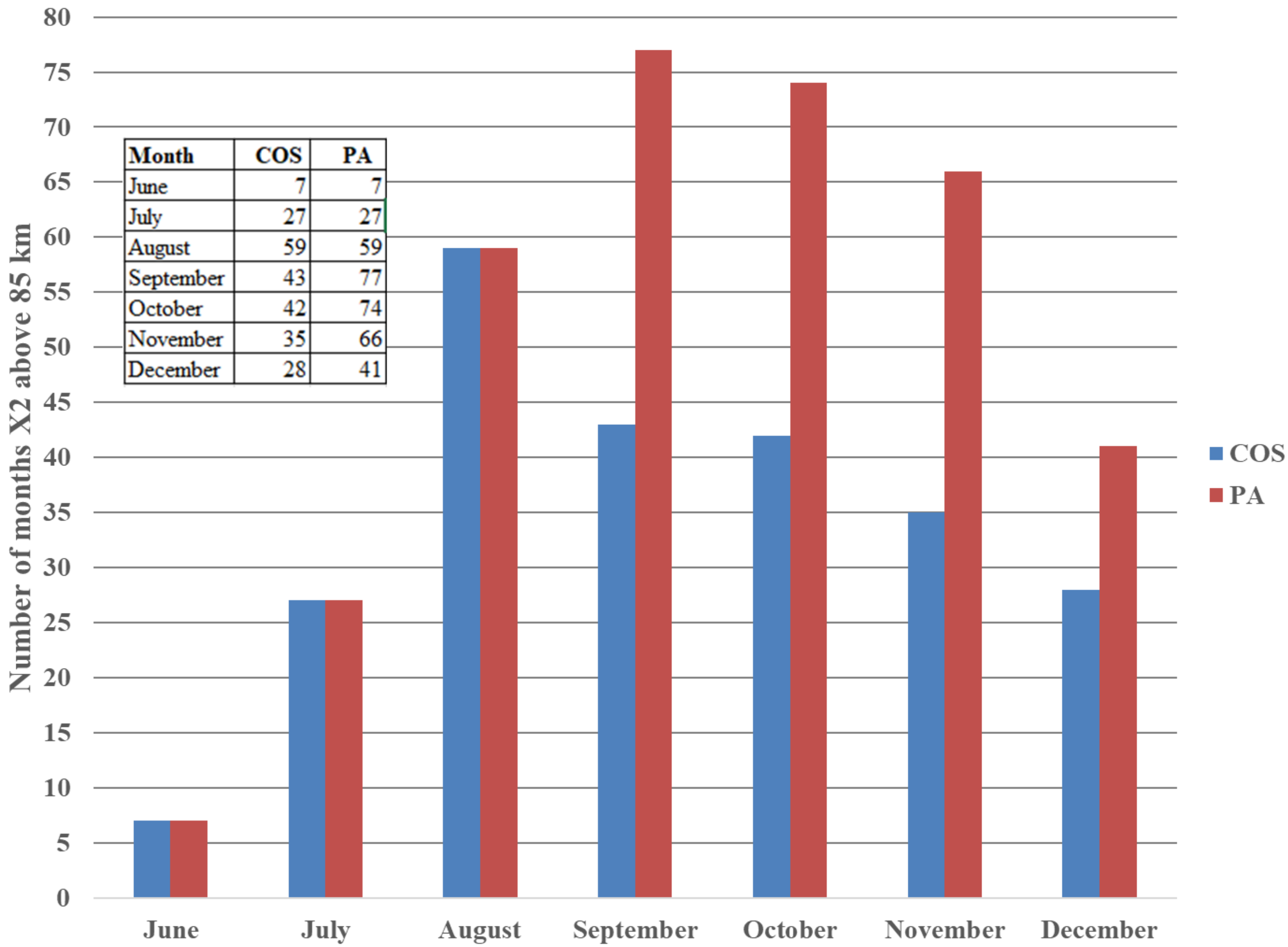


Figure 5-46. Comparison of the frequency of months (June-December) for the COS and PA that CalSim II modeling (n=82) indicates that X2 is at or above 85 km from the Golden Gate Bridge (no overlap of the LSZ with Suisun Bay).

Habitat conditions supporting adult dispersal

PCE 3 – River Flow

The adult dispersal period is defined in this biological opinion as December to March to coincide with most historical salvage of adult fish (Grimaldo *et al*. 2009). During this time, adult delta smelt need unrestricted access to suitable spawning habitat. These areas also should be protected from physical disturbance and flow disruption during adult dispersal. River flow includes inflow into the Delta and outflow from the Delta. Inflow, outflow, and OMR flow influence the vulnerability of delta smelt adults to entrainment at Banks and Jones Pumping Plants. As discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area* sections, scientific understanding of factors affecting entrainment risk suggests that turbidity (PCE 2), in addition to river flow, plays an important role in attracting dispersing adults.

Freshwater flows in combination with increasing turbidity are cues for adult delta smelt to disperse to spawning habitat in December through March (Sommer *et al.* 2011). South Delta water exports could alter critical habitat by drawing turbid Sacramento River water into the central and south Delta, encouraging the dispersal of adult delta smelt further south and east, making them and their offspring vulnerable to entrainment. In the PA, OMR flows are proposed to be slightly more negative than the COS during December through March (Figure 5-46), but only if the water is not turbid. For the south Delta, net OMR flows of -5000 cfs or more positive are expected to be protective of a high fraction of dispersing adults because Sacramento River water flowing into the mainstem of the San Joaquin River is not being rapidly drawn into Old and Middle river under those conditions bringing the turbidity with it. This would indicate that more negative OMR flow conditions in critical habitat during adult spawning are not expected to result in disruption of turbidity cues for dispersing adults or altered transport flows.

OMR Management is proposed as part of the PA and includes short-term periods during which OMR flow may be more negative than -5,000 cfs during Storm-Related Flexibility actions but also includes a real-time decision process to limit the inflow of turbid water into the south Delta and pumping facilities during December through March. These actions include Integrated Early Winter Pulse Protection and Turbidity Bridge Avoidance. These management actions are expected to prevent turbid Sacramento River water from being drawn into the central and south Delta, and will restrict net OMR flows to be -5,000 or more positive. If conditions are conducive for turbidity to be drawn into the south Delta, then OMR flows would not be more negative than -2,000 cfs. As stated above, this is expected to be protective of a high fraction of dispersing adults.

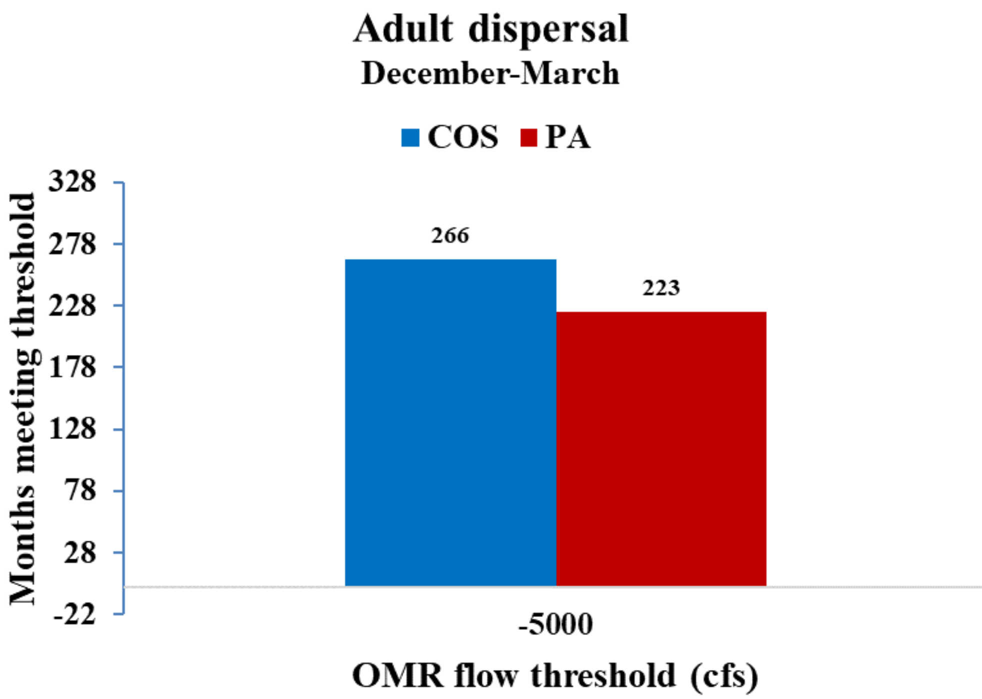


Figure 5-47. Comparison of the frequency of months that the PA and COS were modeled to meet the OMR flow threshold of -5000 cfs during the adult delta smelt dispersal period (December through March). Each month was modeled 82 times for a potential maximum frequency of 82 months times a four-month period or 328 on the y-axis. The CalSim II modeling cannot fully capture real-time operations decisions that affect OMR flow for either scenario.

5.4 Effects to Recovery

The Service issued a *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes* (Recovery Plan) in 1996 (Service 1996). The Service has used the most up-to-date, best available information to outline the recovery needs of delta smelt. Sources used to develop the needs include, but are not limited to:

- the March 5, 1993 delta smelt listing and critical habitat rule;
- the 1996 Recovery Plan;
- the 2008 Service BiOp (Service 2008);
- the September 13, 2010 5-year status review (Service 2010a);
- the April 7, 2010 12- month finding (75 FR 17667; Service 2010b);
- the latest Candidate Notice of Review (Service 2016);
- the draft recovery plan for delta smelt (under development); and
- other resources available to the Service.

Based on available resources, the Service proposes that, in order to recover, delta smelt need a substantially more abundant population, an increase in the quantity and quality of habitat, and other needs as further outlined below:

Abundance - a substantially more abundant population, which is notably linked to the success of recruitment between life stages. Abundance is affected by entrainment, predation, feeding, competition, demographics, reproductive success, and fish condition and health.

Entrainment and Impingement Risk

- A reduction in entrainment and impingement of adult, juvenile, and larval individuals and their food supply at CVP and SWP pumping facilities, over and above reductions achieved under real-time operations of the 2008 Service BiOp, to increase the abundance of the spawning adult population and the potential for recruitment of larvae and juveniles into the adult population. This can be done through OMR modified actions to increase protection among life stages.
- A reduction in entrainment and impingement from other water diversion-related structures within delta smelt critical habitat where delta smelt adults, larvae, or juveniles are known or are likely to be impinged or entrained to increase the adult population and the potential for recruitment of juveniles into the adult population.
- A reduction in entrained food supply within delta smelt critical habitat.

Predation

- Increased escape cover (*i.e.*, sufficient habitat to reduce/avoid predation from observed increases in water clarity).
- Reduction in predators in the Bay-Delta ecosystem to increase survival of adults, larvae, and juveniles from an overall increase in relative abundance of predator species system-wide.

Feeding

- Increased copepod production.

Competition

- Reduction in competition and food web alteration from non-native fish and invertebrates.

Demographic/Genetic

- Maintain or increase genetic diversity within the population and Allee effects (*e.g.*, reduced schooling ability, reduced ability to find mates).

Reproductive Success

- Restoration of migratory and spawning cues from reductions in the spawning season window and modification of natural flow regimes.
- Increase the condition of spawning individuals, such as fish size (*e.g.*, weight, length), fat storage, sufficient calorie intake, and lipid energy.
- Improve delta smelt vital rates, including higher growth rates and higher fecundity levels.

- Improve the sex ratio (males to females) with recognition that there is uncertainty associated with this need and therefore is identified as needing additional research and monitoring.

Fish Body Condition/Health

- Improve physical health through a reduction in contaminants exposure and other pollutants (*e.g.,* metals, pesticides, CEC's [endocrine disruptors], etc.) within its habitat to increase survival of adults, larvae and juveniles.

Habitat - an increase in the quality and quantity of suitable migratory, spawning, and rearing habitat. Improved habitat quality within the Bay-Delta should enhance delta smelt reproduction and allow for recruitment success necessary to the species to survive. Suitable habitat conditions require habitat diversity, water quality, and flow.

Habitat Diversity

- Increase habitat complexity (*e.g.*, reduction in dead end sloughs) and heterogeneity.
- Increase in the quality and quantity of suitable spawning habitat and substrate (*i.e.*, sandy beaches with sufficient water velocities, available for direct use) due to reductions in sandy beaches system-wide.
- Maintain or increase (*i.e.*, protect, restore, create, or enhance) suitable habitat within designated critical habitat (*i.e.*, with PCEs), further preventing reductions in habitat.

Water Quality

- Improve water quality – suitable water quality constituents within optimal range (*i.e.*, turbidity, DO levels, water temperature, pH, salinity).

Flow

- Improve flow conditions – suitable flow conditions (*i.e.*, velocity, timing, [delta] freshwater outflow, salinity, tidal energy, flow suitable for spawning migration, to trigger movement to spawning areas, and egg incubation)

These can be achieved as a result of active or passive management of water and sediment processes in the San Francisco Bay-Delta ecosystem that mimics more natural (*i.e.,* pre-water development) conditions.

Other needs – Other factors that affect delta smelt include climate change, aquatic invasive macrophytes, harmful cyanobacteria blooms (*Microcystis*), disease, and exposure to in-water work activities.

Climate Change

- Maintain and increase sufficient suitable habitat from threats of ecosystem changes (community and habitat shifts).
- Prevent reductions/shifts in suitable habitat due to sea-level rise and increased droughts and temperatures.

- Maximize delta smelt population resilience in the face of the potential adverse effects of ongoing climate change that are occurring in the Bay-Delta ecosystem.

Aquatic Invasive Macrophytes

- Reduce aquatic invasive macrophytes due to increased predator habitat from changes in water quality as a result of increased water clarity, residence times, and flow reductions.

Harmful Cyanobacteria Blooms (*i.e., Microcystis*)

- Reduce harmful cyanobacteria blooms from increased water residence time/flow reductions and increased anthropogenic nutrient inputs.

Disease

- Reductions in disease to increase survival of adults, larvae, and juveniles.

Risk to Individuals from Exposure to In-water Work Activities (*e.g.*, dredging riprapping, suction dredging, agricultural diversions)

- Reduce sources of harassment, harm, or mortality to delta smelt individuals, habitat loss, and effects to prey density (*i.e.*, modification of food supply).

Supplementation – The very low abundance of delta smelt has increased the urgency toward development of a program for supplementing the wild population of delta smelt (Lessard *et al*. 2018). Studies are currently underway to help develop a program for using cultured delta smelt for supplementation efforts. In order for a supplementation program to be fully successful, fish must be released into an environment that provides ample food, low levels of toxic compounds, and low entrainment losses (Service 1996).

5.4.1 Effects of the Proposed Action on Recovery

Reclamation and DWR are proposing measures to minimize the adverse effects of accumulating loss and degradation of habitat to promote the recovery of delta smelt. Habitat loss and degradation are contributing factors to the decline of delta smelt. The proposal to continue restoring intertidal and associated subtidal habitat in the Delta and Suisun Marsh is a reasonable means of minimizing the adverse effects of the loss of individuals, on the species as a whole, and may benefit the recovery of delta smelt. Tidal restoration projects in the estuary have generally created fish feeding benefits very quickly (Cohen and Bollens 2008; Howe and Simenstad 2011). Following Herbold *et al*. (2014), the restoration projects that will be credited to this action in the coming decade will be sited and designed to locally increase food web production in a location that delta smelt should be able to access it. Reclamation and DWR commit to funding and ensuring that monitoring, operation, maintenance, and permanent protection occur on these restored lands. An overall monitoring program developed to focus on the effectiveness of the restoration actions will inform future actions undertaken for the intended food web benefit of delta smelt. The Service leads the FAST, which assists DWR in designing the proposed restoration projects to increase food web production in appropriate locations to benefit delta smelt. DWR has made significant progress in overcoming hurdles which has created momentum in acquiring lands, designing, and constructing restoration projects. This momentum is expected to continue in the coming years in order to complete the remaining restoration acreage to support the recovery need of improving feeding which contributes to increased abundance of delta smelt.

The proposed operation of the CVP and SWP is likely to result in a small increase in delta smelt entrainment risk as compared to the current operations scenario. Measures under Additional Real-Time OMR Restrictions in the PA are proposed to moderate this increase in the level of entrainment during the period when delta smelt may be dispersing (Integrated Early Winter Pulse Protection), dispersing and spawning (Turbidity Bridge Avoidance) and when larvae and juveniles are subject to entrainment by restricting how negative OMR flows can be during these life stage. The water management facilities (RRDS, Colusa Basin Drain, etc.) proposed to be utilized for food enhancement actions are located in areas where entrainment of those food subsidies is not expected to occur.

As discussed in the *Effects to Delta Smelt from the Proposed Action* section, based on the scale and locations of proposed predator hotspot removal, these activities are not expected to have an appreciable positive or negative effect to delta smelt. Subsequent consultations on these activities will more specifically address what effects are anticipated from these activities.

It is unknown if the Summer-Fall Habitat Action will contribute to recovery by improving habitat quality for delta smelt. Specific actions to be taken in applicable water years are to be determined by the Delta Coordination Group based on unique conditions for that year and results of previous implementation of SMSCG operations and food enhancement actions.

Reclamation proposes to support development of a delta smelt supplementation program, including capturing existing genetic diversity and maximizing numbers of delta smelt, and to begin supplementation. Reclamation has proposed to fund a process that would lead to supplementation of the wild delta smelt population with captive-bred fish from FCCL within 3-5 years. By 2030, Reclamation proposes to support a Delta Fish Species Conservation Hatchery to take over the role of supplementing the wild population. The first step in this process will be the development of a supplementation strategy within one year of the issuance of this BiOp that will include details about the capacity needed at FCCL to accommodate production of delta smelt needed to meet genetic and other hatchery considerations with a goal of increasing production to a number and the life stages necessary to effectively augment the population. The Service will be the lead on the development of this supplementation strategy, and will ensure the program is consistent with the recovery needs of delta smelt. This program will likely contribute to recovery by augmenting the population to the point that the wild population will be more resilient to threats, including effects associated with operations of the CVP and SWP.

Reclamation proposes to conduct a sediment supplementation feasibility study to determine whether there are actions they and DWR can take that would increase the turbidity of water in the Delta. There may be significant logistic and legal hurdles to implementing major sediment supplementation efforts, but a careful evaluation of this topic is warranted. This action proposes to conduct a study and therefore will not of itself affect the recovery of delta smelt, but may, at a future date, lead to recovery actions.

As modeled, the PA may increase the level of entrainment of adult and larval delta smelt relative to the COS. However, the negative effect of this increase of entrainment will be minimized by real-time measures that are part of the PA to protect delta smelt. Additionally, supplementation is expected to improve abundance and distribution to help bolster the wild population and make it more resilient. It is unknown what effect to recovery some components of the PA will have, such as implementation of the Summer-Fall Habitat Action and predator hot spot removal. Habitat restoration efforts will contribute to the delta smelt food web once they are constructed and functioning, which is anticipated to contribute to the recovery need of increased abundance by improving food availability for delta smelt in areas where delta smelt should be able to access it. Therefore, the PA is not likely to preclude recovery of the delta smelt.

5.5 Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this BiOp. Future Federal actions that are unrelated to the proposed project are not considered in this section; they require separate consultation pursuant to Section 7 of the Act.

Major human interactions and uses of the landscape within the Action Area include: agricultural practices; recreational uses; urbanization, transportation, transcontinental shipping, and industrial uses. All of these major land uses contribute to greenhouse gas emissions.

5.5.1 Agriculture

Farming occurs throughout the Delta and its watershed, including on lands adjacent to many waterways used by delta smelt. Levees are reinforced with continual vegetation removal and over time, riprapping has accumulated as a commonly deployed method to stabilize the levees and protect the land behind the levees for agricultural purposes. Agricultural practices introduce nitrogen, phosphorous and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman *et al.* 2014); however, urban wastewater treatment provides the bulk of ammonium loading (Jassby 2008). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect delta smelt 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 contaminant exposure.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Action Area, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain many life stages of aquatic species, including delta smelt (Nobriga *et al*. 2004). Most diversions of any substantial size and cost along the Sacramento River have been screened, and in the Delta, newer municipal water diversions and are routinely screened per existing BiOps. Private irrigation diversions in the Delta and Suisun Marsh are mostly unscreened, but the total amount of water diverted onto Delta farms and waterfowl clubs has remained stable for decades

(Culberson *et al.* 2008) so the cumulative impact should remain similar to baseline, and if anything, be lowered somewhat by habitat restoration projects.

5.5.2 Urbanization and Industry

The Delta Protection Commission's *Economic Sustainability Plan for the Delta* reported an urban growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the State as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 (California Department of Finance 2012). Table 5-9 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 5-9. Delta counties and California population, 2000–2050.

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01
Sources: California Department of Finance 2012.					

Table 5-10 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 5-10. Delta communities population, 2000 and 2010.

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%
Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			
Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%

Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.
[a] Freeport had a population of 38; Hood had a population of 271.

Increases in urbanization and housing development 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, and electricity, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require consultation regarding delta smelt.

Adverse effects on delta smelt and its 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, numerous pesticides and herbicides, pharmaceuticals, vehicle and roadway-derived copper, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into Delta waterways from shipping and boating activities and from urban activities and runoff. Implicated as potential stressors to delta smelt, these contaminants may adversely affect delta smelt reproductive success, survival rates, and food supply.

Upgrades to the Sacramento Regional Wastewater Treatment Plant are expected to occur in 2021-2023, which will result in reductions in dissolved ammonium concentrations in the Delta. It is scheduled to significantly reduce its nitrogen effluent concentrations beginning in 2023. Once that happens, it should become apparent within a few years how important ammonium ratios are limiting diatom production in the Bay-Delta.

Other future, non-Federal actions within the Action Area that are likely to occur and may adversely affect delta smelt and their critical habitat 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; and State or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long-term habitat-maintaining processes.

5.5.3 Recreational Uses

Increased urbanization is also expected to result in increased recreational activities in the Action Area. The Delta and Suisun Marsh contain numerous parks, extensive public lands, and many interconnected rivers, sloughs, and other waterways that offer diverse recreation opportunities. Privately owned commercial marinas and resorts allow for boating access to the waterways and a variety of other recreational opportunities and services. Private lands also provide several recreational opportunities, particularly hunting.

The Delta is a regional destination for water-based recreationists because of its mild climate, sport fishing opportunities, large maze of navigable waterways, and favorable water levels during summer when most regional reservoirs experience substantial drawdown. Activities in the Delta include cruising, waterskiing, wakeboarding, using personal watercraft, sailing, windsurfing, and kiteboarding, as well as fishing and hunting (from land and by boat). Non-powered boating activities in the Delta include sailing, windsurfing, kiteboarding, canoeing, and kayaking.

Hunting has long been a recreational activity in the Delta, with waterfowl hunting being the primary type. Most of this hunting is concentrated in Suisun Marsh and the Yolo Bypass, with lesser amounts also occurring in a few locations elsewhere in the Delta. Hunting by boat (typically used as a floating blind) is popular at the larger flooded islands, such as Franks Tract and Sherman Island, because hunters seek open, shallow waters and marsh areas where waterfowl congregate. Licenses and duck stamps to hunt waterfowl are required by the CDFW and the Service. CDFW manages hunting in California, including the public hunting programs at Sherman Island and other smaller wildlife areas. The California Department of Parks and Recreation allow hunting at Franks Tract, designated as Franks Tract State Recreation Area. Boat hunting is also allowed at Big Break, which is managed by the East Bay Regional Park District (Delta Protection Commission 1997). Late fall through early winter is the designated waterfowl hunting season; starting and ending dates vary each year by species and by hunting method.

5.5.4 Greenhouse Gas Emissions

There is an international scientific consensus that most of the warming observed has been caused by human activities (IPCC 2001; IPCC 2007a; IPCC. *2*007b), and that it is "very likely" that it is largely due to man-made emissions of carbon dioxide and other greenhouse gases in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007b; Solomon *et al.* 2009). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2012), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities. Scientific measurements spanning several centuries demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al.* 2009; IPCC 2014).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007; Ganguly *et al.* 2009). These approaches have been downscaled to the western U.S. (Dettinger *et al*. 2015) and to the Central Valley (Dettinger 2005; Dettinger *et al*. 2016). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl *et al.* 2007; Ganguly *et al.* 2009; IPCC 2014).

Ongoing climate change will likely adversely affect delta smelt (Brown *et al*. 2013; 2016a), since climate change will likely result in sea level changes and overall wet and dry cycles. The major factor is the anticipated warming which will increase physiological stress and may result in changes to availability and distribution of habitat and prey, and/or increase numbers of predators, parasites, diseases, and non-native competitors. For additional information on climate change as it relates to delta smelt, see *Status of the Species Within the Action Area*.

5.5.5 Summary of the Cumulative Effects to Delta Smelt

The anticipated cumulative effects to delta smelt within the Action Area include additional urban and commercial development in the Bay-Delta watershed, and the increased stormwater runoff, road building, and changes to contaminant loading that accompany these land use changes. There may be small reductions in regional agriculture and in-Delta irrigation diversions due to the development of the 8,000 acres of habitat restoration and other habitat restoration initiatives like EcoRestore. The Service is not aware of any information that can be used to quantitatively predict what the cumulative effect of such changes would be. Qualitatively, habitat restoration and less irrigation water demand in the Delta have the potential to offset increased contaminant burdens associated with projected human population growth and urban/commercial land conversion. The amount of anticipated change to the regional climate expected in the near term is lower than it is for the latter half of the century. Therefore, it is less certain that any measurable change from current conditions will occur in the next approximately 10 years than by the latter half of the century. For the time being, water temperatures are stressful to delta smelt, but not of themselves lethal in most of the upper estuary (Komoroske *et al.* 2015).

5.5.6 Summary of the Cumulative Effects to Critical Habitat

Among the cumulative effects discussed in *Cumulative Effects* section, urbanization and climate change are most likely to affect critical habitat. PCE 2 (Water Quality) impairment is likely to continue or increase due to ongoing inputs of irrigation drain water, increased stormwater runoff and the pesticides associated with these inputs. Water temperatures, influenced by warming air temperatures from climate change, are expected to rise. Delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the Pacific coast of North America and is living in an environment that is energetically stressful. Thus, any increase in summer water temperatures associated with climate change may present a significant conservation challenge. PCE 3 (River flow) reductions, and the associated PCE 4 (Salinity) intrusion will increase as human population growth places additional demands on water resources and less fresh water will be available to maintain the LSZ at a suitable location particularly for juvenile rearing habitat. Herren and Kawasaki (2001) documented over 2,500 water diversions in the Delta and Suisun Marsh, of which very few are screened. Unscreened diversions represent a risk of entrainment to delta smelt and reducing habitat suitability for all life stages especially larvae and juveniles when river flow is directed over levees onto fields or managed wetlands (Culberson *et al.* 2004). Of the 414 water diversions in Suisun Marsh approximately 98% were unscreened including DWR's Morrow Island Distribution Center. Climate change will also alter the timing and form of precipitation (rain or snow) in the watershed depending on latitude. Sea level rise could accelerate quickly depending on what happens in remote locations; if so, it will likely influence saltwater intrusion into the Bay-Delta. Elevated salinity could push X2 farther up the estuary with mean values increasing by about 7 km by 2100 (Brown *et al.* 2013). The status of critical habitat (PCEs 2, 3 and 4) will likely be degraded by each of these cumulative effects in the near term.

5.6 Effects in the Aggregate to Species and Critical Habitat

5.6.1 Effects of the Aggregate Status of the Species/Environmental Baseline, and Proposed Action for Delta Smelt

The purpose of the aggregate analysis is to evaluate the combined status of the species, the effects of the PA and the cumulative effects of non-Federal activities to determine their combined effects to the species. Reclamation has committed to implementing programmatic actions that will be subject to future consultation, so those effects have been analyzed at a general level since specific details about those activities (such as location, timing, and design) have not yet been developed. Subsequent consultation on those activities will include analyses of effects at a more specific level and will address incidental take of listed species if it is reasonably certain to occur.

As discussed in the *Environmental Baseline* section of this BiOp, the Environmental Baseline does not include the effects of the action under review in the consultation. In this case, the effects of the action are those resulting from the coordinated operations of the CVP and SWP from now until 2030, as proposed by Reclamation in the BA, and are therefore, not included in the Environmental Baseline for this consultation. The *Environmental Baseline* section describes the approach taken to inform the current condition of the delta smelt, including consideration of the without action scenario, past and current operations of the CVP and SWP, and the additional metrics of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions.

Summary of the Status of the Species Range-wide and in the Action Area

The Action Area for this consultation encompasses the entire range of delta smelt including all of the designated critical habitat for this species, so for the purposes of this consultation, status of the species range-wide and in the Action Area are combined. The range-wide status of the delta smelt has been declining since the early 2000s, and is presently at its lowest level. Delta smelt have become almost undetectable in some surveys since 2012 (Moyle *et al.* 2016). The population is thought to be so small that stochastic factors, such as a multi-year drought, the loss of key spawning or rearing sites, or an increase in local abundance of competitors or predators could cause extinction in the wild in the near future (Moyle *et al.* 2016). For an annual species, factors affecting habitat conditions throughout its short life span are important to its success or failure. It is clear from published research that the delta smelt population has been observed to decline as physical aspects of its habitat have been reduced in extent and non-native species have increased (Bennett 2005; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Mac Nally *et al.* 2010; Thomson *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012).

The relative abundance of delta smelt has reached very low numbers for a small forage fish in an ecosystem the size of the Bay-Delta and the species is now considered to be approaching extinction in the wild (Moyle *et al.* 2016; 2018; Hobbs *et al.* 2017). The extremely low 2018-2019 abundance indices reflect decades of habitat change and marginalization by non-native species that prey on and out-compete delta smelt. The anticipated effects of climate change on the Bay-Delta and its watershed such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflow, and the potential for frequent extreme drought, indicate challenges to delta smelt survival will increase, though most of the climate-related habitat challenges are expected to accumulate to problem levels in the latter half of the century.

In the absence of the PA, as depicted under the without action scenario described in the BA, the status of the delta smelt would be somewhat improved because there would be no entrainment or loss of fish in the salvage process. OMR flows would generally be positive because the Banks and Jones pumping plants and their associated fish salvage facilities would not operate. Delta outflow would likely be higher in the spring but lower in the summer and fall relative to the PA, so the location of X2 and the LSZ would likely be more favorable for delta smelt. More sediment supply in the winter and spring could increase turbidity, and spawning substrate during the high-flow winter/spring period would not be reduced. However, as discussed previously, the Environmental Baseline also includes the effects of past and current ecosystem changes, including operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of the delta smelt.

A Current Operations scenario has been incorporated into our effects analysis to aid in identifying aggregate effects (including identifying future effects of the PA components that have not changed from current operations, as well as identifying effects of the components of the PA). Where adverse effects of the PA are expected to increase relative to current operations, those increases and to which life stages they occur, have been explained in our effects analysis. Where it is currently unknown what effects will occur because of a lack of specific information about how the action will be implemented, those have also been noted. There have also been numerous other consultations and projects that have affected delta smelt in addition to past consultations on operations of the CVP and SWP. Additional factors such as habitat restoration, dredging activities, scientific monitoring and research, aquatic weed control, in-water construction projects, predation from non-native fishes, water quality, and other effects from Federal, State, and private actions are also factors that are part of the baseline. These past actions have contributed to the current condition of the species within the Action Area. Therefore, the summaries of aggregate effects to the delta smelt and its critical habitat described below for use in considering whether or not the PA is likely to jeopardize delta smelt or destroy or adversely modify critical habitat (pursuant to the *Analytical Framework for the Jeopardy Determination* and *Analytical Framework for the Adverse Modification Determination*) reflect our consideration of the effects of the PA in light of the without action scenario, the effects of past and current operations of the CVP and SWP, all other relevant factors, and cumulative effects.

Summary of the Effects of the PA on the Reproduction, Numbers, and Distribution of Delta Smelt

<u>Reproduction</u>

Operations of the CVP and SWP as described in the PA will have impacts to delta smelt reproduction. Favorable conditions in the winter and spring months are critical to successful adult delta smelt dispersal and spawning. Overall, modeling provided in the BA shows that under the PA scenario, OMR flows would, on average, be slightly more negative than the modeled COS. In addition, the Storm-Related OMR Flexibility action will allow for maximum exports to be taken during storm events, which may result in OMR flows more negative than -5,000 cfs unless certain conditions are present, such as the risk of formation of a continuous turbidity bridge. However, OMR Management actions and Additional Real-Time OMR Restrictions are designed to provide adult protections to minimize entrainment and are expected to provide conditions similar to the COS. While appropriate spawning substrate exists in the lower San Joaquin River, reverse flows in Old and Middle rivers and a high abundance of predators are presumed to be a significant pressure on delta smelt survival in the south Delta, and few are presumed to survive to reproduce. Entrained adults that do survive to spawn will do so in an environment that subjects their progeny to pressures of entrainment and predation that may exceed those experienced by the adults. However, the majority of dispersing delta smelt adults in most years move up the Sacramento River or into Suisun Marsh as evidenced by historical surveys (Polansky *et al.* 2018), where individuals are much less likely to be entrained into the south Delta, and larvae are entrained from these distant locations at much lower rates than if they were spawned in the San Joaquin channels of the south Delta. In addition, a suite of protective OMR actions will generally keep OMR flow and turbidity within levels that are expected to be similarly protective of dispersing adult delta smelt as those that have occurred over the past decade. The proposed use of quantitative hydrodynamic and delta smelt life cycle models will help ensure that delta smelt recruitment is not impacted by entrainment losses.

The increased production at FCCL and near-term population supplementation will help conserve diversity and increase resilience, and begin to augment the reproduction of delta smelt in the wild. Greater numbers of successfully reproducing delta smelt will bolster the resilience of the population in poor recruitment years and allow the population to withstand conditions such as drought. Eventually, production and supplementation will be substantially increased through the Delta Fish Species Conservation Hatchery, providing additional benefits to delta smelt.

<u>Numbers</u>

By operating the existing CVP and SWP export facilities, there is ongoing potential risk to delta smelt individuals (especially larvae, juveniles, and adults) from entrainment or impingement and increased predation rates. Entrainment levels are expected to remain similar for adults but to slightly increase for larvae and juveniles under the modeled PA conditions relative to the COS. However, Reclamation proposes to implement a suite of protective OMR Management actions (for delta smelt and salmonids) and single-year loss thresholds (only for salmonids) that we anticipate will maintain conditions that are similarly protective for adult delta smelt as those that have been in place since 2009. The intent of actions slated from December to March will be to minimize the effect of entrainment to adult delta smelt dispersing into the south Delta, which will minimize the number of entrained individuals and their progeny that are subjected to entrainment, poor habitat conditions and predation. The proposed larval and juvenile delta smelt protective action is intended to limit entrainment of this life stage to a level that will not exceed the threshold identified by Service life cycle models through real-time management.

The spatial extent of high suitability rearing habitat will be somewhat lower under the PA in Wet years, and somewhat higher in Above Normal and Below Normal years than what would be anticipated under the COS. This statement is largely limited to the months of September and October of Wet and Above Normal water years due to the explicit differences in operations rules between the PA and COS. The suite of management interventions in the Summer-Fall Habitat Action is intended to focus benefits into places like the Cache Slough Complex and Suisun Marsh where outcomes can be controlled and observed fairly carefully, and it will add actions to Below Normal water years, potentially increasing the frequency of years that the delta smelt population receives some helpful management intervention. The effects to individuals and to the population of this adaptive set of actions cannot be quantified at this time. However, the Service anticipates that the actions identified would continue to provide low-salinity habitat in Honker and Grizzly Bays and Suisun Marsh in Above Normal and Wet years and increase its frequency in Suisun Marsh in Below Normal years. Additionally food enhancement actions, described at a programmatic level at this time, may provide better feeding conditions for delta smelt in Suisun Marsh and the Cache Slough Complex. The structured decision making process called for under this action will incorporate new results each year to help refine the potential benefits that may be realized.

The proposed increased production at FCCL and near-term population supplementation will help to offset adverse effects from operations and begin to augment the numbers of delta smelt in the wild. Greater numbers of successfully reproducing delta smelt will bolster the resilience of the population in poor recruitment years and allow the population to withstand poor conditions such as drought. Eventually, production and supplementation will be substantially increased through the Delta Fish Species Conservation Hatchery. Another key component of the FCCL and conservation hatchery project elements is the development of a supplementation strategy and genetics plan. The implementation of a supplementation program will provide benefits by maintaining a genetic bank and reintroducing individuals to alleviate effects of further population decline. The Delta Fish Species Conservation Hatchery is a programmatic project element and will require future consultation.

DWR and Reclamation have committed to completing tidal habitat restoration efforts (8,000 acres) in the Delta by 2030 and the Service is closely involved in planning and permitting processes via the Fishery Agency Strategy Team. The goal of this restoration program is to provide food web benefits to delta smelt in the North Delta Arc. Momentum has been building recently in acquiring lands, designing, and constructing projects which is expected to continue to complete this important effort.

Distribution

Under the PA, the distribution of adult delta smelt will remain largely similar to what would be expected based on the COS. Reclamation and DWR have proposed to manage OMR at the onset of adult dispersal and through the spawning period to minimize any reduction in habitat that might result from periods of higher exports. Larvae that hatch in these areas rely on net downstream transport flows in the spring to avoid eventual entrainment or predation within the large SAV beds in the channels and flooded islands of the south Delta (Appendix 2). Thus, the more negative OMR flow modeled in April and May under the PA relative to the COS may increase the southward transport and entrainment of young-of-the-year delta smelt, but OMR management is anticipated to keep loss of the larval and juvenile life stage within the threshold identified by the Service life cycle models.

Other factors that may affect delta smelt distribution include the operation of the agricultural barriers and the DCC. Dispersing adults may come into contact with these structures as they are moving upstream, but this possibility is low given that the agricultural barriers are put into place relatively late (April) to when delta smelt are no longer thought to be dispersing large distances. Larval distributions will be affected much more by OMR than the operation of the temporary barriers. Based on historical distribution, it is unlikely that this will affect a large number of individuals that were not already entrained into Old and Middle rivers. Individuals encountering the agricultural barriers may be precluded from moving within the channel and made more vulnerable to predators hovering around the barriers and gates, but these fish were already assumed to be entrained or lost to predators in our effects analysis. It is unknown what (if any) effects the DCC or SMSCG operations have on dispersing adults.

The implementation of the PA may lead to contraction of delta smelt distribution by shifting the LSZ east in Wet years relative to the COS during September through December. Maintenance of X2 at 80 km would have fewer effects on delta smelt distribution than the effects predicted based on the PA modeling. The proposed management actions for the Summer-Fall Habitat component include maintaining X2 at a monthly average 80 km in September and October of Wet and Above Normal years, operation of the SMSCG in Below Normal and Above Normal years, and potentially in Wet years, and commitment to food enhancement actions. The PA will provide more suitable rearing habitat for juvenile delta smelt in Honker and Grizzly bays than was predicted in the CalSim II modeling.

The increased production at FCCL and near-term population supplementation will help to offset adverse effects from the PA operations and begin to augment the numbers of delta smelt in the wild which is anticipated to increase distribution. Greater numbers of successfully reproducing delta smelt will bolster the resilience of the population in poor recruitment years and allow the population to withstand conditions such as drought. Eventually, production and supplementation will be substantially increased through the Delta Fish Species Conservation Hatchery.

Overall, while the PA will result in certain negative effects to the reproduction, numbers and distribution of delta smelt, it will also result in beneficial effects through protective real-time operations actions, habitat restoration, and the funding and implementation of a delta smelt supplementation program. Near-term population supplementation will help offset the negative effects of the PA. Augmentation of delta smelt in the wild will enhance the resiliency of the delta smelt population and make them less vulnerable to stochastic events.

5.6.2 Effects of the Aggregate Status of the Critical Habitat/Environmental Baseline, and Proposed Action on Critical Habitat for Delta Smelt

The purpose of the aggregate analysis is to evaluate the combined status of critical habitat, the effects of the PA and the cumulative effects of non-Federal activities to determine their combined effects to the conservation value of the critical habitat.

Summary of the Status and Environmental Baseline for Critical Habitat

As discussed in the *Status of the Critical Habitat Within the Action Area*, the status of the delta smelt critical habitat would be improved under the without action scenario with respect to PCE 1- Physical Habitat, and PCE 2-Water. For PCE 1-Physical Habitat, there would be greater supply of spawning habitat during the winter and spring because outflow is higher. For PCE 2-Water, there would be higher winter-spring inflow and accompanying sediment into the Delta resulting in increased turbidity during winter and spring, as well as the potential for higher resuspension of sediment during summer and fall (Schoellhamer 2011), though this would be affected somewhat by wind speeds (Bever *et al.* 2018). Under the COS, the location of X2 would on average be further westward/downstream in the some of the months that juvenile smelt would be rearing (September-November). The status of delta smelt critical habitat is poor (Table 5-3). The major factors currently limiting the conservation value of critical habitat are:

<u>*PCE 1 – Physical habitat*</u>
Dredging and shipping channel maintenance maintain the estuary's current bathymetry (water depths and water depth variability), and the associated water supply demands needed to maintain the LSZ in Suisun Bay. Levees are covered in large riprap for erosion protection which over time may have reduced the availability of spawning habitat along channel margins in the Delta. By locking the channels in place, it limits or eliminates ecological processes that result from channel meander reducing sediment turnover and enabling SAV to form expansive beds. Over time, these mechanisms may have reduced the availability of spawning habitat along channel margins in the Delta. Although altered, spawning habitat appears to be suitable in parts of Suisun Bay, and the larger channels of Suisun Marsh, the lower Sacramento River to the I-Street bridge (including Cache Slough) and parts of the lower San Joaquin River to approximately the City of Stockton.

<u>*PCE 2 – Water quality*</u>
At the Cache Slough/Liberty Island and the upper Sacramento Deepwater Ship Channel where food availability appears to be adequate (Hammock *et al*. 2015), over-summer water temperatures are warm, increasing metabolic rates, and signs of contaminant exposure have been observed, with urban or agricultural pesticide runoff being likely sources (Weston *et al*. 2014). Perhaps due to the extended warm, low flow conditions that resulted from the recent drought, the proliferation of SAV is worsening in the Cache Slough Complex as well. Agricultural drain water and urban stormwater runoff result in the continual presence of low levels of herbicides, fungicides and insecticides throughout critical habitat. Sediment loading from the Sacramento River watershed continues to decline, reducing sediment load available for the resuspension needed to generate turbid conditions. This likely reduces cover from predators and the light scatter that larvae need to find prey (Baskerville-Bridges *et al*. 2004; Schreier *et al*. 2016). Although water temperatures are a little lower, food availability at the confluence of the Sacramento and San Joaquin and downstream into Suisun Bay is more limited in its ability to support rearing juveniles due to the removal of plankton by the invasive overbite clam (Hammock *et al.* 2015). The water quality PCE is most appropriate in the lower Sacramento River downstream of Rio Vista and in Suisun Bay and Marsh. Fish show less evidence of contaminant-related tissue damage in these areas.

PCE 3 – River flow
Increasing winter river flows, which serve as queues for adult dispersal prior to spawning are appropriate in the Sacramento River and less frequently in the San Joaquin River. In summer, the LSZ has been located upstream into the river channels away from the wind-driven turbidity found in the shallows of Suisun Bay and Marsh. The Delta, particularly since 2011, has seen a proliferation of non-native invasive aquatic vegetation possibly as a result of warmer temperatures, and lessened scour as a result of reduced outflow associated with drought (IEP 2018). Watershed sediment depletion, high summer inflows to the Delta that do not translate into high outflow, and invasive plants, have worked together to increase water clarity and favor non-native fishes (Moyle and Bennett 2008). Modifications to export operations by the 2008 BiOp RPA have resulted in improved larval and juvenile transport flows in the San Joaquin River via Old and Middle river flow, but there is still some entrainment risk to delta smelt adults, larvae and juveniles.

PCE 4 – Salinity
In the winter and spring salinities are suitable for adult dispersal, spawning and larval transport. For juvenile rearing, however, water storage, upstream diversions and reduced outflow have contributed to a more spatially restricted LSZ, which, in turn, has impacted the extent and quality of habitat (Feyrer *et al*. 2011; Bever *et al*. 2016). Currently, summer-fall salinities in Suisun Bay, Suisun Marsh and Montezuma Slough are within delta smelt salinity tolerance during the juvenile rearing period (Komoroske *et al.* 2016). However, delta smelt seldom occur in the estuary where salinities can begin to cause physiological stress, and salinity increases linked to changes in Delta outflow tend to be associated with an eastward shift in the spatial distribution of the delta smelt population (Nobriga *et al.* 2008; Feyrer *et al*. 2007; 2011; Sommer *et al*. 2011).

Summary of the Effects of the Proposed Action on Delta Smelt Critical Habitat

As discussed in the *Status of Critical Habitat Within the Action Area*, the status of the delta smelt population suggests that the current condition of critical habitat is poor. The PA targets appropriate actions to improve delta smelt habitat, although the magnitude and timing of any benefits to delta smelt from habitat restoration and food enhancement actions are uncertain. The PA will result in: (1) small reductions in the food web resulting from increases to exports, but which may be minimized by habitat restoration and food enhancement actions; (2) a Summer-Fall Habitat Action that will provide adequate salinity and possibly elevated food availability in Suisun Marsh in three of five water year types; and (3) improved critical habitat conditions in Wet and Above Normal years as compared to the CalSim II modeling, but generally less favorable critical habitat conditions in Wet years as compared to the COS, and in the months of November and December.

As compared to the COS, the PA concurrently provides adverse and beneficial effects to delta smelt critical habitat (Table 5-8). The PA will have small adverse effects to food web transport and negligible effects to sediment load (PCE 2) from increases in exports; however, these adverse effects are reduced when evaluated with other Proposed Action components (i.e., remainder of the 8,000 acres of tidal habitat restoration, food augmentation studies, Summer-Fall Habitat Action).

As indexed by OMR flows more negative than -5000, CalSim II modeling of the PA predicts a disruption of river flows during adult dispersal and larval and juvenile transport relative to the COS. Proposed OMR management includes short-term restrictions that should maintain this PCE via turbidity management during adult dispersal.

As indicated by hydrodynamic modeling, the PA would degrade salinity for juvenile rearing in Wet years in September through December with monthly average X2 predicted to be upstream of the COS X2 position. The PA would also increase the frequency of time in which the LSZ is located upstream of 85 km, east of the Suisun embayments and into the more uniformly deep river channels. Predicted adverse salinity conditions from water operations should be minimized by the Summer-Fall Habitat Action which will support contiguous low-salinity habitat from Cache Slough Complex to the Suisun Marsh from June to October through summer and fall SMSCG operations and outflow augmentation in conjunction with food actions to supplement the prey base for delta smelt. Because Reclamation and DWR would maintain X2 at a monthly average 80 km in September and October of Wet and Above Normal years, the action would provide appropriate rearing habitat in Honker Bay, upper Grizzly Bay, and Suisun Marsh. The modeling predicts degraded habitat conditions compared to the COS in November and December, which are consequential for an annual fish. Improved conditions beyond those modeled are likely to occur, primarily in Suisun Marsh, in November and December in the years following the Summer-Fall Habitat Action. In years without the action, conditions will be similar to those predicted by the modeling, which in Dry and Critical water years is the same as the COS.

The spatial extent of high suitability rearing habitat will be somewhat lower under the PA in Wet years, and somewhat higher in Above Normal and Below Normal years than under the COS. This statement is largely limited to the months of September and October of Wet and Above Normal water years due to the explicit differences in operations rules between the PA and COS. The suite of management interventions in the Summer-Fall Habitat Action is intended to focus benefits into places like the Cache Slough Complex and Suisun Marsh where outcomes can be controlled and observed fairly carefully, and it will add actions to Below Normal water years, potentially increasing the frequency of years that the delta smelt population and its critical habitat receive some helpful management intervention. The Service anticipates that the actions identified would continue to provide low-salinity habitat in Honker and Grizzly Bays and Suisun Marsh in Above Normal and Wet years and increase its frequency in Suisun Marsh in Below Normal years. Additionally food enhancement actions, described at a programmatic level at this time, may provide better feeding conditions for delta smelt in Suisun Marsh and the Cache Slough Complex. The structured decision making process called for under this action will incorporate new results each year to help refine the potential benefits that may be realized.

The effects to water quality resulting from the PA are likely to be negligible for all delta smelt life stages, and effects to river flow for larval and juvenile transport and adult dispersal are anticipated to be overall similar to the COS. For rearing delta smelt, the conservation value of physical habitat may improve as a result of restored tidal marsh habitat. The frequency of years that actions will occur that are designed to reduce salinity intrusion may increase, although the spatial extent of suitable low-salinity rearing habitat varies depending on water year type.

Conditions in November and December would be less favorable in all water year types. Food enhancement may provide better feeding conditions for rearing delta smelt.

5.6.3 Summary of Effects in the Aggregate to Species and Critical Habitat

The abundance of delta smelt has been declining for many years. There are many causes for this decline, including the effects of past water operations. All indications are that this decline will continue into the future without intervention, such as supplementation of the wild population. Various factors have contributed to the current condition of delta smelt, including projects that have caused reduced water quality, habitat loss or modification, and direct mortality of delta smelt. It is likely that effects of ongoing and future factors, such as climate change, will contribute to continuation of the decline. There are some actions that have been or are planned with the intention of making delta smelt more resilient to the ongoing threats (e.g. Delta Smelt Resiliency Strategy). Restoration efforts have been completed or are underway which are designed to contribute to the food web for delta smelt. Reclamation and DWR have also proposed to conduct a sediment supplementation feasibility study to determine methods to reintroduce sediment in the Delta to increase turbidity which would provide better habitat conditions for all life stages of delta smelt, including increased cover for juveniles and feeding facilitation for larval smelt.

It is anticipated that the PA will have negative, positive, and uncertain effects on delta smelt. Overall, modeling provided in the BA predicts that under the PA scenario, OMR flows would, on average, be slightly more negative than the modeled COS, particularly in April and May when larvae that are spawned in to the south Delta will be most susceptible. However, the majority of dispersing delta smelt adults in most years move up the Sacramento River as evidenced by historical surveys, where individuals (including eggs and larvae) will not be entrained to the pumps. A suite of protective OMR actions will generally keep OMR flow and turbidity within levels that are expected to be protective of dispersing adult delta smelt. The model predicts that operations will alter and contract the suitable habitat for juvenile rearing delta smelt and increase the frequency and duration of years that the LSZ is located in areas less favorable for delta smelt. The Summer-Fall Habitat Action would improve habitat conditions from those modeled as X2 will be at 80 km during Wet and Above Normal years, the SMSCG will be operated to create fresher conditions in the marsh, and food enhancement actions will be implemented. The Summer-Fall Habitat Action relies on a yearly structured decision-making process that will consider conditions for that year and determine what actions to implement to protect rearing delta smelt.

According to the PA modeling, OMR flows would be slightly more negative than the COS. Real-time OMR management actions are expected to help obviate this effect, which will provide similar protections to the COS for dispersing and spawning adults and their progeny. Habitat conditions for rearing delta smelt vary depending on year type, but the frequency of actions designed to improve salinity conditions may increase from the COS. Habitat restoration and supplementation will help to minimize the effects of the PA on numbers of delta smelt. The overall distribution of delta smelt is expected to remain largely similar as a result of the PA to its current distribution. There may be changes in extent and location in some seasons or water year types, depending on how some of the proposed activities are implemented.

The increased production at FCCL and the Delta Fish Species Conservation Hatchery and subsequent supplementation of the wild population will help to offset adverse effects from the operations. This may broaden the distribution of delta smelt depending on the life-stages and subsequent release locations for hatchery fish. Greater numbers of successfully reproducing delta smelt will bolster the resilience of the population in poor recruitment years and allow the population to withstand poor conditions such as drought.

As discussed in the *Status of Critical Habitat Within the Action Area*, the status of the delta smelt population suggests that the current condition of critical habitat is poor. The PA targets appropriate actions to improve delta smelt habitat, although the magnitude and timing of any benefits of habitat restoration and food web studies to delta smelt are uncertain. The PA will result in: (1) small reductions in the food web resulting from increases to exports, but which may be compensated for by habitat restoration and food web supplementation actions; (2) improved salinity and possibly food availability in Suisun Marsh and the LSZ in three of five water year types as a result of implementation of the Summer-Fall Habitat Action; and (3) improved critical habitat conditions in Wet and Above Normal years as compared to the modeling, but generally less favorable critical habitat conditions in Wet years as compared to the COS, and in the months of November and December in all water year types.

Critical habitat was designated to support delta smelt to successfully complete their life cycle. The intended conservation value of delta smelt critical habitat is to consistently provide all of the needed habitat attributes corresponding to where delta smelt reside during their life cycle. These habitat attributes need to overlap in order to provide suitable habitat for delta smelt to survive and successfully reproduce. In addition, the area of overlapping habitat attributes must be of a sufficient quantity and quality to support the population. The effects to water quality resulting from the PA are likely to be negligible for all delta smelt life stages, and effects to river flow for larval and juvenile transport and adult dispersal are anticipated to be overall similar to the COS. For rearing delta smelt, the conservation value of physical habitat may improve as a result of restored tidal marsh habitat. The frequency of years that actions will occur that are designed to reduce salinity intrusion may increase, although the spatial extent of suitable low-salinity rearing habitat varies depending on water year type. Conditions in November and December would generally be less favorable in all water year types; however, it is not clear how much this change will affect the conservation value of the critical habitat in these late fall months as water temperatures cool and seasonal storms and windier weather often return to the Bay-Delta region which may improve the suitable habitat when X2 is located further east. Food enhancement may provide better feeding conditions for rearing delta smelt.

5.6.4 Summary of the Effects of the PA on the Recovery of Delta Smelt

Implementation of the PA is anticipated to contribute in various ways to the recovery needs of increased abundance, better quality and quantity of habitat, or other needs. Under the without action scenario, these PA elements would not affect delta smelt because there would be no entrainment. As compared to the current operations scenario, the entrainment risk for adult delta smelt, related to exports from the south Delta, would remain relatively the same under the PA due to the suite of protective OMR actions designed to keep OMR flow and turbidity within levels that are expected to be protective of dispersing adult delta smelt. Larval and juvenile entrainment may increase under the PA. The effect to the species of this increased risk is likely to be minimized by the larval/juvenile entrainment action and supplementation efforts. Reclamation has proposed to fund a program that will result in supplementation of the wild delta smelt population with captive-bred fish from FCCL within 3-5 years. By 2030, Reclamation proposes to support a Delta Fish Species Conservation Hatchery to take over the role of supplementing the wild population. The Service will ensure that the supplementation program is consistent with the recovery needs of the delta smelt. Overall, the operation and expansion of the FCCL and a Delta Fish Species Conservation Hatchery will support our work to stabilize and improve delta smelt population health.

The effects to recovery of other components of the PA, including the Summer-Fall Habitat Action, predator hotspot removal, and food subsidy activities, are unknown at this time. Further information will be developed through additional study and considerations and used to inform decisions about how to implement those actions. For the programmatic elements of the PA, subsequent consultation will be completed which will consider the effects to recovery of delta smelt.

Continuation of the habitat restoration efforts will contribute to the delta smelt food web once they are constructed and functioning, which is anticipated to increase abundance by improving food availability. The momentum that has been generated in acquiring lands, designing, and constructing restoration projects is expected to continue in order to complete the proposed habitat restoration acreage. This habitat restoration is a reasonable means of minimizing the adverse effects of the loss of individuals, on the species as a whole, and may benefit the recovery of delta smelt.

As modeled, the PA may increase the level of entrainment of adult and larval delta smelt relative to the COS. However, the negative effect of this increase of entrainment will be minimized by real-time measures that are part of the PA to protect delta smelt. Additionally, supplementation is expected to improve abundance and distribution to help bolster the wild population and make it more resilient. Habitat restoration efforts will contribute to the delta smelt food web once they are constructed and functioning, which is anticipated to contribute to the recovery need of increased abundance by improving food availability for delta smelt in areas where delta smelt should be able to access it. Therefore, the PA is not likely to preclude recovery of the delta smelt.

5.7 Conclusion

After reviewing the current status of the delta smelt and its critical habitat, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. Additionally, it is the Service's biological opinion that the PA is not likely to destroy or adversely modify delta smelt critical habitat. We have reached these conclusions because:

Implementation of the following protective actions in the PA are designed to minimize impacts to delta smelt and its critical habitat.

1. The PA includes OMR Management actions that will be implemented to provide protections to minimize entrainment of dispersing adult delta smelt and their progeny. This will also minimize the number of delta smelt subject to poor habitat conditions and predation. These protective actions are designed to prevent conditions which are conducive to entrainment, such as formation of turbidity bridges, and maintain the intended conservation value of critical habitat.
2. The PA includes a Summer-Fall Habitat Action that would improve habitat conditions from those modeled, including maintaining a monthly average X2 at 80 km during Wet and Above Normal years, operating the SMSCG in Below Normal and Above Normal years and potentially in Wet years (if preliminary analysis shows expected benefits) to create fresher conditions in the marsh and implementing food enhancement actions which will provide suitable rearing habitat for juvenile delta smelt in Honker and Grizzly bays, Suisun Marsh and Cache Slough.
3. The PA includes increased production at FCCL and near-term population supplementation that will help conserve diversity and increase resilience, and begin to augment the reproduction of delta smelt in the wild. Greater numbers of successfully reproducing delta smelt will bolster the resilience of the population in poor recruitment years and allow the population to withstand conditions such as drought.
4. The PA includes completion of 8,000 acres of habitat restoration for delta smelt, with the goal of providing food web benefits to delta smelt in the North Delta Arc. Momentum has been building and is expected to continue to fulfill this important measure.

The 2008 BiOp RPA included actions to reduce entrainment, provide for increased high quality low-salinity habitat in certain year types, create additional subtidal habitat and monitor ongoing operations. The current PA includes similar actions to the RPA to address entrainment risk, reduced habitat quality, and habitat restoration as articulated in the Effects Analysis. The PA addresses the stressors identified in 2008 RPA and in the Effects Analysis in a manner that is protective of delta smelt.

5.8 Delta Smelt Literature Cited

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6.0 CALIFORNIA CLAPPER RAIL

6.1 Status of the Species

6.1.1 Legal Status

The California clapper rail (*Rallus longirostris obsoletus*) was federally listed as endangered in 1970 (35 FR 16047). The California clapper rail is a Fully Protected Species under California law (California Department of Fish and Wildlife Code §3511). Critical habitat has not been proposed or designated for this species.

6.1.2 Natural History/Biology

This subspecies is one of three in California listed as endangered under the Act. The other subspecies are the light-footed Clapper rail (*R. l. levipes*), which is found in tidal marshes in southern California and northwestern Baja California, and the Yuma Clapper rail (*R. l. yumanensis*), which is restricted to the Colorado River Basin. A detailed account of the taxonomy, ecology, and biology of the California clapper rail can be found in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Service 2013b).

California clapper rails occur almost exclusively in tidal salt and brackish marshes with unrestricted daily tidal flows, adequate invertebrate prey food supply, well-developed tidal channel networks, and suitable nesting and escape cover for refuge during extreme tides. They exhibit strong site fidelity and territorial defense and are considered sensitive to disturbance. They tend to have relatively small average home ranges of 4.7 hectares (11.6 acres) and core use areas of 0.9 hectare (2.2 acres).

6.1.3 Range-wide Status and Distribution

A five-year review was completed in 2013 (Service 2013c). Historically, the California clapper rail was abundant in all tidal salt and brackish marshes in the San Francisco Bay vicinity, as well as in all of the larger tidal estuaries from Marin to San Luis Obispo counties. Current distribution is restricted almost entirely to the marshes of the Bay Area and where the only known breeding populations occur (Figure 6-1).

California clapper rail population numbers have generally fluctuated over time and have never improved to a level warranting consideration for upgrading the status of the species since its original listing as endangered in 1970. Citing various sources, the 2013 five-year review of the California clapper rail reported a population estimated at 4,200 to 6,000 birds between 1971-1975, at only 1,500 birds between 1981-1987, and reaching an estimated all-time historical low of about 500 birds in 1991. The five-year review noted that California clapper rail numbers have rebounded slightly since the early 1990s, but that substantial increases in population may be difficult to achieve due to the current disjunct distribution of their habitat (Service 2013c).

The Invasive Spartina Project (ISP), a multi-partner, regional non-native Spartina control program, conducts annual San Francisco Bay Estuary-wide California clapper rail surveys at program-associated sites. Annual ISP California clapper rail surveys at 30 sites across the estuary from 2005-2010 showed an increase from 80 birds in 2005, to 140 birds in 2007, before declining to below 60 birds in 2010 (McBroom *et al.* 2011). The ISP has expanded the number of sites included in its rail surveys, and for 158 sites across the estuary from 2010-2015, the project reported fluctuating numbers with 577 rails in 2010, a low of 498 in 2013, and a rebound to 670 birds in 2015 (McBroom 2016).

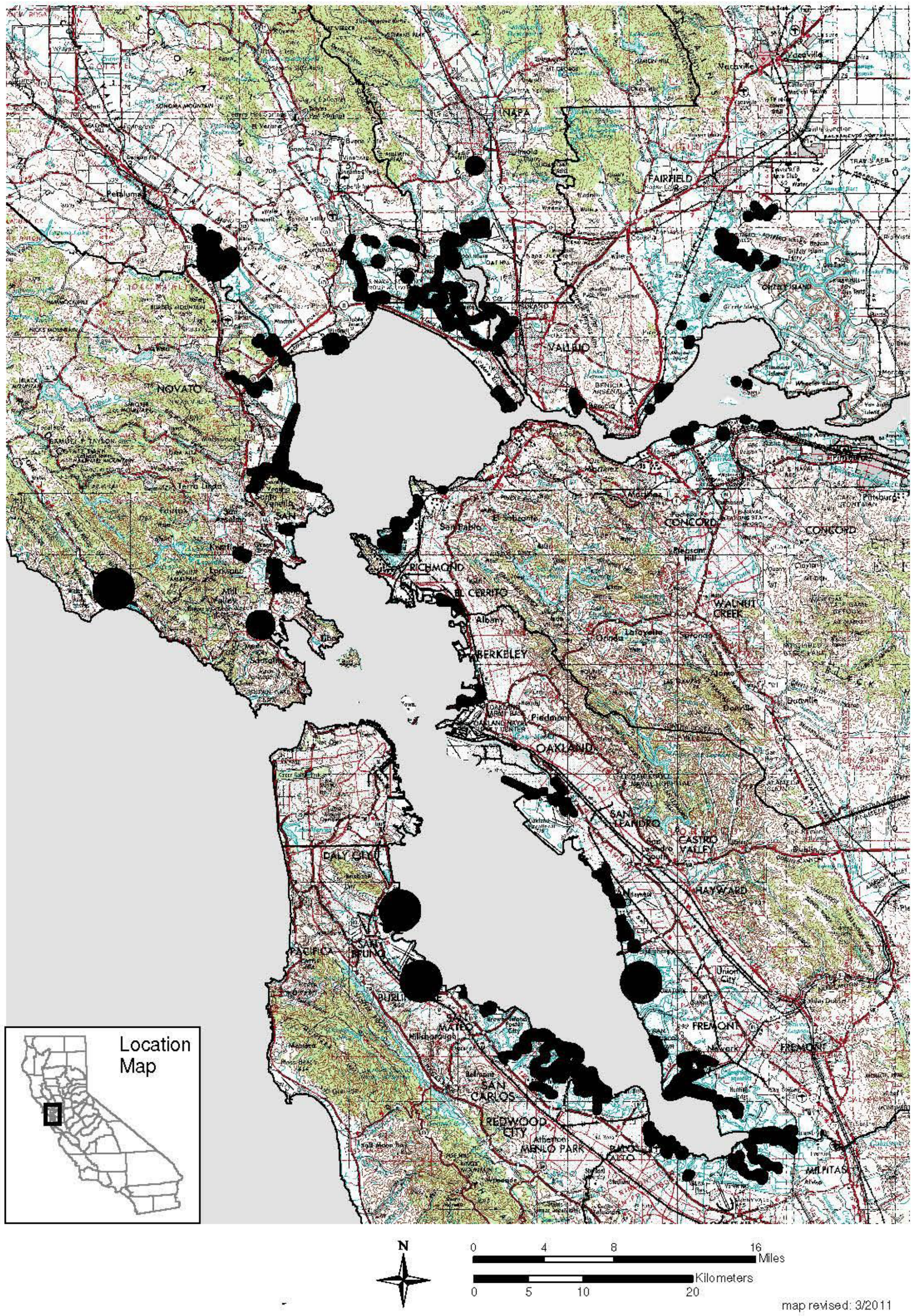

Figure 6-1. Known current distribution of California clapper rail (Service 2013b).

6.1.4 Threats

Threats to this species include, but are not limited to, habitat destruction and modification, low adult survivorship (ranging from 0.49 to 0.52), and predation of adults and eggs/nestlings (Service 2013b).

6.1.5 Recovery

Recovery of the California clapper rails requires a combination of interim and long-term actions. Interim actions are those necessary to maintain current populations, while long-term actions focus on recovering the species throughout its range. Interim actions involve monitoring current populations (number and distribution), non-native predator and invasive plant control, reducing human disturbance and protection of existing habitat. Long-term actions involve large-scale tidal marsh restoration and implementation of long-term management plans.

6.2 Environmental Baseline

On-going rail monitoring in the Suisun Marsh by the CDFW has shown sporadic detections of California clapper rails within the Action Area in the past 17 years (16 individuals sighted since 2002). This species has been detected at several locations in Suisun Marsh, including occurrences along Suisun Slough, Cutoff Slough, Hill Slough, Goodyear Slough, Rush Ranch, and Ryer Island (Service 2013a). Given the variable history of California clapper rail presence in Suisun Marsh, Suisun may represent crucial habitat for this critically endangered subspecies of clapper rail (CDFW 2016). Suisun Marsh has very limited high marsh vegetation which the California clapper rail require. According to the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*, one of the criteria for California clapper rail to be downlisted is to have a minimum of 5,000 acres of contiguous high quality tidal marsh habitat with well-developed channel systems and high-tide refugial/escape cover at the high marsh/upland transition zone and or inner-marsh of the Western Grizzly and Suisun Bays and marshes of Suisun Hill and Cutoff Slough (within the Suisun Bay Recovery Unit) (Service 2013a, Service 2013b).

Tidal marshes are fragmented throughout Suisun. Out of 70,000 acres (28,330 hectares) of land in Suisun, about 63,260 acres (25,600 hectares) are managed or leveed marshes and 6,670 acres (2,700 hectares) are tidal or muted (restricted) tidal marshes (CDFW 2017). These tidal marshes are divided into several larger marshes, such as tidal portions of Solano Land Trust's Rush Ranch (1,040 acres, 420 hectares), CDFW's Hill Slough Wildlife Area (865 acres, 350 hectares), and CDFW's Peytonia Slough Ecological Reserve (520 acres, 210 hectares), as well as many smaller marsh fragments (CDFW 2017). The vast majority of California clapper rails do not move more than one kilometer, though post-breeding dispersal may occur in fall and early winter (Albertson & Evens 2000). The last time a California clapper rail was detected by CDFW surveys was in 2011 at Rush Ranch (CDFW 2017). The vast majority of the California clapper rails are found in the San Pablo and San Francisco Bay, downstream of Suisun Marsh, where water salinities are higher. Salinity influences other variables, such as vegetation and invertebrates. Suisun Marsh is generally too fresh to support vegetation, such as *Spartina foliosa*, which may also contribute to low California clapper rail densities.

The Service has consulted on numerous consultations in the Suisun Marsh in the Action Area with a majority of the consultations being related to on-going maintenance activities or conversion of managed marsh to another use, such as tidal marsh restoration. The June 2013, *Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and Project-Level Actions in Solano County, California* (08ESMF00-2012-F-0602-2) was issued to the Corps to cover projects that fall under the Corps' Regional General Permit, their Letters of Permission, or individual permits in the Suisun Marsh. Example tidal marsh restoration projects that have been consulted on in the Action Area include Tule Red (08FBDT00-2016-F-0071), Blacklock (1-1-06-I-1880), and Montezuma Wetlands (1-1-99-F-12).

6.3 Effects of the Proposed Action

6.3.1 Tidal Habitat Restoration in Suisun Marsh

Depending on the nature, scope, location, and timing of restoration actions associated with individual restoration projects, there is a potential to adversely affect California clapper rails during implementation of construction, long-term management, or monitoring activities. California clapper rails do not occupy managed seasonal wetlands; therefore flooding managed wetlands for the purpose of restoration would not affect California clapper rails. California clapper rails inhabit suitable tidal wetlands and tidal sloughs in the Suisun Marsh. Restoration activities in these areas could potentially disrupt California clapper rail breeding and foraging in tidal wetlands if conservation measures are not implemented properly or at all. Reclamation has proposed to implement restoration projects consistent with conservation measures identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp (Service 2013a). Conducting presence/absence pre-construction study surveys will identify any new nest locations and presence of breeding individuals prior to implementing proposed project activities. The surveys will focus on potential habitat that may be disturbed by construction activities during the breeding season to ensure that these species are not nesting in these locations. If presence is determined, construction activities, including vegetation clearing, would be limited to months outside the breeding season, and staging areas would be sited at least 100 feet from water bodies. No construction activities will occur within 700 feet of identified nests or until after the nesting season.

Restoration construction may require the use of heavy equipment such as excavators, back hoes, bulldozers, and dump trucks in order to reconstruct interior site elevations, create levees, and breach levees. Proposed ground disturbing activities may result in disturbance, harm, injury, or death of California clapper rails, nests, or their young through the loss or degradation of their habitat, crushing by equipment and machinery, loss of breeding activity, nest abandonment, or increased risk of predation. Individual clapper rails may be disturbed by noise and vibrations associated with the use of heavy equipment used within or adjacent to habitat disrupting feeding, sheltering, or breeding activities. California clapper rails that are disturbed may be flushed from protective cover or their territories exposing the rails to predators. The level of disturbance would be exacerbated if the construction activities occurred during the rail's breeding season resulting in loss of breeding activity or if the work occurred during an extreme high tide when the California clapper rails are most likely to escape into adjacent areas to seek upland refugia cover. Displaced California clapper rails may have to compete for resources in occupied habitat, and may be more vulnerable to predators. Disturbance during the breeding season may disrupt breeding or cause nest abandonment resulting in the mortality of all the eggs and chicks in the nest. With implementation of the conservation measures, impacts to individuals will be minimized or avoided.

There could be a loss of foraging habitat throughout the Suisun Marsh as a result of construction-related activities. However, restoration activities are expected to be minor, temporary losses and not substantial given the amount of foraging habitat remaining. Conversion of managed wetlands to tidal wetlands would result in increased California clapper rail breeding and foraging habitat. As the restored areas evolve into a functioning, vegetated tidal wetland, it is expected to provide permanent, sustainable, suitable habitat for the California clapper rails. Habitat levees, if part of the restoration design, would provide refugia from high water events. Temporary disturbance of individual California clapper rails and their habitat would occur initially, but the long term effects would be increased suitable tidal marsh habitat which would benefit the entire California clapper rail population.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation. This could include tiering or appending to the existing Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

6.3.2 Suisun Marsh Salinity Control Gates (Proposed Flow Changes)

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. Depending on the timing of the proposed operations, SMSCG operations may overlap with the California clapper rail late breeding season and potential presence in the Suisun Marsh. California clapper rails hunt mussels, crabs, and clams (Service 2013b). SMSCG reoperations are expected to temporarily lower marsh salinities which may create a potential shift in their prey base availability and distribution in Suisun Marsh but this is unknown. Adverse effects to California clapper rails are not expected to occur. If through planning and implementation of the project-level activities, adverse effects to California clapper rails are realized and were not analyzed herein, reinitiation is required.

6.4 Effects to Recovery

Reclamation has proposed to minimize and avoid adverse effects from tidal marsh restoration by implementing conservation measures consistent with those identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp to promote the recovery of California clapper rails. Threats from habitat loss, reduction in habitat quality, predation, non-native plants, and human-related disturbances are contributing factors to the decline of this species. Implementation of restoration actions in the Suisun Marsh may result in short-term adverse effects to California clapper rails in order to gain an increase in long-term habitat benefits, thereby assisting in the recovery of this species. Therefore, we conclude that the PA will not negatively affect, and may contribute to, recovery of the California clapper rail.

6.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect California clapper rail. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the California clapper rail.

6.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the California clapper rail.

6.6.1 Reproduction

Pre-construction surveys associated with an individual tidal marsh restoration project will inform new locations of California clapper rail nest sites in the Suisun Marsh. Consistent with the conservation measures identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp, if California clapper rails are detected in the immediate work area, the PA will avoid and minimize effects to nesting or breeding individuals and their nest through the implementation of daily work windows, work restrictions, and avoidance buffers. Therefore, the PA will not expected to negatively affect California clapper rail reproduction range-wide, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

6.6.2 Numbers

The vast majority of California clapper rails are found in the San Pablo Bay and San Francisco Bay, downstream of Suisun Marsh, where water salinities are higher (CDFW 2018). Salinity influences other variables, such as vegetation and invertebrates. Some studies have found two habitat variables of importance: youthful marshes (low stem densities and little residual vegetation produced by occasional scouring) and extensive *Spartina* (cordgrass) beds (Albertson & Evens 2000, Conway *et al.* 1993). More specifically, Zedler (2003) found that *Spartina foliosa* height and density characteristics were the most important habitat variables for predicting California clapper rail habitat suitability (CDFW 2018). Suisun Marsh is generally too fresh to support *Spartina foliosa*, which may also contribute to low California clapper rail densities (CDFW 2018).

With implementation of the PA, low to no mortality or injury of individuals are expected to occur from tidal marsh restoration if conservation measures are implemented fully and properly. Restoration actions would contribute to the recovery of California clapper rail by creating more suitable habitat for California clapper rails. Therefore, the PA is not expected to reduce the number of California clapper rails.

6.6.3 Distribution

The number of California clapper rails affected by restoration actions will be relatively low in relation to the species' population numbers range-wide. Although there is the potential to harm or disturb individuals in a way that may result in altered normal behavior, it is still expected that these activities will not cause substantial disturbance to California clapper rails. Implementation of conservation measures will minimize or avoid the potential for disturbing California clapper rails. Therefore, we do not expect the PA to reduce the species' distribution relative to its range-wide condition.

6.7 Conclusion

After reviewing the current status of California clapper rail, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of California clapper rails likely to be affected by the PA will be low relative to the number of California clapper rails range-wide.

2. Reclamation has proposed to implement the conservation measures proposed in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

3. The PA is being implemented in a manner that will restore and create more suitable, sustainable habitat for the California clapper rail long-term.

6.8 California Clapper Rail Literature Cited

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7.0 CALIFORNIA LEAST TERN

7.1 Status of the Species

7.1.1 Legal Status

The Service listed the California least tern as endangered on June 2, 1970 (35 FR 8491 8498), and the species is a Fully Protected Species under California law (California Department of Fish and Wildlife Code, Section 3511). We issued a revised recovery plan for the species in 1985 (Service 1985). Critical habitat has not been proposed or designated for this species.

7.1.2 Natural History

The status of the California least tern can be found in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp (Service 2013). A detailed account of the taxonomy, ecology, and biology of the California least tern is presented in the approved recovery plan for this species (Service 1985).

California least terns forage in nearshore oceans, harbors, marina channels, tidal estuarine channels, and sheltered shallow bays (Atwood and Kelly 1984). Adults forage mostly within 2 miles of breeding colonies, and at many sites foraging is primarily in nearshore ocean waters less than 60 feet deep (Service 1985). They feed on small fish that they catch by plunging into the water from flight. In a study of fish dropped by California least tern at 10 nesting areas, researchers found 49 species of fish, all individuals less than 1 year old. Northern anchovy (*Engraulis mordax*) and silverside species (*Atherinidae*) represented 67 percent of the total sample (Atwood and Kelly 1984).

California least terns are migratory colonial nesters, usually arriving in breeding areas by late April and departing again in August (Massey 1974). After the initial nesting period that begins on their arrival in April, a second wave of nesting may occur from mid-June to early August. These are mainly re-nests after initial failures and second year birds nesting for the first time (Massey and Atwood 1981). Nesting California least terns usually occupy a sand-shell beach relatively free of plant growth (Massey 1974). The nest is typically a shallow, round depression, constructed by a bird sitting and kicking its feet backwards while rotating its body. This may occur several times before an egg is laid (Massey 1974; Wolk 1974). Terns may use "sideways building" after scrape construction, which consists of the sitting bird reaching out with its bill to pick up additional nest material, such as small shells and shell fragments, and depositing them into the nest (Wolk 1974).

Early in the breeding season, California least terns display night roosting behavior. Prior to incubation, terns will sleep at night at varying distances from the nesting sites. Once incubation begins, birds roost at night on the nest. Terns use roosting sites away from breeding colonies prior to egg laying, apparently for predator avoidance. By not sleeping within the colony until eggs are laid, the terns may delay the colony being discovered by a nocturnal predator by 2 to 3 weeks (Service 1985).

California least terns begin incubation after laying the first egg. Both parents participate in incubation, which lasts 20 to 25 days (Massey 1974). Clutch size ranges from one to three eggs, with two eggs being most common (Massey 1974; Ehrlich *et al.* 1988).

Least tern chicks are semi-precocial (capable of a high degree of independent activity from birth) and are fed small fish by parents within hours of hatching (Massey 1974; Ehrlich *et al.* 1988). Chicks will begin leaving the nest in one to two days (Massey 1974) and fledge at approximately 20 days. Juveniles and adults will fish, loaf, preen, and roost together for several weeks after fledging; adults will continue to feed juveniles during this period (Massey 1974).

California least terns leave nesting areas by August to spend winter months along the west coast of Baja California, the west coast of Mexico, and further south, possibly from the Gulf of California to Guatemala (American Ornithologists' Union (AOU) 1957; Service 1985; Thompson *et al.* 1997).

7.1.3 Range-wide Status and Distribution

For the most recent comprehensive assessment of the species' range-wide status and distribution, please refer to the California Least Tern (*Sterna antillarum browni*) 5-Year Review: Summary and Evaluation (Service 2006). Additionally, in 2009 the Service published a Spotlight Species Action Plan for the California least tern (Service 2009).

Least terns nest along the California coast and the Pacific coast of the Baja California Peninsula, Mexico (Figure 7-1). Approximately 98 percent of breeding least terns nest in the United States, and San Diego Counties, and 75% of the population occurred in these counties in 2016 (Figure 7-2). On the Baja California Peninsula, least terns nest at sites from Ensenada de la Paz in the north to San José del Cabo in the south (Patten and Erickson 1996).

Wintering grounds remain poorly described, but include coastal mainland Mexico, Guatamala, Baja California, Costa Rica, and possibly Peru (Atwood and Minsky 1983, Howell and Webb 1995, Vaucher 1988, Ridgely and Gwynne 1989, Schulenberg *et al.* 1987).

The least tern population has not been intensively studied in Mexico; however, surveys of the Pacific coast of the Baja California Peninsula between 2006 and 2008 did document breeding activity at eight colonies estimating 261 adults and 141 nests (Rosemartin and Van Riper III 2012).

United States surveys from 1971 to 1973 found 624 pairs of least terns at 19 nesting areas in California (Bender 1974a, 1974b). As conservation measures were implemented throughout the 1970s, 1980s, and into the 1990s, the number of least terns increased, peaking at an estimated 7,100 least tern pairs in 2009 (Marschalek 2010). An abundant food supply and active conservation measures, particularly predator management, likely contributed to the observed population growth. Between 2010 and 2016, there was a significant decline in the number of least terns observed. The estimated number of least terns decreased to 6,437 pairs in 2010 (Marschalek 2011), and by 2016 had dropped to estimated 3,989 to 4,661 pairs (Frost 2017), just over half of the 2010 population estimate. The cause of the population decline appears to be reduced productivity, which had been reported beginning in approximately 2001 (Figure 7-3).

Figure 7-1. United States nesting areas of the California least tern (*Sternula antillarum browni*), 2016. Multiple nest sites may be used within the depicted nesting areas.

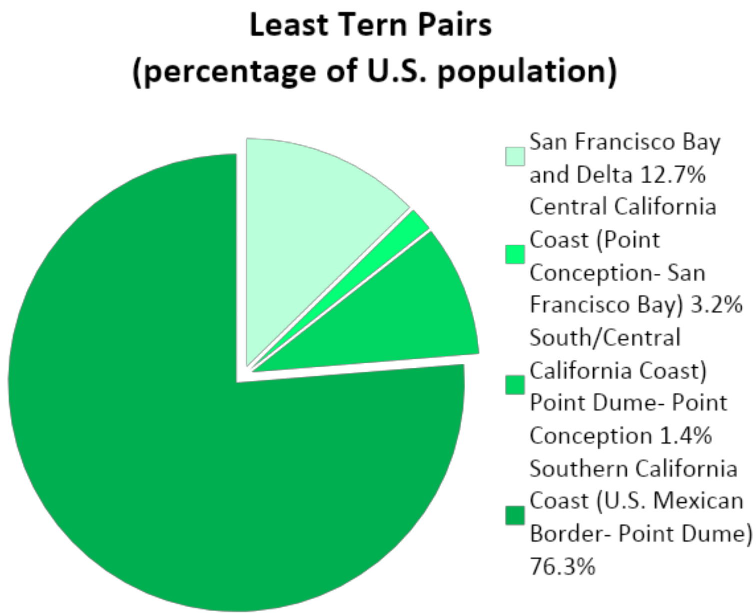

Figure 7-2. 2016 Distribution of California least tern (*Sternula antillarum browni*) nesting pairs by region. Data derived from minimum pair estimates in Frost 2016. Southern California includes San Diego, Orange, and Los Angeles Counties.

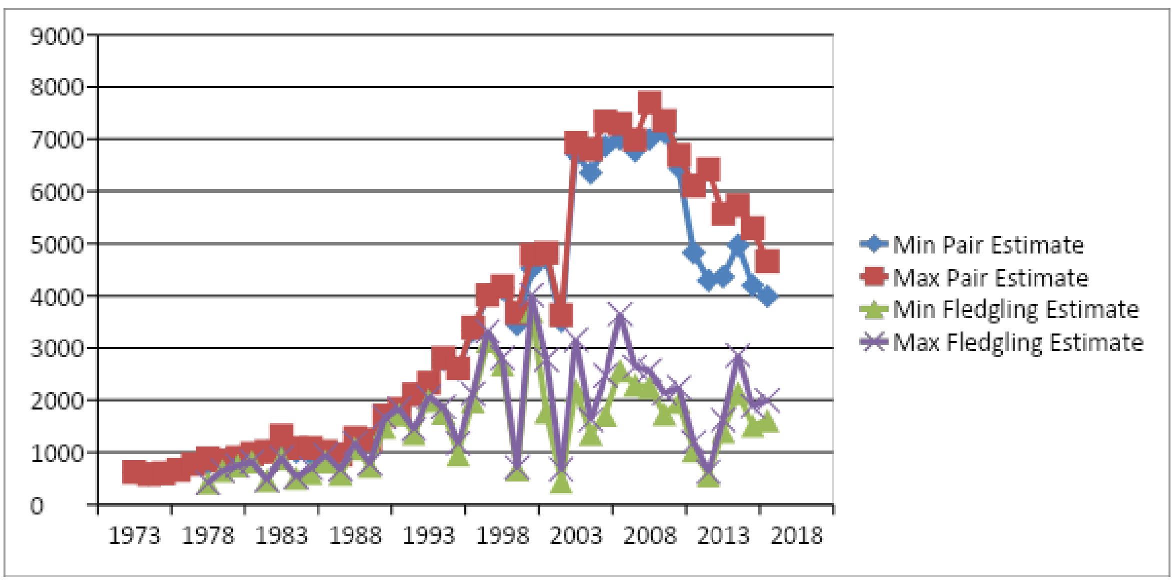

Figure 7-3. Minimum and maximum estimations of breeding pairs and fledglings produced for the California least tern (*Sternula antillarum browni*) in the United States[1]

7.1.4 Threats

[1] **Note:** Statewide surveys with unified methods began in 1973; reliable chick counts began in 1978. Data are from CDFW annual reports (Bender 1974a, 1974b; Atwood *et al.* 1977; Atwood *et al.* 1979; Gustafson 1986; Massey 1988, 1989; Johnston and Obst 1992; Obst and Johnston 1992; Caffrey 1993, 1994, 1995, 1997, 1998; Keane 1998, 2000, 2001; Patton 2002; Marschalek 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012; Frost 2014, 2015, 2016).

At the time of listing, scientists recognized destruction and degradation of nesting habitat as two of the primary threats facing the California least tern (Craig 1971). While many least tern nest sites are now afforded protection, some remain vulnerable to destruction associated with development pressure, and many suffer degradation as a result of close proximity to urbanization (Service 2006). Threats identified in the California Least Tern: 5-Year Review include coastal development, human population growth, and intensified use of beaches, which increase the potential for human activities and disruption in the vicinity of nest sites. The best available scientific and commercial data indicate that the magnitude of these threats will continue to increase as the population in California continues to grow. In addition, climate change, changes in vegetation cover on nesting sites, limited food availability, and predation can result in direct and indirect impacts to the least tern.

The Service's recommendation in the California Least Tern: 5-Year Review was that the California least tern be reclassified from endangered to threatened due to some reduction of impacts of threats and increase in population, recognizing that threats had not been reduced to the point that California least terns would be secure without intensive, site-specific management. We also recommended revisiting the recovery plan, continued management and monitoring of nesting sites, creation of new sites, and expansion of existing sites (Service 2006).

Additionally, since the issuance of the five-year status review, studies and observations continue to see the effects of lower forage fish supply and reduced numbers of breeding pairs and productivity due to El Niño Southern Oscillation Events. With larger storms and tides, loss of breeding areas and washed out nests are likely increase in the future.

7.1.5 Recovery

The primary goals outlined in the 1985 Recovery Plan for the California Least Tern are to prevent extinction and return the California least tern population to a stable, non-endangered status (Service 1985). We state that reclassification to threatened status may be considered if 1,200 breeding pairs in California occur in 15 secure management areas with a 3-year mean reproduction rate of 1.0 (one fledgling per breeding pair) (Service 1985). We also state that delisting may be considered if the population reaches 1,200 breeding pairs distributed in at least 20 of 23 coastal management areas with the following provisions:

- Sufficient habitat to support at least one viable colony (consisting of a minimum of 20 breeding pairs with a five-year mean reproductive rate of at least 1.0 young fledged per year, per breeding pair) at each of the 20 coastal management areas that are managed to conserve least terns (which must include San Francisco Bay, Mission Bay, and San Diego Bay); and
- Assured land ownership and management objectives for future habitat management for the benefit of California least terns, and the security and status of Baja California colonies are assessed for incorporation into recovery objectives (Service 1985).

7.2 Environmental Baseline

Nesting has occurred sporadically with an increase in inland sites from the bay area toward the Delta and Central Valley (Service 2006). Low detections of California least terns have been documented in the Action Area within Suisun Marsh (CDFW 2019). A breeding colony has been documented on the east side of Montezuma Slough near Collinsville in 2006, at a Montezuma Wetlands dredge disposal site. After initially being sighted at Montezuma in 2005, California least terns nested at the site in 2006 and 2007. In summer 2005, approximately 15 to 20 California least terns were observed on a shell mound in Cell 3/4. The next year, California least terns nested on another shell mound in Cell 3/4. The California least terns nested successfully at the project site in 2006 and have nested each year since then. Table 7-1 below presents the number of California least terns observed at the site.

Table 7-1. California least terns observed at Montezuma Wetlands dredge disposal site.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
nests	45	31	35	27	17	15	31	29	16	16	6	9	18
chicks	not counted	16	24	17	23	1	42	19	4	21	5	8	17
fledglings	not counted	6	11	7	5	0	18	2	1	0	1	5	0

The Service has consulted on numerous consultations in the Suisun Marsh in the Action Area with a majority of the consultations being related to on-going maintenance activities or conversion of managed marsh to another use, such as tidal marsh restoration. The June 2013, *Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and Project-Level Actions in Solano County, California* (08ESMF00-2012-F-0602-2) was issued to the Corps to cover projects that fall under the Corps' Regional General Permit, their Letters of Permission, or individual permits in the Suisun Marsh. Example tidal marsh restoration projects that have been consulted on in the Action Area include Tule Red (08FBDT00-2016-F-0071), Blacklock (1-1-06-I-1880), and Montezuma Wetlands (1-1-99-F-12).

7.3 Effects of the Proposed Action

7.3.1 Tidal Habitat Restoration in Suisun Marsh

Depending on the nature, scope, location, and timing of restoration actions associated with individual restoration projects, there is a potential to adversely affect California least terns during implementation of construction, long-term management, or monitoring activities. Reclamation has proposed to implement restoration projects consistent with conservation measures identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp. Based on implementation of these conservation measures, all construction-related activities during the breeding season in the vicinity of active nests would be avoided as described in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

Construction activities may disturb California least terns. If present, California least terns moving through the Suisun Marsh and surrounding areas seeking out suitable nesting habitat or to forage in the bays, sloughs, and managed wetlands individuals may be affected or disturbed altering their normal behavior. Restoration construction may require the use of heavy equipment such as excavators, back hoes, bulldozers, and dump trucks in order to reconstruct interior site elevations, create levees, and breach levees. Noise and vibrations created by heavy equipment may also temporarily disturb individuals. However, due to their highly mobile nature and ability to forage in a variety of habitats it is unlikely that these activities will cause substantial disturbance to California least terns.

It is expected that construction activities would not significantly affect foraging habitat because open water habitat is abundant in the Suisun Marsh. Conversion of suitable habitat in managed wetlands to tidal wetlands would result in an increase in foraging habitat because the tidal wetland restoration areas would be subject to tidal action and therefore would be inundated permanently or more frequently than under existing managed wetlands. As the restored areas evolve into a functioning tidal wetland, it will continue to provide suitable habitat for the California least tern.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation. This could include tiering or appending to the existing Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

7.3.2 Suisun Marsh Salinity Control Gates (Proposed Flow Changes)

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. Depending on the timing of the proposed operations, SMSCG operations may overlap with the California least tern late breeding season and potential presence in the Suisun Marsh to forage. California least terns hunt smaller fish such as silversides, perch, anchovies, small crustaceans, and other smaller fish (Service 1985). SMSCG reoperations are expected to temporarily lower marsh salinities creating a potential shift in their prey base availability in Suisun Marsh. However, foraging is readily available in the Suisun Marsh and the restoration and enhancement projects are expected to increase food quality of habitat available to the California least tern. Adverse effects to California least terns are not expected to occur. If through planning and implementation of the project-level activities, adverse effects to the California least tern are realized and were not analyzed herein, reinitiation will occur.

7.4 Effects to Recovery

Reclamation has proposed to minimize and avoid adverse effects from tidal marsh restoration by implementing conservation measures consistent with those identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp to promote the recovery of California least terns. Implementation of restoration actions in the Suisun Marsh may result in short-term adverse effects to California least terns in order to gain an increase in long-term habitat benefits, thereby assisting in the recovery of this species. Therefore, we conclude that the PA would not negatively affect, and may contribute to, recovery of the California least tern.

7.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect California least tern. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the California least tern.

7.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the California least tern.

7.6.1 Reproduction

California least terns are known to breed and nest at one location in the Suisun Marsh. Pre-construction surveys associated with an individual tidal marsh restoration project will inform other potential locations. Consistent with the conservation measures identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp, the PA will avoid effects to nesting or breeding individuals and their nest from restoration construction activities. Therefore, the PA is not expected to negatively affect California least tern reproduction range-wide, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

7.6.2 Numbers

With implementation of the PA, no mortality or injury of individuals are expected to occur from tidal marsh restoration. Restoration actions would contribute to the recovery of California least tern by creating more foraging habitat for California least terns. Therefore, the PA is not expected to reduce the number of California least terns.

7.6.3 Distribution

The number of California least terns in the Suisun Marsh are relatively low in relation to the species' population numbers range-wide. Although there is the potential to disturb individuals in a way that may result in altered normal behavior, it is still expected that these activities will not cause substantial disturbance to California least terns. California least terns are highly mobile birds with the ability to forage in a variety of habitats throughout the Suisun Marsh. Implementation of conservation measures will minimize the potential for disturbing California least terns. Therefore, we do not expect the PA to reduce the species' distribution relative to its range-wide condition.

7.7 Conclusion

After reviewing the current status of California least tern, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of California least terns likely to be affected by the PA will be low relative to the number of California least terns range-wide.
2. Reclamation has proposed to implement the conservation measures proposed in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.
3. The PA is being implemented in a manner that will restore and create more suitable, sustainable habitat for the California least tern long-term.

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8.0 GIANT GARTER SNAKE

8.1 Status of the Species

The Service published a proposal to list the giant garter snake as an endangered species on December 27, 1991 (56 FR 67046). Critical habitat has not been designated for this species. The Service reevaluated the status of the snake before adopting the final listing rule, and it was listed as a threatened species on October 20, 1993 (58 FR 54053). A Draft Recovery Plan was proposed for the snake on July 2, 1999 (Service 1999) and revised in 2015 (Service 2015). A 5-year review was conducted in 2006 where no change of status was recommended (Service 2006). An additional 5-year review was conducted in 2012 where no change of status was recommended (Service 2012). In 2017, the Service issued the final *Recovery Plan for the Giant Garter Snake* (*Thamnophis gigas*) (Recovery Plan) (Service 2017). Please refer to the 2017 Recovery Plan for the species' description, habitat preference, and life history.

8.1.1 Habitat Loss

Historical records suggest that the giant garter snake inhabited freshwater marshes, streams, and wetlands along with their adjacent associated upland habitats throughout the length of the Sacramento and San Joaquin valleys in Central California. Today only about 5 percent of its historical wetland/upland habitat acreage remains. Nine populations are recognized in the Recovery Plan following an update of the thirteen populations described in the original listing. This change is based on recent surveys, which indicate that two populations were extirpated, and on genetic research, which led to the grouping together of some of the previously described populations.

The loss and subsequent fragmentation of habitat is the primary threat to the giant garter snake throughout the Central Valley of California. Habitat loss has occurred from urban expansion, agricultural conversion, and flood control. Habitat fragmentation has ultimately resulted in the snake being extirpated from the southern one-third of its range in the San Joaquin Valley.

8.1.2 Other Threats

In addition to large landscape level habitat conversion, the Sacramento/San Joaquin Delta populations of the giant garter snake are subject to a number of other existing and potential threats which include roads and vehicular traffic, climate change, and predation by non-native species. The recovery strategy is primarily 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. This strategy ultimately supports the recovery goal of establishing and protecting self-sustaining populations of the giant garter snake throughout the full ecological, geographical, and genetic range of the species.

Climate change has been linked to increases in the frequency and intensity of weather events, such as heat waves, droughts, and storms (Lenihan *et al.* 2003; California Climate Action Team 2006; IPCC 2007). Extreme events, in turn may cause mass mortality of individuals (by affecting habitat or ecosystem characteristics, for example) and significantly contribute to determining which species will remain or occur in natural habitats (Whitfield *et al.* 2007). As California's average temperature and precipitation change, species ranges tied to climate dependent habitats are moving northward and upward, but in the future, range contractions are more likely than simple northward or upslope shifts (Loarie *et al.* 2008, 2009). Research has already revealed correlations between climate warming and declines in amphibians and reptiles in different parts of the world (Whitfield *et al.* 2007; McMenamin *et al.* 2008; Mitchell *et al.* 2008; Huey *et al.* 2010).

There are three habitat components that appear to be most important to the giant garter snake (G. Hansen 1982, 1986, 1988; Wylie *et al.* 1996, 1997; Halstead *et al.* 2010). A freshwater aquatic component with protective emergent vegetative cover that will allow foraging, an upland component near the aquatic habitat that can be used for thermoregulation and for summer shelter in burrows, and an upland refugia component that will serve as winter hibernacula. Further detailed descriptions of these habitat components can be found in the Recovery Plan.

The giant garter snake is considered a semi-aquatic species and due to its habitat preferences, giant garter snake is subject to the detrimental effects of floods and drought. This is likely to be exacerbated with the increase in frequency and intensity of flood and drought events due to climate change. Giant garter snakes may be displaced during a flood, buried by debris, exposed to predators, and subject to drowning when burrows and over-wintering sites become inundated with water. Giant garter snakes are not known to occupy the area within the Sutter Bypass which is flooded regularly (Wylie *et al.* 2005); although snakes are known to occupy the Yolo Bypass during the active season when flooding is unlikely (E. Hansen 2009). Snakes appear to survive at least some inundation of their burrows. Wylie observed snakes emerging from burrows after a period of inundation (G. Wylie pers comm. 2016).

Because of the giant garter snake's dependence upon permanent wetlands, water availability will play a significant role in its survival and recovery. In a state where much of the wetland habitat is maintained by managed water regimes, the lack of sufficient water supply may preclude consistent and timely delivery of water to sustain suitable habitat for giant garter snake. Drought conditions place additional strains on the water allocation system. Where populations currently persist on only marginal habitat, emergent drought or higher temperature conditions are likely to result in high rates of mortality in the short term with the effects of low fecundity and survivorship persisting after the drought has ceased (McMenamin *et al.* 2008; Mitchell *et al.* 2008). It is unknown how quickly giant garter snake populations may rebound after severe climatic conditions, particularly since these conditions might further exacerbate the impact from existing threats to giant garter snake, such as habitat loss and fragmentation, and small, isolated populations. Giant garter snake as a species has survived recorded historic droughts, but presumably under conditions where fewer cumulative threats existed.

Nearly all of the research on movement for the giant garter snake has been conducted on individuals in the Sacramento Valley; however, the geography in the Sacramento/San Joaquin Delta is comparably different to the Sacramento Valley due to the island structure of the Delta. These islands are surrounded by numerous large water bodies, large tributaries and experiences a significant tidal influence from the San Pablo and San Francisco Bays. Giant garter snakes have been found on the various islands in the Delta and utilization and/or the frequency to which they use the large rivers and open tributaries surrounding these islands for dispersal is currently unknown. Giant garter snakes are apparently capable of long-distance movements, although less movement is observed when water is maintained on-site through the summer that supports their habitat (Wylie *et al.* 2002a,b). Movement statistics of giant garter snakes vary greatly and it is likely that their movement is different due to the geographical difference of the Delta to the Sacramento Valley. Based on the research conducted in the Sacramento Valley, Hansen (1986) reported that individuals move less than 100 ft (30.5 m) during the spring in favored habitat. At the Colusa Drain, distances between captures of individuals ranged from 0.7 to 3.3 km (Wylie 2003). Using radio telemetry at the same location in 2006, individual mean movement distance was 63 m/day (range of 3–173 m/day), with a corresponding individual movement rate of 104 m/day (range of 12–287 m) during the "active season" (Wylie and Amarello 2006). Mean maximum individual movement distance was 862 m (range of 34–2,791 m), and total movement over the time radio-tracked averaged 4,761 m (range of 107–16,995 m) Wylie and Amarello 2006). Active-season minimum total distance moved at the same site in 2004 ranged from 0.7 to 215 km (Wylie and Martin 2004c).

8.2 Environmental Baseline

Three populations described in the Recovery Plan occur in the Action Area.

Yolo Bypass Population. The Yolo Bypass is a leveed, 59,300-acre floodplain located about 5 miles west of Sacramento. It is California's largest contiguous floodplain and provides valuable habitat for a wide variety of aquatic and terrestrial species (Sommer *et al.* 2001). When flooded, the Yolo Bypass provides up to about 59,300 acres of shallow floodplain habitat, with a typical mean depth of 6.5 feet or less. Depending on the amount of flow, the size of the flooded area of the Yolo Bypass can range from 1.2 to 6 miles wide over its 41-mile length (Sommer *et al.* 2008). The 16,770-acre Yolo Bypass Wildlife Area (YBWA) is located in the Yolo Bypass from the railroad crossing just north of the I-80 causeway between West Sacramento and the City of Davis, California. The YBWA is managed by CDFW for recreation, hunting and environmental education. The YBWA is bounded to the west and east by the bypass levees with a small portion lying outside the western levee. Elevations vary with some areas remaining dry during all but the highest Yolo Bypass flood levels. The eastern bypass levee separates the Yolo Bypass from the Sacramento River Deep Water Ship Canal.

Portions of the YBWA are managed as prime farmland to grow crops that provide valuable habitat for a diversity of wildlife species. Rice crops provide habitat for a variety of waterfowl and giant garter snakes. The YBWA includes a variety of created and natural wetlands. Some of these wetlands are permanently flooded with islands and shallow underwater shelves while others are managed as seasonal wetlands that are flooded up during the waterfowl over-wintering and migration seasons and drained from April through August. These wetland systems are connected with agricultural fields through a variety of drainage facilities including pumps, delivery ditches, water control structures, and drainage systems.

There are 39 records in the California Natural Diversity Database (CNDDB) (CDFW 2018) of giant garter snakes in the Yolo Bypass with the majority of sightings located at the upper portion of the Bypass between Interstate 5 and Interstate 80 in a location known as Conaway Ranch. The most recent occurrence was documented in 2017 in the Southern portion of the Bypass along Shag Slough near Liberty Island. Field research conducted by Brian Halstead of U.S. Geological Survey (USGS) - Western Ecological Research Center captured several giant garter snakes in the southern portion of the Bypass in Lookout Slough (B. Halstead pers. comm. 2019).

Delta Basin Population. The Action Area includes the sub-population in the Delta Basin Population and Recovery Unit as defined in the Recovery Plan for Giant Garter Snake (Service 2017). The Delta Basin includes portions of Sacramento, Yolo, Solano, Contra Costa, and San Joaquin counties. A large portion of the Sacramento-San Joaquin Delta area has not been comprehensively surveyed for the giant garter snake, primarily because the majority of land is privately owned. The population status of giant garter snakes in the Delta is relatively undetermined and likely underestimated because sightings are sporadic in time and distance. As an example, an individual giant garter snake was sighted on Sherman Island near the Antioch Bridge in 1987 with a single reoccurring sighting in 2012 (CDFW 2012) and a newer sighting in April of 2016 (Service 2016). A documented sighting of a dead individual was recorded around Empire Cut in the south Delta (CDFW 2010), a live individual was found at Webb Tract in the central Delta (CDFW 2014), and the most recent occurrences of several live and one dead individual were found in the riprap shoreline on Jersey Island with another possible individual sighted across the waterway by the landowner on Bradford Island during the installation of the 2015 rock drought barrier on False River (DWR 2015). Up to six confirmed sightings of individuals on Sherman Island, Twitchell Island, and Bradford Island have been documented since March of 2016 (Service 2016). Most recently, seven giant garter snakes were observed basking in the riprap shoreline of Jersey Island during a pre-construction survey on May 31, 2017. Seven giant garter snakes were again documented the following day on June 1, 2017. Ten snake skin sheds, presumed to be giant garter snakes from the visible faint stripe patterning, were also documented in the same vicinity (Stillwater Sciences 2017).

The recent sightings within the last seven years were mostly by chance and not part of focused surveys which in contrast have had difficulty detecting giant garter snakes in the Delta. Swaim Biological Consulting conducted a series of surveys for giant garter snakes from 2004 to 2005 near the City of Oakley in Contra Costa County, which comprises a large portion of the Hotchkiss Tract immediately south of Bethel Island. No giant garter snakes were found although the trapping effort included both aquatic and terrestrial trap-lines, and was conducted during the active season for the snake (Swaim 2004, 2005a, 2005b, 2005c, 2005d, 2006). DWR also conducted a trapping survey of various sites within the Delta including Sherman Island and Holland Tract that met habitat assessment criteria for giant garter snakes during the summer of 2009 (DWR 2010). No giant garter snakes were trapped or observed during those surveys either.

Currently, the only known source population for giant garter snakes in the Delta region is located in the Eastern Delta at Caldoni Marsh near the City of Stockton. However, it is unlikely that the recent occurrences of giant garter snakes found in the Central and Western Delta originated from Caldoni Marsh considering the distances of those occurrences from Caldoni Marsh, the distances between occurrences, and the estimated dispersal range from telemetry studies. The recent number of documented occurrences within close proximity of each other in the western portion of the Delta suggests there is likely a reproducing population of giant garter snakes in this region. It should also be noted that giant garter snakes in this area are evidently using a habitat feature such as riprap along the edge of a large body of moving water like the San Joaquin River that other giant garter snakes have not been observed using with any frequency elsewhere.

Large (400 - 700 acres) non-tidal wetland restoration efforts were conducted both on Sherman Island through DWR and on Twitchell Island through a partnership of DWR and Ducks Unlimited. These non-tidal inter-island wetlands provide high quality habitat that could support a giant garter snake population. Otherwise, it is largely unknown whether other reproducing source populations of giant garter snakes occur within the various wetland habitats of the Central and Western Delta. Focused surveys in these areas are hindered either due to inaccessibility to privately owned lands or lack of resources.

Colusa Basin Population. The Action Area includes the sub-population in the Colusa Basin Population and Recovery Unit as defined in the Recovery Plan for Giant Garter Snake (Service 2017). The Colusa Basin Recovery Unit is comprised of mostly agriculture lands predominantly in rice production which also include the Sacramento National Wildlife Refuge (NWR), the Delevan NWR, Glenn-Colusa Canal, Colusa Trough, Colusa Drain, and several wetland habitats between the towns of Chico and Woodland from north to south and between the western edge of the Sacramento Valley to the Sacramento River from west to east.

There are 81 records in the CNDDB (CDFW 2018) of giant garter snakes in the Colusa Basin Recovery Unit. The USGS has conducted trapping surveys of giant garter snakes at the Sacramento NWR Complex (Wylie *et al.* 1997, 2000, 2002b). Wylie, in conjunction with Refuge staff, observed giant garter snakes at each of the Federal wildlife refuges (Colusa, Delevan, and Sacramento) that comprise the Sacramento NWR complex. Wylie *et al.* (2000a, 2002a) located 81 and 102 giant garter snakes, respectively, in the years 2000 and 2001 within the Colusa NWR. It is also documented that giant garter snakes occur outside of NWR lands in the adjacent rice production areas. The Colusa NWR represents a stable, relatively protected sub-population of snakes within the Colusa Basin Colusa NWR and continues to reflect a healthy population of giant garter snakes with successful recruitment of young (Wylie *et al.* 2004a, 2005).

Outside of protected areas, however, giant garter snakes in the Colusa Basin clusters are still subject to all threats identified in the final listing rule, including habitat loss due to development, fluctuations in the number of acres in rice production, maintenance of water channels, and secondary effects of urbanization. Restored areas that provided summer water were more effective in meeting the habitat needs of giant garter snakes; therefore, giant garter snakes 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. The aquatic component of the habitat is important because the snake forages on frogs, tadpoles and fish. The 2005 Monitoring Report for the Colusa NWR (Wylie *et al.* 2005) concluded that, "The management of the Colusa Refuge for GGS, which began with the restoration of Tract 24, has clearly benefited the snakes in the restored wetlands and other habitats by maintaining and increasing stable summer water habitats for the snakes, maintaining connectivity among wetland habitats and carefully managing marsh vegetation."

Stony, Logan, Hunters, and Lurline Creeks, as well as the Colusa Drain, and Glenn-Colusa, Tehama Colusa, and Colusa Basin Drainage Canals, and associated wetlands, are important as snake habitat and movement corridors for giant garter snakes. These waterways and associated wetlands provide vital permanent aquatic and upland habitat for snakes in areas with otherwise limited habitat (Wylie *et al.* 2005).

There are three established giant garter snake conservation banks in the Action Area. The Colusa Basin Mitigation Bank has restored and conserved 163 acres for the giant garter snake, the Ridge Cut Giant Garter Snake Conservation Bank has restored and conserved 185.9 acres for the giant garter snake, and the Pope Ranch Conservation Bank (which all credits have been sold and is inactive) has restored and conserved 391 acres for the giant garter snake. Habitat has also been preserved, created, or restored in the Action Area as a result of section 7 consultations between the Service and other Federal agencies. Projects such as the Sherman Island Whale's Mouth Wetland Restoration Project (Service File No. 08FBDT00-2014-F-0027) restored approximately 600 acres of palustrine emergent wetlands and the Twitchell Island East End Habitat Restoration Project (Service File No. 08FBDT00-2013-I-0013) restored approximately 740 acres of palustrine emergent wetlands in the western portions of the Sacramento-San Joaquin Delta.

There are various section 7 consultations with biological opinions for giant garter snake that occur throughout the Action Area. Large scale habitat restoration projects such as the Prospect Island Habitat Restoration Project (Service File No. 08FBDT00-2018-F-0069) will convert portions of terrestrial habitat that could be utilized by giant garter snake to aquatic habitats for fish species. The Corps dredges the Sacramento and Stockton Deep Water Shipping Channels annually and deposits the dredged material into landside placement sites throughout the Delta that have or are near suitable habitat for giant garter snake (Service File Nos. 08FBDT00-2017-F-0098, 08FBDT00-2017-F-0099). CDFW was issued a grant from the Service to conduct routine vegetation maintenance and to manage wildlife habitat for waterfowl and other species that utilize emergent wetland habitats throughout the YBWA. This requires the use of mowers and other large equipment to operate within suitable habitat for giant garter snake (Service File No. 08FBDT00-2012-F-0011). Several flood protection projects such as the Twitchell Island Levee Improvement Project (08FBDT00-2015-F-0023) proposed to repair or build new levees that have or were near suitable giant garter snake habitat.

8.3 Effects of the Proposed Action

8.3.1 Seasonal Operations

Operations of the pumping facilities are not expected to affect giant garter snake; however, if aquatic habitat in the Delta may be affected by changing in-Delta land management (Colusa Basin Drain Food Web Routing) as a result of water quality changes by the PA, reinitiation may be necessary.

8.3.2 Colusa Basin Drain Food Web Routing

Reclamation determined that increasing flows into the Yolo Bypass during late summer and fall would be expected to increase surface water and improve habitat conditions for giant garter snake in the Yolo Bypass; and therefore, would have a beneficial effect on giant garter snake. While some of this may be true in portions of the bypass, the BA did not specify where in the Colusa Drain or in the Yolo Bypass those effects would be beneficial or if there are potential adverse effects from increased flood flows. It is unknown how this proposed movement of water in late summer and fall will have an effect on foraging opportunities or affect cover for sheltering and the opportunity to evade predators. It is possible that flood flows in the late summer could create conditions that make the water too swift to allow for successful foraging, create more open water with reduced edge habitats from which giant garter snake forage, create more open water that encourages the recruitment of large predatory fish, and/or reduce upland habitats that giant garter snakes require for brumation/aestivation. It is also unknown how the increase in flood flows would affect the giant garter snake's prey base. Following the spring mating season, birthing for giant garter snake occurs from mid-July to early October with average litter size of 17 young (Halstead *et al.* 2011). The Proposed Action is proposed to occur during an important time for young of the year when they are actively foraging in order to grow quickly and increase their chances of surviving through the winter and into the following year. Gravid females are also actively foraging and the size of the young is heavily linked to availability of food resources in any given year (Halstead *et al.* 2011). It is possible that the Proposed Action could increase the giant garter snake's prey base and be beneficial. Conversely, it is also possible that the Proposed Action could adversely affect the giant garter snake's food base by decreasing food abundance or changing the prey base. These adverse effects, if they occur, are not expected to be of a significant magnitude and will likely be short-term.

This action is addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

8.3.3 Delta Cross Channel Improvements

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, the physical improvements of the Delta Cross Channel structure could result in loss of up to 0.2 acre of upland and 0.4 acre of aquatic habitat for giant garter snake. Effects for construction activities associated with the Delta Cross Channel are the same as described below in the Tidal Habitat Restoration. Because the footprint of any improvements would be very small, this is not expected to result in long-term negative impacts to this species.

This action is addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

8.3.4 Tidal Habitat Restoration

Construction and ground disturbing activities related to tidal habitat restoration are likely to adversely affect giant garter snake. Construction activities at each site will likely include ground clearing, grading, and vehicular use including transport of construction equipment and materials. Giant garter snake may be killed or injured by vehicles and heavy construction equipment used as part of the restoration. This effect would be most likely to occur during site clearing (up to several days at each location). Vehicle strikes are a common threat to giant garter snake and several occurrence records of giant garter snake in CNDDB are from dead individuals found along roadsides which were struck by vehicles. Giant garter snakes commonly use roadside ditches for movement corridors or for foraging and are known to use roadsides for basking sites. The recent documented observations of giant garter snakes using riprap along major river levee banks also show that giant garter snakes can use this habitat for basking and sheltering and possibly for foraging or brumation/aestivation. This makes giant garter snakes highly vulnerable to vehicle strikes as giant garter snakes bask on the road or cross back and forth over roads from the various suitable aquatic and upland habitats.

Associated equipment noise, vibration, and increased human activity may interfere with normal behaviors. These behaviors include feeding, sheltering, movement between refugia and foraging habitats, and other essential behaviors of giant garter snake. Project related activities that occur in areas that have suitable habitat but create intolerable levels of disturbance may force individuals from cover and potentially subject them to circumstances that otherwise would not occur and could result in an increased threat to their survival such as predation.

Tidal habitat restoration may also result in conversion/loss of suitable aquatic and upland habitat into less suitable tidal wetlands. Natural food sources may also be reduced as a result of habitat disturbance and loss. Short-term temporal effects will occur when vegetative cover is removed within upland habitat during project implementation, which may also subject this species to an increased risk of predation. Since snakes use small mammal burrows, soil crevices, and/or rock crevices for shelter for brumation during the winter season and aestivation during extremely hot days during their active period, the PA will likely have some adverse effect by causing snakes to move away from suitable habitat or by disrupting brumation/aestivation if snakes are occupying a burrow or rock outcropping. As ground squirrel burrows can be deep and long, maintenance equipment may come into direct contact with an aestivating snake and a snake could be killed from ground disturbing activities. Snakes in terrestrial habitat may also become entombed under soil, crushed or damaged by equipment or personnel, thereby resulting in harm or mortality to individuals.

These actions associated with Tidal Habitat Restoration are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation. Reclamation is proposing to minimize the adverse effects of the loss of suitable habitat that cannot be avoided from these future restoration projects by implementing actions to promote the recovery of the affected species in a manner where the mitigation is commensurate with the adverse effect. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a rate of 3:1 as described in Appendix E Section E.2.4.1 of the BA.

8.4 Effects to Recovery

For a species like the giant garter snake that has lost much of its former habitat, recovery would necessitate the conservation of much of the remaining habitat that still supports it. For future habitat restoration projects associated with the Proposed Action, Reclamation is proposing to minimize the adverse effects of the loss of suitable habitat that cannot be avoided by implementing actions to promote the recovery of the affected species in a manner where the mitigation is commensurate with the adverse effect. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a rate of 3:1 as described in Appendix E Section E.2.4.1 of the BA. Habitat loss and degradation are contributing factors to the decline of giant garter snake; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the giant garter snake. Consequently, we conclude that the PA would not interfere with the recovery of the giant garter snake.

8.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect giant garter snake. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the giant garter snake.

8.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to the reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the giant garter snake.

8.6.1 Reproduction

The giant garter snake is found in the Action Area and several occurrences have been documented from 2013 to 2018 in the western Delta (CDFW 2019; DWR 2015; Service 2019; Stillwater Sciences 2017) and giant garter snakes have been continuously documented throughout the Sacramento Valley (CDFW 2019; Service 2017). The Proposed Action may reduce local reproduction as disturbances from construction and the removal of habitat are likely to interfere with normal giant garter snake mating behaviors and fecundity. In areas that will experience construction actions, it is anticipated that disturbance would cause a reduction in reproductivity; however, this is anticipated to result in loss of a relatively small number of giant garter snakes and the Service anticipates that giant garter snakes will be able to recover the loss of reproduction potential in habitat areas that are not proposed to experience significant habitat loss (future restoration projects associated with the programmatic actions in the PA). It is anticipated that the effects will not reduce the range-wide reproductive capacity of the species.

8.6.2 Numbers

The bulk of the giant garter snake's population occurs in the Sacramento Valley with smaller populations located in the Delta and in the San Joaquin Valley (CDFW 2019; Service 2017). We anticipate the PA may result in adverse effects to the giant garter snake; however, it is unknown the extent or the number of giant garter snake that will be affected as the BA did not specify to what extent those effects would be from increased flood flows. Therefore, it is unknown if the PA would reduce the number of giant garter snakes within a portion of the Action Area. However, it is anticipated to reduce the giant garter snake's numbers outside of the Action Area and we conclude that the overall number of giant garter snakes throughout the species' range is not expected to decline.

8.6.3 Distribution

The number of giant garter snakes likely to be affected by Proposed Action activities is unknown as the BA did not specify to what extent those effects would be from increased flood flows; however, the Service anticipates that the PA will not alter the distribution of the giant garter snake and we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition because effects from the proposed flood flows would be confined to the Colusa Drain and YBWA within the Yolo and Delta Basin subpopulations. Any effects on distribution from future habitat restoration associated with the PA will be addressed separately as part of that specific project analysis.

8.7 Conclusion

After reviewing the current status of the giant garter snake, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of giant garter snakes likely to be affected by PA activities is proportionally small compared to the overall range-wide numbers.

2. Reclamation has proposed conservation measures to avoid and minimize potential effects for future habitat restoration or construction projects that are associated with the PA.

3. Reclamation proposes to restore or protect habitat that could support the giant garter snake as described in Appendix E Section E.2.4.1 of the BA.

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9.0 LEAST BELL'S VIREO

9.1 Status of the Species

Least Bell's vireo is one of four subspecies of Bell's vireo and is the only subspecies that breeds entirely in California and northern Baja California. All *Vireo bellii* individuals in California (aside from the far southeastern edge of the state) are reasonably certain to be members of the Federal and State protected least Bell's vireo subspecies (Klicka *et al.* 2016). The Service listed the least Bell's vireo as endangered on May 2, 1986 (51 FR 16474). Critical habitat was designated for least Bell's vireo on February 2, 1994, consisting of ten units across Santa Barbara, Ventura, Riverside, and San Diego counties (59 FR 4845). Critical habitat does not occur within the Action Area; therefore, it will not be addressed further in this BiOp.

Large-scale loss of habitat reduced the number of sites where it breeds and curtailed its numbers; nest parasitism by the brown-headed cowbird (*Molothrus ater*) reduced nesting success within much of the remaining breeding habitat. At the time of listing, the Service estimated that 300 territorial males remained in the United States.

9.1.1 Recovery Plan

The draft recovery plan for the least Bell's vireo (Service 1998) describes a strategy for securing and managing riparian habitat within its historical breeding range; the Service also recommended annual monitoring, range-wide surveys, and research to monitor and guide recovery. Specifically, the draft recovery plan recommends the criteria for achieving threatened status as stable or increasing populations or metapopulations, each consisting of several hundred or more breeding pairs that are protected and managed at 11 sites along the central and southern California coast and in the vicinity of Anza Borrego in the desert. Recommended delisting criteria include meeting the goal for threatened status, establishing increasing populations or metapopulations along the Salinas River and in the San Joaquin and Sacramento valleys, and a reduction or elimination of threats to the point where least Bell's vireo populations can persist without significant human intervention. Recovery Action 1 of the Recovery Plan directs the Service to "Protect and manage riparian and adjacent upland habitat within the least Bell's vireo's historical range" (Service 1998).

9.1.2 Five-Year Review

The Service completed a 5-year review of the status of the least Bell's vireo in 2006 (Service 2006c). We are incorporating the document by reference to provide additional information relevant to the status of the species. The following paragraphs provide a summary of the relevant information in the 5-year review; unless otherwise noted, all of the following information is from the 5-year review.

In our 5-year review, we recommended revising the status of the species from endangered to threatened because of a ten-fold increase in abundance since listing, expansion of breeding locations throughout southern California, and conservation and management of suitable breeding habitat throughout its range. By 2005, the Service was aware of approximately 2,968 known territories in the United States with the greatest increases in San Diego and Riverside counties. The number of pairs in Orange, Ventura, San Bernardino, and Los Angeles counties also increased substantially; a few isolated individuals and breeding pairs have also been observed in Kern, Monterey, San Benito, and Stanislaus counties. Since publication of our 5-year review, surveys have detected breeding territories along the Amargosa River in the northern Mojave Desert (McCreedy and Warren 2015a) and Whitewater Canyon, Chino Canyon, and Mission Creek in the Coachella Valley (Hargrove *et al.* 2014). The increase in the abundance of least Bell's vireos since the listing is primarily due to efforts to reduce threats such as loss and degradation of riparian habitat and parasitism by brown-headed cowbirds. The control of invasive plants has also increased the amount of suitable habitat available for nesting.

The 5-year review also contained several recommendations for future management of the least Bell's vireo. These recommendations are to finalize a recovery plan for the least Bell's vireo with realistic, objectively based recovery goals; provide funding and technical support for further studies investigating continuing threats from parasitism by brown-headed cowbirds and invasion of riparian habitats by exotic plants, and potentially elevated predation pressures due to habitat fragmentation or presence of exotic predators; develop and implement a systematic program to survey the Salinas, San Joaquin, and Sacramento Valleys and inform future management; and develop systematic survey programs for watersheds in southern California that are not regularly surveyed within a given 5-year period.

Since the completion of the 5-year review, the Service has issued numerous biological opinions that addressed effects of Federal actions on the least Bell's vireo; the biological opinions concluded that the actions were not likely to jeopardize the continued existence of the least Bell's vireo primarily due to avoidance of construction impacts during the breeding season. Most of these biological opinions addressed effects from urban development, transportation, military readiness, and utility transmission projects. Five biological opinions addressed regional-scale habitat conservation plans regarding urban development and conservation of listed species using an ecosystem-level planning approach. These regional plans identify conservation targets, monitoring needs, and adaptive management strategies for the least Bell's vireo. These plans are expected to provide long-term protection, monitoring, and management of core occurrences of vireos in Kern, Riverside, Orange, and San Diego counties.

The 5-year review does not discuss water infrastructure projects such as dams, in-channel diversions, or flow alternation with regard to the threats it may pose to least Bell's vireos. The 5-year review noted that in many situations where riparian habitat is impacted by authorized Federal and State actions, an equal or greater amount of riparian habitat is restored (i.e., through active planting and maintenance of riparian habitat) or enhanced (i.e., through giant reed [*Arundo donax*] and other exotic plant removal) to offset the impacts. There have been many localized restoration efforts and improved condition overall of southern California's riparian habitats since the vireo was listed. However, development adjacent to riparian zones is a threat to the species. Vireo territories bordering on agricultural and urban areas are less successful in producing young than territories bordering on native upland plant communities (Kus 2002).

West Nile virus may affect some groups of birds disproportionately, either temporarily or persistently (George *et al.* 2015). For example, George *et al.* (2015) found that red-eyed vireos (*Vireo olivaceus*) "experienced significant declines in survival associated with the arrival of [West Nile virus], followed by recoveries to pre-[West Nile virus] levels. Conversely, warbling vireos (*Vireo gilvus*) experienced smaller annual declines in survival than red-eyed vireos after the arrival of West Nile virus but the survival rate continued to decline in subsequent years. We do not know how West Nile virus would affect the least Bell's vireo over time.

9.1.3 Reproduction

The main impediments to successful reproduction for least Bell's vireos are nest parasitism by brown-headed cowbirds and availability of suitable breeding habitat. We expect that the continued management of brown-headed cowbirds and restoration of riparian habitat is likely to allow for the continued successful reproduction of the least Bell's vireo within its current breeding range in southern California.

Brown headed cowbirds are abundant throughout the Central Valley where there is an ample supply of ruderal habitat and the nests of host bird species. Brown-headed cowbirds are an invasive species and were not recorded west of the Colorado River before 1870. Their range expanded west and north at a rapid rate through the early 1900's (Laymon 1987). The extent of cowbird management in the Central Valley and its effectiveness is unknown.

There are two necessary habitat features for least Bell's vireo to breed: (1) the presence of dense cover within 1-2 meters of the ground, where nests are typically placed; and (2) a dense, stratified canopy for foraging (Goldwasser 1981; Gray and Greaves 1981; Salata 1981; RECON 1989). Least Bell's vireo will nest in a variety of plant species, provided that the overall habitat structure is present. A major component of habitat structure is willow species of various ages across the landscape. Young willows and sandbar willows provide dense cover from the ground up to several meters. As Goodding's black willow (*Salix gooddingii*), red willow (*Salix laevigata*), and arroyo willow (*Salix lasiolepis*) grow, larger branches lift the canopy over California wild rose (*Rosa californica*), poison oak, California blackberry, and California grape creating a layered structure for nesting and foraging. Least Bell's vireo may attempt as many as five nests in a breeding season (March 15 to July 15), although most fledge young from only one or two nests. The likelihood of re-nesting depends on the time of season, the pair's previous reproductive effort, the success of previous efforts, and other factors. Few nests are initiated after mid-July.

The recent invasion of the polyphagous shot hole boring beetle (*Euwallacea fornicates*) into southern California riparian habitats is a new threat that could adversely affect the recovery of least Bell's vireo. The boring beetle and it's fungal associates in the genus *Fusarium* have decimated the structural component of least Bell's vireo habitat by targeting black willow, red willow, and arroyo willow stems over one-inch diameter. Sprouting willow shoots provide vireo habitat structure, but are recolonized by the beetle when stems resprout from the roots. Least Bell's vireo occupancy has declined in riparian habitats decimated by the shot hole boring beetle (Kus pers. comm. 2017). Birds were not previously banded in areas with significant habitat reduction, thus there is no record of where displaced vireos dispersed. Although the boring beetle has impacted high quality riparian habitat throughout San Diego County, the least Bell's vireo population in southern California has remained somewhat stable.

9.1.4 Numbers

The Service does not conduct regular surveys throughout the range of the least Bell's vireo. The USGS collects data from biologists conducting surveys for the least Bell's vireo; various workers survey some areas regularly and other results are acquired from surveys that are conducted in support of other activities (e.g., monitoring, preparation of environmental documents for development reviews, etc.). Additionally, not all sites are surveyed every year and the precise locations of surveys may vary from year to year. Consequently, the numbers of territorial males in the following table (Table 9-1, adapted from Kus *et al.* 2017) do not represent a trend; they do, however, indicate that least Bell's vireos have greatly increased in abundance since the time of listing.

Table 9-1. Estimated number of territorial male least Bell's Vireos based on survey data compiled by the Riparian Birds Working Group (Kus *et al.* 2017)

Year	Number of Territorial Males
2003	1,604
2004	2,098
2005	2,068
2006	1,823
2007	2,088
2008	2,521
2009	3,075
2010	3,280
2011	2,917
2012	2,455
2013	2,597
2014	2,477
2015	2,833
2016	2,844

Extensive riparian habitat exists on private lands throughout the Sacramento River Watershed within the Central Valley that is not regularly monitored by avian ecologists; therefore, the numbers and distribution of least Bell's vireo in the Central Valley is relatively unknown. Vireos were observed nesting at the San Joaquin River National Wildlife Refuge in 2005 and 2006 (Wood *et al.* 2006; Howell *et al.* 2010), and were observed attempting to establish territory in lower Putah Creek in 2011 (CDFW 2013), but no populations are known to have established. Intensive surveys for least Bell's vireo have not been conducted across the Central Valley in recent years.

9.1.5 Distribution

Least Bell's vireo had a historical distribution that extended from coastal southern California through the San Joaquin and Sacramento Valleys as far north as Tehama County near Red Bluff (Kus 2002). The Sacramento and San Joaquin Valleys were the center of the historical breeding range supporting 60 to 80% of the population (51 FR 16474). At the time of Federal listing in 1986, over 99 percent of the least Bell's vireo population was found south of Santa Barbara County (Service 2006a) and limited to only 300 breeding pairs (Service 1998).

Historically, the least Bell's vireo was a common breeder in riparian habitat throughout coastal southern California and the Central Valley, including the San Joaquin Valley to the south and the Sacramento Valley to the north (Goldman 1908, Grinnell and Miller 1944). Although once one of the most abundant species in California, measurable population declines were observed in the Sacramento and San Joaquin valleys as early as the 1930s (Grinnell and Miller 1944). Data on least Bell's vireos from the 1940s through the 1960s are lacking, but extensive surveys of the Central Valley in the late 1970s did not detect a single individual (Goldwasser *et al.* 1980).

The current distribution of the least Bell's vireo has increased to some degree since its listing in 1986, although it remains absent from large parts of its former range in the Central Valley. Least Bell's vireos have spread through riparian habitat in southern California and small numbers of birds have begun to venture into central coastal California, the southern Central Valley, and the Mojave Desert. We expect that the distribution of least Bell's vireos is likely to continue to increase slowly in the future.

9.2 Environmental Baseline

The species is beginning to recolonize its historic range in central and northern California and is known to occupy habitat within the Action Area (Table 9-2). No surveys were conducted for the BA; however, Reclamation proposes to conduct surveys in suitable habitat.

The drastic decline of the species in the Action Area is likely a direct result of habitat loss. From the 1800s to the 1970s, there was a 95% loss of riparian habitat in the Central Valley (Smith 1977; Katibah 1984). Current estimates for riparian vegetation within the Central Valley are still fractions of historic totals despite restoration and enhancement projects. The Sacramento Valley region currently contains 67,897 acres (27,477 hectares) of riparian vegetation (15.9% of the pre-1900 riparian area). The Yolo-Delta region currently contains 32,870 acres (13,302 hectares) (13.9% of the pre-1900 area). The San Joaquin Valley region currently contains 24,948 acres (10,096 hectares) (12.6% of the pre-1900 area) (Dybala *et al.* 2017). Major contributing factors to the loss of riparian habitat throughout the Action Area include hydrologic regulation and decreased flows in rivers from dams, in-channel water diversions, and groundwater pumping, construction of flood control levees and bank protection, conversion of riparian zones to agriculture and grazing, timber harvest, mining, and urbanization (Katibah 1984; Strahan 1984; Scott and Marquiss 1984; Golet *et al.* 2001; Greco 2013; Fremier *et al.* 2014; Dybala *et al.* 2017).

The disturbances that led to the current state of riparian forests in the Action Area are not limited to discrete events resulting in immediate and drastic changes to the system, but also include actions that result in continuous, on-going effects with compounding impacts to riparian ecosystems. When the system has a long history of human alteration, the environment slides farther from historical conditions into the future. Without addressing these effects over time, environments with a long history of human alteration will incrementally lose natural attributes and move closer to a more completely human-dominated landscape that lacks the structure or function to support natural ecosystem processes (Fremier *et al.* 2014). This phenomena has been observed and modeled in rivers within the Action Area. While major changes were reported during the construction and initial operation of major CVP projects in the mid 1900's, continued shifts in vegetation community composition in terms of dominant species, age, canopy height, and patch sizes (Greco *et al.* 2007; Greco 2013) and changes in channel morphology (Michalková *et al.* 2010) have been documented in recent decades. The effects of dam-induced reduction of mean annual peak discharge flow (CALFED 2000), reduction of flood discharge volume (Greco 2013), reduction in stream power (Fremier 2007), sediment starvation (Michalková *et al.* 2010), and reduced bank erosion rates and overbank deposition (USDA 1999) all contribute to changes to successional riparian forest ecosystems. As the ability of the river channel to migrate laterally is restricted by reductions in stream power from dams and water diversions (Larsen *et al.* 2006; Fremier *et al.* 2014) and the quantity of new land production is continuously reduced, the amount of new pioneer riparian forests is subsequently decreased (Greco *et al.* 2007; Greco 2013; Dufour *et al.* 2014). This is evident by the lower fraction of early successional riparian vegetation, which the least Bell's vireo is dependent upon for breeding, along the Sacramento and San Joaquin Rivers in areas where restoration or active management actions have not been undertaken to maintain plant diversity (Strahan 1984; Howell *et al.* 2010; Greco 2013; Dufour *et al.* 2014).

In recent years, there have been a number of observations of adult least Bell's vireos and nesting activity in central and northern California, indicating the species is attempting to recolonize the Central Valley. Additionally, recent modeling of habitat suitability suggests that parts of the Central Valley are highly suitable for least Bell's vireos (Klicka *et al.* 2016). However, the least Bell's vireo population in Central and Northern California has remained very low. Limited suitable habitat between the species' stronghold in the riparian corridors of southern California and suitable restored habitats in the Central Valley may be limiting the ability of the species to disperse and recolonize the northern extent of its historic range.

From 1993 to 2016, there was an average of 1.3 least Bell's vireo observations in Central and Northern California per year (Howell *et al.* 2010). Table 9-2 contains a summary of all confirmed occurrences of least Bell's vireos within the counties included in the Action Area. The only place within the Action Area with confirmed successful nesting is the San Joaquin River National Wildlife Refuge (SJRNWR) in Stanislaus County. In restored riparian habitat in SJRNWR, there were successful nesting events by a pair of vireos in 2005 and 2006, along with an unsuccessful nesting attempt in 2007 (Howell *et al.* 2010). A single male exhibiting territorial breeding behavior was observed in the refuge on multiple occasions in 2012 and 2016. The bird observed in 2016 was documented utilizing both restored riparian habitat and non-restored habitat including the edges of a dirt road and almond orchard. Two singing males were detected in the YBWA in mid-April 2010, and again in 2011 (CDFW 2013). No least Bell's vireos were detected in the Yolo Bypass Wildlife Area during surveys in 2012, however one bird was heard singing east of the Bypass along Putah Creek that summer (Ebird 2019). A singing male was detected in 2013 (Ebird 2019), but surveys were not conducted in 2014 (Whisler personal communication 2015). No least Bell's vireos have been detected in the Yolo Bypass since 2013. Based on these recent observations, the Service has updated the current mapped range of the species to include the breeding areas in Yolo County and the SJRNWR (Service 2019).

Table 9-2. Summary of records of least Bell's vireo in counties in or abutting the Action Area since 1985.

County	Year	Count	Months Present	Notes	Source
Marin	1985	1	Non-breeding season		Baily and Campbell 1985
Sacramento	1993	1	Non-breeding season		Bailey *et al.* 1994
Sacramento	1995	1	Non-breeding season		Bailey *et al.* 1996
Santa Cruz	1996	1	May		Ebird
Santa Clara	1997	2	Breeding season (April – August)	Breeding pair, success of nest unknown	Roberson *et al.* 1997
Santa Clara	2001	3	May	Same area as 1997 observation	CDFW
Merced	2004	1	Non-breeding season		Sterling 2004
Solano	2005	1	Breeding season (April – August)		Cole *et al.* 2005
Stanislaus	2005	4	June	Breeding pair and two fledglings in SJRNWR	Howell *et al.* 2010
Contra Costa	2005	1	May		Ebird
San Francisco	2005	1	November		Ebird
Stanislaus	2006	5	July	Breeding pair and three fledglings in SJRNWR	Howell *et al.* 2010
Sacramento	2006	1	August		Ebird
Fresno	2006	1	January	Lost Lake Recreation Area	Ebird (unpublished PRBO data)
Santa Clara	2006	1	May	Pajaro River estuary	Glover *et al.* 2007
San Joaquin	2006	1	August	Dry Creek	Ebird
Stanislaus	2007	1	May	Unsuccessful breeding attempt in SJRNWR	Howell *et al.* 2010
San Francisco	2009	1	June	Southest Farallon Island	Ebird
Merced	2010	1-2	May-July	San Luis NWR	Ebird

San Mateo	2010	1-2	May, June	Bedwell Bayfront Park-Menlo Park	Ebird
Yolo	2010	2	April – August	Yolo Bypass Wildlife Area, Putah Creek. 2 singing males, birds observed carrying nesting materials.	Ebird, CDFW
Yolo	2011	2-3	May – June	Yolo Bypass Wildlife Area, Putah Creek	Ebird
Santa Cruz	2011	1	September	Natural Bridges State Park (coast)	Ebird
Merced	2012	2	May-July	Merced NWR	Ebird
Stanislaus	2012	1	May – July	SJRNWR	Ebird
Yolo	2012	1	May	Putah Creek east of Davis	Ebird
Sacramento	2013	1	April	Bufferlands-Upper Beach Lake	Ebird
Yolo	2013	1	May	Yolo Bypass Wildlife Area	Ebird
Sonoma	2015	1	October	Campbell Cove	Ebird
Kings	2015	1	May	Lockhart's Corner (next to canal)	Ebird
Santa Clara	2016	1	May	Gold Street Ponds (next to Bay)	Ebird
Stanislaus	2016	1	June	SJRNWR	Howell *et al.* 2010
San Joaquin	2017	1	May	Near Mokelumne River	Ebird
Contra Costa	2018	2	June	Bradford Island, multiple sightings. Confirmed 1 male bird, sex of 2nd bird unconfirmed	Ebird
Merced	2018	1	May	Los Banos Waterfowl Management Area	Ebird

Conservation actions have been undertaken within the Action Area to improve habitat for least Bell's vireos. The specific habitat needs of least Bell's vireos for nesting, including willow-dominated riparian woodland with dense understory vegetation maintained, in part, in a non-climax stage by periodic floods or other agents (Service 1994), are not addressed in all riparian restoration projects. A habitat suitability model developed for least Bell's vireos identified that nesting birds typically use riparian vegetation with dense and layered canopy over 26 feet (8 meters) tall, with highest foliage density within 3-6 feet (1-2 meters) of the ground where they place their nests (Kus 1998). In evaluating riparian restoration sites in southern California, Kus (1998) found that many restoration sites only partially matched the habitat suitability model, including sites with patches that were suitably dense but failed to meet the canopy height requirement or sites where trees were suitably tall but lacked sufficient understory. Without active management (e.g. occasional mowing, burning, flooding, etc.) or restoration of natural ecological processes, such as hydrological and fire regimes, to maintain appropriate successional stages of riparian vegetation restoration projects may not provide suitable habitat for least Bell's vireos long-term (Howell *et al.* 2010; Dybala *et al.* 2016). The design and implementation of the restoration sites utilized for nesting by least Bell's vireos in SJRNWR incorporated recommendations from the Riparian Bird Conservation Plan (RHJV 2004), the Endangered Species Recovery Program (California State University–Stanislaus), and the SJRNWR comprehensive conservation plan (Service 2006) for providing suitable habitat for riparian nesting songbirds (Howell *et al.* 2010).

The least Bell's vireo is a priority species for the Central Valley Project Conservation Program (CVPCP). The CVPCP is managed by Reclamation to support projects to protect, restore, and enhance special-status species and their habitats affected by the CVP (Reclamation 2019). One example of a CVPCP funded restoration project designed to provide nesting habitat is Dos Rios Ranch, however no least Bell's vireos have been observed in the project area since implementation (Dybala *et al.* 2016). The Service also supports conservation efforts for least Bell's vireo with grants made from the Cooperative Endangered Species Conservation Fund's Endangered Species Act grants. At least one project within the Action Area has received grant funding through the Service to support least Bell's vireo recovery. In 2016, the Yolo County Habitat Conservation Plan (HCP) received a $820,660 Habitat Conservation Planning Assistance Grant from the Service to protect and enhance land within the Action Area for the conservation of least Bell's vireo, along with 11 other species (Service 2016). The Yolo County HCP was signed in 2018 and is now being implemented.

Riparian corridors within the Action Area currently have the potential to support populations of least Bell's vireo during breeding and migration (Howell *et al.* 2010; Klicka *et al.* 2016). Least Bell's vireos rarely over-winter in California and are not anticipated to regularly occupy habitat in the Action Area between November and March. Based on recent observations of attempted and successful breeding, restored and managed riparian habitats along the San Joaquin and Sacramento Rivers are currently playing an important role in the dispersal of the species from southern California back into its historic range in the Central Valley. While the species does not have a final recovery plan, the Service has established delisting criteria, including "stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, having become established and are protected and managed at the following sites: Salinas River, a San Joaquin metapopulation, and a Sacramento Valley metapopulation" (Service 1998, Service 2006). While it is possible that a few more least Bell's vireo breeding territories are dispersed across the region than what has been reported, this delisting criterion is far from being met. The Service has not yet completed a population viability analysis (PVA) for least Bell's vireo, nor a final recovery plan. However, researchers have attempted to model the potential response of the least Bell's vireo population within the Action Area to large-scale riparian restoration. Dybala *et al.* (2017) estimated that the population of least Bell's vireos across the Sacramento Valley, San Joaquin Valley, Tulare Basin, and Yolo Basin-Delta could increase to between 1,000 and 10,000 individuals within 10 years if 31,923 acres (12,919 hectares) of riparian habitat were restored. The researchers also predicted the species could be become resilient within 100 years if 460,848 acres (186,499 hectares) were restored (Dybala *et al.* 2017). Within the Action Area, the least Bell's vireo is likely in the beginning phases of reoccupation of its Central Valley breeding habitat from which it has been extirpated since the 1970s. If existing and permitted (but not yet implemented) Federal actions to restore riparian habitat within the Central Valley are successful in creating and maintaining suitable habitat for the least Bell's vireo, the Service expects the species' numbers to increase in the Action Area during the timespan of the Proposed Action (2019-2030).

The Service has formally consulted on 27 projects within the Action Area since 2001. Six of these consultations were for projects within the Sacramento and American Rivers watersheds, and the remaining 21 were for projects within the San Joaquin and Stanislaus Rivers watersheds. These consultations were for a variety of different types of projects including transmission line maintenance, geotechnical investigations, bridge rehabilitation and repair, and restoration. One of these was the San Joaquin River Restoration Programmatic Biological Opinion (Service File Number 08ESMF00-2012-F-0125).

9.3 Effects of the Proposed Action

9.3.1 Sacramento River

Seasonal Operations

Least Bell's vireo do not currently occupy breeding habitat in the upper Sacramento River and are unlikely to recolonize the area during the timeframe of the PA. However, any changes to the riparian habitat throughout the vireo's historic breeding range in central California may adversely affect the population's ability to disperse and colonize new areas beyond the current breeding habitats occupied in southern California.

Reclamation's PA includes proposed flow changes in the Sacramento River resulting in less than 5% percent decrease in average flows in November and less than 5% increase in average flows in May and June. Reclamation stated in their BA that the proposed "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." Reclamation also determined that the PA would provide benefits to the species' habitat as compared to the without action scenario by increasing fall flows, avoiding drought stress in riparian or wetland vegetation, and by keeping more constant spring flows, avoiding erosion at restoration sites.

Periodic flooding and erosion are important to maintaining non-climax stage willow-dominated riparian woodlands. Additionally, mean modeled flows are presented in a monthly time-step - the averaging of flows over a month dampen the actual fluctuations that are critical for maintaining suitable riparian habitat. The Service assumes seasonal operations will maintain current vegetation, contributing to the further reduction of natural successional processes that result in non-climax stage riparian woodlands and loss of suitable vireo habitat over time. Additionally, proposed seasonal operation may increase the likelihood that invasive riparian plants will survive dry summer and fall conditions and persist long-term. The changes in flow and operations may result in indirect impacts through changes in riparian habitats if vireo recolonize the Sacramento River Valley during the PA's timeframe.

North Delta Food Subsidies/Colusa Basin Drain Study

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass, which includes a disjunctive 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 vireo are likely to nest. 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. The proposed flows are unlikely to result in direct harm to individual viroes, and may result in indirect beneficial impacts through improvement in habitat conditions and prey base.

<u>9.3.2 Stanislaus River</u>

Seasonal Operations

Least Bell's vireo do not currently occupy breeding habitat in the Stanislaus River; however, the Service believes there is a moderate-to-high potential for the species to recolonize the area during the timeframe of the PA based on past successful breeding in the San Joaquin National Wildlife Refuge near the confluence of the San Joaquin and Stanislaus Rivers. Any changes to the riparian habitat throughout the vireo's historic breeding range in central California may adversely affect the population's ability to disperse and colonize new areas beyond the current breeding habitats occupied in southern California.

Reclamation's PA includes proposed flow changes in the Sacramento River resulting in less than 5% percent decrease in average flows in November and less than 5% increase in average flows in May and June. Reclamation stated in their BA that the proposed "changes are unlikely to produce any measurable change in quantity or quality of least Bell's vireo habitat in the upper Stanislaus watershed, and there is no apparent mechanism by which these changes could result in harm to individual least Bell's vireos." Reclamation also determined that the PA would provide benefits to the species' habitat as compared to the without action scenario by increasing fall flows, avoiding drought stress in riparian or wetland vegetation, and by keeping more constant spring flows, avoiding erosion at restoration sites.

However, lower flows in the spring under the PA could potentially result in less riparian vegetation recruitment. The PA will likely result in flows being generally more stable. Any changes in the natural flow regime of the river will likely result in an increase in non-native invasive plant species and a reduction of native riparian recruitment. This may reduce the amount of surrounding suitable non-climax stage willow-dominated riparian habitat over time. The Service agrees with Reclamation's determination that changes in flow and operations are unlikely to result in direct harm to individual vireos. The changes in flow and operations may result in indirect impacts through changes in riparian habitats if vireo recolonize the Sacramento River Valley during the PA's timeframe.

Salmonid Spawning and Rearing Habitat Restoration

Reclamation did not provide an estimate of the area of riparian vireo habitat that may be removed to create side channel habitat. In their BA, Reclamation only mentions gravel placement in-stream when discussing effects to vireo. However, the Service anticipates that construction of side channels in the Stanislaus River will result in loss of up to 43 acres of potentially suitable vireo riparian habitat.

Construction-related effects on the vireo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction that may disrupt normal behavioral patterns. Reclamation proposes to avoid disturbance of occupied vireo habitat through implementation of AMM-LBV in Appendix E of the BA. Reclamation will conduct pre-construction surveys in potential suitable habitat. Subsequent avoidance and minimization measures will be implemented if vireo are detected including establishing 500-foot no-disturbance buffers around nest sites and limiting disturbance from construction noise, light, and vehicle operations within 1,200 feet of suitable habitat during migration and nesting seasons. However, the vireo occur in extremely low densities in the Action Area and may not be easily detected through pre-construction surveys. As such, potential adverse effects to vireo from construction may not be fully avoided by implementing the measures in AMM-LBV, but this measure serves to minimize the possibility of vireos being exposed to disturbance from construction.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

<u>9.3.3 San Joaquin River</u>

Proposed Flow Changes

In the lower San Joaquin watershed, the effects of the PA in terms of changes in quantity or quality of least Bell's vireo habitat from the current condition are almost nonexistent. While baseline conditions for vireo in the lower San Joaquin River are impaired by decades of hydrologic alteration, agricultural activities, and habitat loss, the Service does not foresee any subsequent harm to vireo in terms of changes in quantity or quality of least Bell's vireo habitat in the lower San Joaquin watershed during the PA timeframe.

Lower San Joaquin River Habitat Restoration

*Permanent Habitat Loss*

The restoration of floodplain habitat in the Lower San Joaquin River would result in the permanent removal of up to 28 acres of vireo habitat. Reclamation states that the habitat consists primarily of small patches but are in close in proximity to other areas of potentially suitable habitat along the San Joaquin River. Although much of this component would occur north of the San Joaquin River portion of the 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.

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.

*Temporary Habitat Loss*

If Reclamation incorporates multi-species restoration methods to create and maintain large patches of riverine and floodplain habitats (particularly willow-dominated riparian woodland with dense understory vegetation maintained, in part, in a non-climax stage by periodic floods or other agents) and adjacent buffers of coastal sage scrub, chaparral, or other upland plant communities (Service 1994) that provide for the breeding and foraging needs of vireo, the loss of 28 acres of vireo habitat due to construction could be minimized by the creation or restoration of suitable vireo habitat as part of this habitat restoration program. Under this potential scenario, what would otherwise be considered a permanent loss of habitat would be a temporary loss instead.

*Periodic Inundation*

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 148 acres of habitat for the least Bell's vireo. 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 some riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species by promoting vegetation succession.

*Construction-Related Effects*

Occurrences of least Bell's vireo in recent decades in the San Joaquin Valley suggest that the reestablishment of a breeding population is a possibility in this area. If the least Bell's vireo nest in construction areas, 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. Injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys, establishment of 500-foot no-disturbance buffers around active nests, and limitation of disturbance from construction noise, light, and vehicle operations within 1,200 feet of suitable habitat during migration and nesting seasons, 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, Reclamation 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 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, Reclamation 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 Proposed Action activities seldom if at all, residual lighting effects on the species are expected to be negligible.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

9.3.4 Bay-Delta

Intertidal and Associated Subtidal Habitat Restoration

Least Bell's vireos are not known to breed in tidal habitat in the Bay-Delta, however, they are commonly observed in coastal areas in Southern California. It is likely the species occasionally migrates through the Bay-Delta and may use riparian habitat in the area for resting and foraging during migration. Recent sightings in Contra Costa County on Bradford Island (Ebird 2019) may indicate the species is attempting to colonize riparian habitat within the delta for breeding.

Construction-related effects on the vireo include the potential for injury or mortality from noise and visual disturbance to individuals in the vicinity of construction. Reclamation proposes to avoid disturbance of occupied vireo habitat through implementation of AMM-LBV in Appendix E of the BA. Reclamation proposes to avoid disturbance of occupied vireo habitat through implementation of AMM-LBV. Reclamation will conduct pre-construction surveys in potential suitable habitat. Subsequent avoidance and minimization measures will be implemented if vireo are detected including establishing 500-foot no-disturbance buffers around nest sites and limiting disturbance from construction noise, light, and vehicle operations within 1,200 feet of suitable habitat during migration and nesting seasons. Since vireo are not expected to nest in intertidal and subtidal habitats, the implementation of the measures in Appendix E of the BA should avoid impacts to vireo.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

9.4 Effects to Recovery

For a species like the least Bell's vireo that has lost much of its former known occupied habitat, recovery would necessitate the conservation of much of the remaining habitat that still supports it. Reclamation is proposing to minimize the adverse effects of the loss of suitable habitat from the Proposed Action by implementing actions to avoid impacts to the species.

Reclamation has not proposed to minimize the adverse effects from the loss of suitable habitat by implementing actions to promote the recovery of the affected species in a manner where the measures are completely commensurate with the adverse effects in the Action Area. Reclamation has also not proposed to restore or protect suitable habitat to offset the total loss of suitable habitat. Reclamation has proposed to avoid and minimize impacts from construction to occupied suitable habitat through implementation of AMM-LBV, however, these measures are unlikely to reduce potential effects from operations activities. Habitat loss and degradation are contributing factors to the decline of least Bell's vireo; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the least Bell's vireo. All habitat restoration included in the PA is focused on benefits to fish species. Proposed and on-going restoration actions included in the baseline are not sufficient to meet the estimated riparian habitat area needed to support the recovery of vireo in the Central Valley (Dybala *et al.* 2017). However, limited suitable habitat between the species' stronghold in the riparian corridors of southern California and suitable restored habitats in the Central Valley may be the primary limiting factor for the species to disperse and recolonize the northern extent of its historic range. Noise, lighting and vibration also have the potential to temporarily affect the least Bell's vireo. These threats will be minimized by Reclamation's proposal to avoid and minimize impacts suitable habitat for the least Bell's vireo through implementation of AMM-LBV. The relatively small amount of habitat that will be lost according to the BA will not appreciably alter conditions in the Action Area, and very few individuals are known or believed to occupy or expected to occupy the Action Area for the duration of the PA. Consequently, we conclude that the PA would not interfere with the recovery of the least Bell's vireo.

9.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect least Bell's vireo. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the least Bell's vireo for the entire Action Area. In addition, the use of agricultural pesticides decreases the quantity and quality of prep for insectivorous birds such as the least Bell's vireo. The continued use of pesticides is likely limiting the prey base available in migratory habitat and in breeding habitat near agricultural areas.

9.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the least Bell's vireo.

9.6.1 Reproduction

Breeding least Bell's vireos are relatively rare in the Action Area. If vireos do attempt to nest within areas of restoration activities, implementation of AMM-LBV is expected to result in avoidance of disturbance to breeding vireos or their young. Therefore, the PA is not expected to negatively affect least Bell's vireo reproduction, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

9.6.2 Numbers

As described in the Reproduction section above, the number of least Bell's vireos in the Action Area is relatively low, based on recent and past records. Also, Reclamation has proposed measures to avoid and minimize the effects of the PA on the species (AMM-LBV). Proposed Action components most likely to directly affect least Bell's vireos are the salmonid restoration projects which will be subject to subsequent consultations. These effects would only be likely to occur if vireos move into the area affected by these projects. Proposed pre-construction surveys may miss migratory birds or dispersing juveniles and construction-related activities could result in harm from the disruption of normal behavioral patterns. The proposed measures in AMM-LBV are expected to be adequate to avoid take from direct mortality.

Despite the proposed protection measures, we anticipate the PA may still result in effects to the least Bell's vireo; however, the number of least Bell's vireos affected would be low because of their rarity within the Action Area. This is especially true relative to the range-wide numbers. Therefore, the PA is not expected to reduce the number of least Bell's vireos range-wide.

9.6.3 Distribution

In recent years, there have been a number of observations of adult least Bell's vireos and nesting activity in or near the Action Area, indicating the species is attempting to recolonize the Central Valley. Additionally, recent modelling of habitat suitability suggests that parts of the Central Valley are highly suitable for least Bell's vireos (Klicka *et al.* 2016). Least Bell's vireo may attempt to breed and nest in willow-dominated riparian woodland habitat in the Action Area. However, the least Bell's vireo population in Central and Northern California has remained very low and is expected to remain low during the timeframe of the PA. With the implementation of the proposed avoidance and minimization measures in the BA, there is unlikely to be a measurable effect on the species from loss of suitable habitat.

During migration, least Bell's vireos may stop to rest and forage in variety of vegetation types along rivers and streams affected by operations or construction of salmonid restoration sites; however, the reduction of this stop-over habitat will not have a measurable effect on the species.

The number of least Bell's vireos likely to be affected by Proposed Action activities will be very low. We do not expect that any least Bell's vireos will be directly killed by construction of restoration activities or by the proposed changes in operations, and that very few least Bell's vireos will be harmed by loss of habitat due to the PA activities. We also conclude that least Bell's vireos will continue to survive in the Action Area regardless of the activities. Consequently, the PA will not alter the distribution of the least Bell's vireo and we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition.

9.7 Conclusion

After reviewing the current status of least Bell's vireo, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of least Bell's vireos likely to be affected by the PA will be low relative to the number of least Bell's vireos range-wide.

2. The amount of least Bell's vireo habitat that is likely to be affected by the PA is relatively small compared to the amount of habitat range-wide.

3. Reclamation has proposed conservation measures, such as pre-construction surveys, to avoid or minimize direct effects to vireos from construction associated with restoration activities.

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10.0 SALT MARSH HARVEST MOUSE

10.1 Status of the Species

10.1.1 Legal Status

The salt marsh harvest mouse (*Reithrodontomys raviventris*) was federally listed as endangered in 1970 (35 FR 16047). The list at the species level includes two subspecies: the northern salt marsh harvest mouse (*R. r. halicoetes*), found in San Pablo and Suisun Bays, and the salt marsh harvest mouse (*R. r. raviventris*), found in the marshes of Corte Madera, Richmond, and South San Francisco Bay. The salt marsh harvest mouse is a Fully Protected Species under California law (California Department of Fish and Wildlife Code §4700). Critical habitat has not been proposed or designated for this species.

10.1.2 Natural History/Biology

A detailed account of the taxonomy, ecology, and biology of the salt marsh harvest mouse can be found in the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Service 2013b).

The salt marsh harvest mouse is restricted to saline (salty) or brackish (somewhat salty) marsh habitats, with *Sarcocornia*-dominated (pickleweed) marsh plain middle zone, as well as and a high marsh zone being important features. Telemetry studies found mean home ranges to be approximately 0.21 hectare (0.52 acre) for the northern subspecies and approximately 0.15 hectare (0.37 acre) for the southern subspecies (Service 2010). Shellhammer (2009 in Service 2010) identified that generally salt marsh harvest mice do not cross large areas of open habitat (*i.e.*, open space or unvegetated habitat).

10.1.3 Range-wide Status/Distribution

Data are limited for estimating historical range-wide population and distribution. The salt marsh harvest mouse probably occupied most of the middle tidal, or *Sarcocornia*-dominated (pickleweed), marsh plains and high marsh zones of San Francisco Bay, San Pablo Bay, and Suisun Marsh prior to the significant marsh reclamation of the 1840s. However, by the time of listing, it is likely that populations of the species range-wide had fallen to low levels (Service 2010).

Survey data for the species is generally sparse, with most surveys having been site-specific and relatively short term. For the northern population, the fringing salt marshes along norther San Pablo Bay (Petaluma River to Mare Island Strait), particularly the Highway 37/Mare Island Marsh and additional tidal/microtidal marshes, do support fluctuating populations of salt marsh harvest mice. Due to its large size and deep (broad) suitable salt marsh habitat, Suisun Marsh is an important site for the northern subspecies population and may contain the largest population for the species in the entire remaining range (Service 2010). Standardized annual surveys conducted there since 1997 by CDFW and DWR, have demonstrated fluctuations, but have shown high and increasing capture efficiencies of 10.0-11.5%, which indicates the population may be increasing. Surveys at other sites in the northern population's range have demonstrated similar capture efficiencies. Similarly, recent research about demography and habitat use in Suisun Marsh (Sustaita *et al.* 2011) captured 1,191 individual salt marsh harvest mice in 28,104 trap nights, for an estimated density of 2.5-3.4 mice/hectare.

In general, the status of the southern population is currently considered to be more precarious than the northern population. Few major, resilient, or secure populations persist and those that do are very small and isolated compared with the historical pattern of distribution and abundance (Service 2010). Studies by Shellhammer (Service 2010) indicate that population size is generally correlated with the depth of the Sarcocornia plain (*i.e.*, the middle zone of tidal marshes). Shellhammer further noted that most of the marshes of the South San Francisco Bay are strip-like marshes and, as such, support few salt marsh harvest mice.

10.1.4 Threats

The most fundamental reason for the decline of the salt marsh harvest mouse is loss of habitat through filling (*i.e.*, destruction), subsidence, and vegetation change (Service 1984, Shellhammer 2000). Predation has also been identified as an influential threat (Service 2013b).

10.1.5 Recovery

The basic strategy for recovery of the salt marsh harvest mouse is the protection, enhancement, and restoration of extensive, well-distributed habitat suitable for the species. There are short- and long-term components of the general recovery strategy, as well as specific geographic elements. Both interim and long-term components are necessary; neither alone is sufficient to recover the salt marsh harvest mouse. We have identified 5 recovery units: Suisun Bay Area, San Pablo Bay, Central/South San Francisco Bay, Central Coast, and Morro Bay. Recovery criteria comprise a combination of numerical demographic targets and measures that must be taken to directly ameliorate or eliminate threats to the species in the appropriate subset of the above recovery units.

10.2 Environmental Baseline

There are numerous documented CNDDB occurrences of salt marsh harvest mouse in the Suisun Marsh portion of the Action Area (CDFW 2019). This species has been observed in tidal wetlands and along sloughs as well as within managed wetlands. 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). Wetlands in Suisun Marsh support patchy and unstable, but sometimes sizeable populations of salt marsh harvest mice with fairly high densities despite management activities occurring in the marsh (Service 2013b). Salt marsh harvest mice are also sometimes found in significant numbers in grasslands at the upper edge of diked marshes in the Suisun Bay (Zetterquist 1976; Shellhammer *et al.* 1988).

Perennial pepperweed (*Lepidium* latifolium) is an aggressive, non-native herbaceous weed displacing native vegetation in the Suisun Marsh and other locations throughout California. Pepperweed occurrence within the Action Area is high. Pepperweed can be problematic to control because of its underground rhizomes that are difficult to kill with broad-spectrum herbicides. Limited success has occurred in the Action Area to control and manage the overtaking of pepperweed long-term. Pepperweed poses a serious threat to many native ecosystems and can displace threatened and endangered species, like the salt marsh harvest mouse, or interfere with the regeneration of important plant species.

Downlisting criteria of the salt marsh harvest mouse include achieving, within the Suisun Bay Recovery Unit, conservation of 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. Currently, 2,500 acres of suitable habitat throughout the Marsh has been conserved as salt marsh harvest mouse habitat. The salt marsh harvest mouse Conservation Areas are Peytonia Slough; Hill Slough West Ponds 1, 2, 4, and 4A; Hill Slough East Areas 8 and 9; a portion of Joice Island. Crescent Unit, a portion of Lower Joice Island; Blacklock; and Grizzly Island Ponds 1 and 15. Mitigation areas are Island Slough Ponds 4 and 7 (Service 2013a).

The Service has consulted on numerous consultations in the Suisun Marsh in the Action Area with a majority of the consultations being related to on-going maintenance activities or conversion of managed marsh to another use, such as tidal marsh restoration. The June 2013, *Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and Project-Level Actions in Solano County, California* (08ESMF00-2012-F-0602-2) was issued to the Corps to cover projects that fall under the Corps' Regional General Permit, their Letters of Permission, or individual permits in the Suisun Marsh. Example tidal marsh restoration projects that have been consulted on in the Action Area include Tule Red (08FBDT00-2016-F-0071), Blacklock (1-1-06-I-1880), and Montezuma Wetlands (1-1-99-F-12).

10.3 Effects of the Proposed Action

10.3.1 Tidal Habitat Restoration in Suisun Marsh

Depending on the nature, scope, location, and timing of restoration actions associated with individual restoration projects, there is a potential to adversely affect salt marsh harvest mice during implementation of construction, long-term management, adaptive management, or monitoring activities. The salt marsh harvest mouse inhabits suitable vegetation communities in tidal and managed wetlands in the Suisun Marsh. The PA may result in harm, injury, or death of salt marsh harvest mice through the loss and degradation of their habitat from flooding and through crushing by equipment and machinery. Salt marsh harvest mouse habitat may be destroyed or fragmented by levee breaching, levee creation, and other activities that involve the movement of the soil or other material. Individual salt marsh harvest mice may also be disturbed by noise and vibrations associated with levee breaching, levee creation, and construction activities within or adjacent to salt marsh habitat resulting in the disruption of feeding, sheltering, or breeding activities. Salt marsh harvest mice that are disturbed may be flushed from protective cover or their territories exposing the mice to predators. Disturbance to females from March to

November may cause abandonment or failure of the current litter. Thus, displaced salt marsh harvest mice may suffer from increased predation, competition, mortality, and reduced reproductive success. The likelihood of disturbance of salt marsh harvest mice during construction activities increases if these activities occur during an extreme high tide event when the mice are likely to escape the adjacent flooded marsh to seek higher ground on the outboard levees. Salt marsh harvest mice are most vulnerable to disturbance and predation during extreme high tide events particularly if there is a lack of upland refugia cover. Construction activities will not occur during high tides, consistent with the conservation measures identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

Conversion of suitable habitat in managed wetlands to tidal wetlands would result in a temporary reduction in suitable habitat. As the restored area evolves into a functioning, vegetated tidal wetland, it is expected to provide permanent suitable and sustainable habitat for the salt marsh harvest mouse. Restoration activities likely would be located throughout the Suisun Marsh and would be implemented over a span of years, rather than concentrated in a small geographic area or time frame that would have a potentially greater effect on this species. It is expected that suitable adjacent areas would continue to provide habitat for salt marsh harvest mouse between breaching the levee and the establishment of a fully functioning tidal wetland. Temporary losses of suitable habitat would be compensated for by the creation of tidal wetlands and through the individual project restoration designs.

Construction activities related to tidal restoration actions could result in the introduction or spread of noxious weed species, which could displace native species, thereby changing the diversity of species or number of any species of plants. The non-native invasive, perennial pepperweed is common in Suisun Marsh. Perennial pepperweed establishes poor above-ground cover as it is leafless in the winter and provides little cover during high winter tides. Without suitable upland refugia cover, salt marsh harvest mice are vulnerable to predation during high tide events when the mice escape the flooded marsh to seek higher ground. Perennial pepperweed also interferes with the establishment of marsh gumplant, a tall native evergreen sub-shrub used by salt marsh harvest mice for high tide cover in the high marsh. Spreading rhizomatous and by seed, perennial pepperweed may also displace pickleweed and other native salt marsh vegetation essential to the salt marsh harvest mouse. As described in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp, several measures will be implemented to minimize the spread of nonnative plants as part of the restoration design and during project implementation. Additionally, proposed restoration sites will be managed to promote tidal wetland vegetation so when inundation occurs, there is minimal potential to support nonnative species.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation. This could include tiering or appending to the existing Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

10.3.2 Suisun Marsh Salinity Control Gates (Proposed Flow Changes)

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. Salt marsh harvest mice are assumed to be present during the times of the year in which operations will be occurring in the Suisun Marsh. SMSCG reoperations are expected to temporarily lower marsh channel salinities but effects to mouse habitat are unknown. If it is determined that a proposed change in Suisun Marsh Salinity Control Gates operation is likely to adversely affect salt marsh harvest mice, reinitiation pursuant to 50 CFR 402.16 is required.

10.4 Effects to Recovery

Reclamation has proposed to minimize and avoid adverse effects from tidal marsh restoration by implementing conservation measures consistent with those identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp to promote the recovery of salt marsh harvest mouse. Continued threats from habitat loss due to filling, diking, subsidence, changes in water salinity, non-native species invasions, sea level rise associated with global climate change, and contamination are contributing factors to the decline of this species. Habitat suitability of many marshes is further limited by small size, fragmentation, and lack of other vital features such as sufficient refugial habitat. Implementation of restoration actions in the Suisun Marsh may result in short-term adverse effects to salt marsh harvest mouse in order to gain long-term habitat benefits, thereby assisting in the recovery of this species. Therefore, we conclude that the PA would not negatively affect, and may contribute to, recovery of the salt marsh harvest mouse.

10.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect salt marsh harvest mouse. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the salt marsh harvest mouse.

10.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the salt marsh harvest mouse.

10.6.1 Reproduction

There is ample documentation of salt marsh harvest mice in tidal wetlands and along sloughs as well as within managed wetlands. While restoration activities may result in temporary adverse effects, implementation of conservation measures from the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp will minimize those effects and provide long-term benefits to the species. Therefore, the PA is not expected to negatively affect salt marsh harvest mouse reproduction range-wide, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

10.6.2 Numbers

Patchy and unstable, though sometimes sizable populations of salt marsh harvest mouse occupy tidal marshes of Suisun Marsh. In the diked marshes areas of Suisun Marsh, there are relatively stable populations of fairly high densities (Service 2013b). With implementation of the PA, low mortality or injury of individuals are expected to occur from tidal marsh restoration in the Suisun Marsh area if conservation measures are implemented fully and properly. Restoration actions would contribute to the recovery of salt marsh harvest mice by creating more sustainable habitat for salt marsh harvest mice. Therefore, the PA is not expected to reduce the range-wide numbers of salt marsh harvest mice.

10.6.3 Distribution

We do not anticipate that the range-wide distribution of the salt marsh harvest will be reduced because effects to the species from restoration construction activities will be minimized by the implementation of conservation measures from the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp. As restored areas evolve into functioning, vegetated tidal wetland, they are expected to provide benefits by adding permanent suitable and sustainable habitat for the salt marsh harvest mouse. Therefore, we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition.

10.7 Conclusion

After reviewing the current status of the salt marsh harvest mouse, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of salt marsh harvest mice likely to be affected by the PA will be low relative to the number of salt marsh harvest mice range-wide.

2. Reclamation has proposed to implement the conservation measures proposed in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

3. The PA is being implemented in a manner that will restore and create more suitable, sustainable habitat for the salt marsh harvest mouse long-term.

10.7 Salt Marsh Harvest Mouse Literature Cited

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11.0 SOFT BIRD'S-BEAK AND SUISUN THISTLE

11.1 Status of the Species

11.1.1 Status of the Soft Bird's-beak

Legal Status

Soft bird's-beak (*Chloropyron molle* ssp. *molle*) was listed as endangered in its entire range on November 20, 1997 (Service 1997).

Natural History/Biology

The principal habitat of the soft bird's-beak is the high marsh zone or upper middle marsh zone of brackish marshes with full tidal range (Peinado *et al.* 1994). It is rarely found in non-tidal conditions. Abundance is usually greatest in or near the upper-marsh upland ecotone (Chuang and Heckard 1973, Ruygt 1994). Large, dense patches are sometimes found along the margins of emergent salt pans, or scalds (Ruygt 1994).

Soft bird's-beak is an annual plant that evidently regenerates from a persistent dormant seed bank. The longevity of the seed bank is unknown. However, some colonies have failed to emerge for several years and then reappeared. Population densities vary from isolated individuals (less than 0.5 per square meter to more than 450 per square meter), with densities of 100 to 200 per square meter common (Ruygt 1994).

Branching and flower development begin as early as May (Ruygt 1994) and continue throughout the summer. Flower production correlates with the degree of branching and plant size (Ruygt 1994, Grewell *et al.* 2003, Grewell 2004). Fruits and seeds mature from July to November. Flowering has been known to occur, however, as late as November, indicating a significant overlap between flowering and fruiting (seed production) time. Some fruits begin to mature around early July.

The status of the soft bird's-beak and information about its biology, ecology, distribution, and current threats are available in the *Recovery Plan for the Tidal Marsh Ecosystems of Northern and Central California* (Service 2013b).

Range-wide Status and Distribution

There are currently 11 populations with documented occurrences in nine general areas: Rush Ranch, Hill Slough, Joice Island, Benicia State Recreation Area, Point Pinole, Concord Naval Weapons Station, Fagan Slough, McAvoy Boat Harbor, and Denverton. Our understanding of the soft bird's-beak is based on limited and opportunistic survey data. No recent comprehensive range-wide status survey has been conducted for the soft bird's-beak. The largest populations today are located mostly in old relict tidal marshes in Suisun Marsh. The most recent near-comprehensive census was conducted in 2000 (Service 2013b). The census covered Hill Slough marsh and Rush Ranch, both in Suisun Marsh, Solano County. The largest population was found at Hill Slough Wildlife Area and covered approximately 2 hectares (4.7 acres) (Service 2013b). Since then experimental reintroductions at Rush Ranch have occurred.

Population size and distribution are extremely variable among years for this species. Each population of soft bird's-beak is comprised of many shifting colonies or subpopulations. Because colonies may fail to emerge in some years, it can be difficult to determine with confidence when a population has become extirpated.

Threats

The Service's January 2009 five-year review for the soft bird's-beak recommended the soft bird's-beak remain listed as endangered due to the continuation of threats from muting (damping) of tides and salinity, invasive non-native plants, seed predation, sea level rise predicted to result from global climate change, mosquito abatement, oil spills, and (for these small populations) random events.

Recovery

None of the recovery units have met the *Recovery Plan for the Tidal Marsh Ecosystems of Northern and Central California* downlisting criteria for the protection, management, and restoration of suitable tidal marsh habitat (Service 2013b).

11.1.2 Status of the Suisun Thistle

Legal Status

Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) was listed as endangered in its entire range on November 20, 1997 (Service 1997).

Natural History/Biology

Suisun thistle is associated with the upper intertidal marsh plain along the steep, peaty banks of natural, mature, small tidal creeks, banks, ditches, and marsh edges that are very infrequently flooded but generally not along gently sloping terrestrial edges (Service 2013b). All Suisun thistle populations today occur in peaty organic marsh soils, old bay muds of fine estuarine sediments (silty clays) with relatively high organic content in the upper horizons, and increasing mineral content with depth (Joice series soils).

Suisun thistle is known to be restricted to freshwater-influenced brackish marshes, and is absent in the freshwater tidal marshes of the west Delta and the tidal marshes of central San Pablo Bay to the west.

Suisun thistle is an annual plant, dying after one year of seed reproduction. Its vegetative period is usually one year (biennial), but if small vegetative plant size or unfavorable environmental conditions delay flowering, it may regenerate from the central root crown for more than one year. Flowering occurs throughout the summer in most years, and continues through production of ripe seedheads (Service 2013b).

The status of the Suisun thistle and information about its biology, ecology, distribution, and current threats is available in the *Recovery Plan for the Tidal Marsh Ecosystems of Northern and Central California* (Service 2013b).

Range-wide Status and Distribution

There is scarce information on the historical distribution of the Suisun thistle. Since the time of listing and in the absence of recent surveys, the species is thought to be present at the two sites known prior to the listing (Peytonia Slough Ecological Reserve and Rush Ranch), plus upper Hill Slough and the Joice Island portion of Grizzly Island Wildlife Area, all in Suisun Marsh; however, the colonies at Rush Ranch and the colonies at Joice Island, which are at the eastern end of Rush Ranch have generally been interpreted as one population, for a total of three populations (Service 2013b). Potential habitat exists on private land directly adjacent to the three known populations on CDFW and Solano Land Trust properties. The status of the species on private land is unknown.

Threats

The soft bird's-beak and Suisun thistle are threatened by similar factors because they occupy the same tidal marsh ecosystem. These general threats are covered in the *Status of the Soft Bird's-beak*.

11.2 Environmental Baseline

11.2.1 Soft Bird's-beak Environmental Baseline

Soft bird's-beak is thought to be limited to three general locations in the Suisun Marsh portion of the Action Area: Rush Ranch, CDFW's Joice Island Unit of the Grizzly Island Wildlife Management Area, and the Hill Slough marsh (DWR 2001); however, this species also occurs on Luco Slough and east of Bradmoor Island (CDFW 2019). The Hill Slough population accounts for more than 80% of the occurrences of this species in the Action Area (Service 2013b).

11.2.2 Suisun Thistle Environmental Baseline

This species is known to exist only in Suisun Marsh and typically is found in the Action Area in the middle to high marsh zone along tidal channels and in irregularly flooded estuarine wetlands (DWR 2001). Three populations of Suisun thistle are known (DWR 2001), and there are four occurrences in the Action Area (CDFW 2019). One population occurs on CDFW's Peytonia Slough Ecological Reserve. The second population and the remaining occurrences are associated with the Cutoff Slough tidal marshes and CDFW's Joice Island Unit of the Grizzly Island Wildlife Management Area.

11.2.3 Previous Consultations in the Action Area

The Service has consulted on numerous consultations in the Suisun Marsh in the Action Area with a majority of the consultations being related to on-going maintenance activities or conversion of managed marsh to another use, such as tidal marsh restoration. The Service issued a biological opinion in June 2013, Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and Project-Level Actions in Solano County, California (08ESMF00-2012-F-0602-2), to the Corps to cover projects that fall under the Corps' Regional General Permit, their Letters of Permission, or individual permits in the Suisun Marsh. Example tidal marsh restoration projects that have been consulted on in the Action Area include Tule Red (08FBDT00-2016-F-0071), Blacklock (1-1-06-I-1880), and Montezuma Wetlands (1-1-99-F-12).

11.3 Effects of the Proposed Action

11.3.1 Tidal Habitat Restoration in Suisun Marsh

Soft bird's-beak and Suisun thistle are known to occur in the Action Area. Construction activities associated with tidal wetland restoration could affect these plant populations. Soft bird's-beak and Suisun thistle may be directly or indirectly affected by a restoration project; however, adequate buffer areas would be established to exclude activities that would directly remove or alter the habitat of an identified population or result in indirect adverse effects on the species' habitat. However, indirect effects related to restoration, such as scour adjacent to the breach location, could result in a loss of suitable habitat for soft bird's beak and Suisun thistle. Breach size and location would be selected to minimize the effects of scour on soft bird's-beak and Suisun thistle. Additionally, restoration of tidal marshes is expected to create a range of marsh elevation habitat that would support soft bird's beak and Suisun thistle. Long term effects of large scale tidal marsh restoration will result in increased habitat for these rare plants.

Construction activities related to tidal restoration actions could result in the introduction or spread of noxious weed species, which could displace native species, thereby changing the diversity of species or number of any species of plants. Soil-disturbing activities during construction could promote the introduction of plant species that currently are not found in the Action Area, including exotic pest plant species. Construction activities also could spread exotic pest plants that already occur in the Action Area. Individual restoration sites will be managed to promote tidal wetland vegetation so when inundation occurs, there is minimal potential to support nonnative species.

Tidal wetland restoration will occur by breaching and/or lowering exterior levees to restore tidal inundation to restoration sites. Breach locations will be chosen to minimize temporary upstream tidal muting. Restoration projects will be spread throughout the Suisun Marsh and implemented over several years. Interval implementation and the effect of sea level rise would minimize the potential for substantial tidal muting. Although tidal muting could result in a temporary reduction in the tidal water surface elevation range, the overall acreage of tidal wetlands in the Suisun Marsh would increase substantially as a result of restoration actions and provide for more suitable habitat for the soft bird's-beak and Suisun thistle.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits will be addressed in subsequent consultation prior to implementation. This could include tiering or appending to the existing Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

11.3.2 Suisun Marsh Salinity Control Gates (Proposed Flow Changes)

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. SMSCG reoperations are expected to lower marsh salinities creating a potential vegetation shift in Suisun Marsh. Changes in tidal stage, flow, or erosion were not analyzed in the ROC BA and therefore effects are uncertain at this time.

11.4 Effects to Recovery

Reclamation has proposed to minimize and avoid adverse effects from tidal marsh restoration by implementing conservation measures consistent with those identified in the Suisun Marsh Plan Programmatic Biological Opinion to promote the recovery of soft bird's-beak and Suisun thistle. Continued threats from muting (damping) of tides and salinity, invasive non-native plants, seed predation, sea level rise predicted to result from global climate change, mosquito abatement, oil spills, and (for these small populations) random events are contributing factors to the decline of soft bird's-beak (Service 2013b). Habitat loss is the primary cause of decline of the Suisun thistle (Service 2013b). Implementation of restoration actions in the Suisun Marsh may result in short-term adverse effects to the soft bird's-beak and Suisun thistle in order to increase long-term habitat benefits, thereby assisting in the recovery of this species.

11.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect soft bird's-beak and Suisun thistle. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the soft bird's-beak and Suisun thistle.

11.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the soft bird's-beak and Suisun thistle.

11.6.1 Reproduction

Suisun thistle is an annual plant, dying after one year of seed reproduction (Service 2013b). The reproductive output of individual plants and colonies of Suisun thistle has not been quantified.

No quantitative data are available on seed set, seed abortion, or seed predation. Individual branched plants may produce hundreds of seedheads. Soft bird's-beak is also an annual plant but will regenerate from a persistent dormant seed bank. The longevity of the seed bank is unknown; however, some colonies have failed to emerge for several years and then reappeared. Factors, such as predation, disease, and wind dispersal, can influence the seed production and impact plant species success (Service 2013b). While restoration activities may result in adverse effects, implementation of conservation measures identified in the Suisun Marsh Plan Programmatic Biological Opinion will avoid or minimize those effects and provide long-term benefits to the soft bird's-beak and Suisun thistle. Therefore, the PA is not expected to negatively affect the soft bird's-beak and Suisun thistle reproduction range-wide, and we conclude that the effects would not reduce the range-wide reproductive capacity for both species.

11.6.2 Numbers

Limited documented locations of soft bird's-beak and Suisun thistle exist in the Suisun Marsh. With implementation of the PA, a low amount of direct mortality or injury of individual plants and colonies are expected to occur from tidal marsh restoration or implementation of facilities like the Suisun Marsh Salinity Control Gates in the Suisun Marsh area if conservation measures are implemented properly and fully. Restoration actions would contribute to the recovery of soft bird's-beak and Suisun thistle by creating more sustainable habitat for these species and may result in increased numbers of both plants.

11.6.3 Distribution

We do not anticipate that the range-wide distribution of the soft bird's-beak and Suisun thistle will be reduced because the Proposed Action may have short-term adverse effects but is expected to have long-term benefits. Although the Action Area overlaps the entire Suisun thistle's range, the PA is not expected to reduce the distribution. The effect to these species from restoration construction activities will be minimized by the implementation of the conservation measures from the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp. Therefore, we do not expect Reclamation's actions will reduce the species' distribution of soft bird's-beak and Suisun thistle.

11.7 Conclusion

After reviewing the current status of the soft bird's-beak and Suisun thistle, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of these species. We have reached this conclusion because:

1. The low number of individuals likely to be affected by the PA will not appreciably reduce the likelihood of soft bird's-beak and Suisun thistle survival and recovery and restored wetlands may result in increased numbers of both plants species.

2. Reclamation has proposed to implement the conservation measures proposed in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

3. The PA is being implemented in a manner that will restore and create more suitable, sustainable habitat for the soft bird's-beak and Suisun thistle long-term.

11.8 Critical Habitat

11.8.1 Status of Soft Bird's-beak Critical Habitat

The Service designated critical habitat for soft bird's-beak on April 12, 2007 (Service 2007). The PCEs defined for soft bird's-beak were derived from its biological needs. Based on our current knowledge of the life history, biology, and ecology of the species, and the habitat requirements for sustaining the essential life-history functions of the species, the Service determined that the PCEs essential to the conservation of the soft bird's- beak are:

1. Persistent emergent, intertidal, estuarine wetland at or above the mean high-water line (as
2. extended directly across any intersecting channels);
3. Rarity or absence of plants that naturally die in late spring (winter annuals); and
4. Partially open spring canopy cover (approximately 790 nMol/m2/s) at ground level, with many small openings to facilitate seedling germination.

Five units have been designated as critical habitat for soft bird's-beak in Contra Costa, Napa, and Solano Counties, California. Contra Costa, Napa, and Solano Counties have approximately 22 acres, 384 acres, and 1,870 aces of critical habitat, respectively. Common threats that may require special management considerations or protections of the PCEs for soft bird's-beak in all five units include: (1) mosquito abatement activities (ditching, 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; (2) general foot and off-road vehicle traffic through soft bird's beak populations that could result in their damage and loss in impacted areas; (3) increases in the proliferation of nonnative invasive plants from human-induced soil disturbances leading to the invasives outcompeting soft bird's beak; (4) control or removal of nonnative invasive plants, especially *Lepidium latifolium,* which, if not carefully managed, can damage soft bird's beak populations through the injudicious application of herbicides, by direct trampling, or through the accidental transport of invasive plant seeds to new areas; and (5) presence of *Lipographis fenestrella* (a moth) larvae that could reduce the reproductive potential of soft bird's beak through flower, fruit, and seed predation.

11.8.2 Status of Suisun Thistle Critical Habitat

The Service designated critical habitat for Suisun thistle on April 12, 2007 (Service 2007). The PCEs defined for Suisun thistle were derived from its biological needs. Based on our current knowledge of the life history, biology, and ecology of the species, and the habitat requirements for sustaining the essential life-history functions of the species, the Service determined that the PCEs essential to the conservation of the 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 %; and
3. Gaps in surrounding vegetation to allow for seed germination and growth.

The three units designated as critical habitat for Suisun thistle comprise 2,052 acres of Solano County. Common threats that may require special management considerations or protections of the PCEs for Suisun thistle in all three 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 C. *hydrophilum* var. *hydrophilum* colonies, or in soil disturbance and compaction, leading to a disruption in natural marsh ecosystem processes; (4) the proliferation of nonnative invasive plants, especially *Lepidium latifolium,* leading to the invasives outcompeting C. *hydrophilum* var. *hydrophilum;* and (5) programs for the control or removal of non-native invasive plants, which, if not conducted carefully, can damage C. *hydrophilum* var. *hydrophilum* 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.

<u>11.8.3 Soft Bird's-Beak Environmental Baseline</u>

Three critical habitat units identified for soft bird's-beak occur in the Action Area. These units are Unit 2, Hill Slough Wildlife Management Area; Unit 4, Rush Ranch/Grizzly Island Wildlife Management Area; and Unit 5, Southampton Marsh. Soft bird's-beak occurs in each of these Units.

<u>11.8.4 Suisun Thistle Environmental Baseline</u>

Three critical habitat units have been identified for Suisun thistle in the Action Area. These units are Unit 1, Hill Slough Wildlife Management Area; Unit 2, Peytonia Slough Ecological Reserve; and Unit 3, Rush Ranch/Grizzly Island Wildlife Management Area. Suisun thistle occurs in each of these Units.

<u>11.8.5 Previous Consultations in the Action Area</u>

The Service has consulted on numerous consultations in the Suisun Marsh in the Action Area with a majority of the consultations being related to on-going maintenance activities or conversion of managed marsh to another use, such as tidal marsh restoration. The Service issued a biological opinion in June 2013, Biological Opinion on the Proposed Suisun Marsh Habitat Management, Preservation, and Restoration Plan and Project-Level Actions in Solano County, California (08ESMF00-2012-F-0602-2), to the Corps to cover projects that fall under the Corps'

Regional General Permit, their Letters of Permission, or individual permits in the Suisun Marsh. Example tidal marsh restoration projects that have been consulted on in the Action Area include Tule Red (08FBDT00-2016-F-0071), Blacklock (1-1-06-I-1880), and Montezuma Wetlands (1-1-99-F-12).

11.8.6 Effects of the Proposed Action on Soft Bird's-beak and Suisun Thistle Critical Habitat

Tidal Habitat Restoration in Suisun Marsh

Within Suisun Marsh there are 2,052 acres of critical habitat designated for Suisun thistle in Units 1, 2, and 3, and 1,870 acres of critical habitat designated for soft bird's-beak in Units 2, 4, and 5. Reclamation has proposed to minimize and avoid adverse effects to individuals from tidal marsh restoration by implementing conservation measures consistent with those identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp, such as pre-construction surveys associated with each tidal marsh restoration project that will inform new locations of individuals. Indirect effects related to restoration, such as scour adjacent to the breach location, could result in a loss of critical habitat. Breach size and location would be selected to minimize the effects of scour on special-status species habitat. Creation of tidal marsh may create additional habitat within critical habitat units for these species. PCEs will remain intact, contributing to the high conservation value of the unit as a whole, and sustaining the unit's role in the conservation and recovery of the soft bird's-beak and Suisun thistle.

These actions are addressed programmatically in this consultation, so further detail about expected effects and benefits will be addressed in subsequent consultation prior to implementation. This could include tiering or appending to the existing Suisun Marsh Habitat Management, Preservation, and Restoration Plan BiOp.

Suisun Marsh Salinity Control Gates (Proposed Flow Changes)

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. SMSCG reoperations are expected to lower marsh salinities creating a potential shift vegetation in Suisun Marsh. Changes in tidal stage, flow, or erosion were not analyzed in the ROC BA and therefore effects are uncertain at this time.

11.8.7 Cumulative Effects for Soft Bird's-beak and Suisun Thistle Critical Habitat

The activities described in Section 5.5 for delta smelt critical habitat are also likely to affect soft bird's-beak and Suisun thistle critical habitat. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the soft bird's-beak and Suisun thistle critical habitat.

11.8.8 Conclusion

After reviewing the current status of the soft bird’s-beak and Suisun thistle critical habitat, Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service’s biological opinion that the PA is not likely to destroy or adversely modify soft bird’s-beak or Suisun thistle critical habitat. We have reached this conclusion because:

1. Creation of tidal marsh may create additional habitat within critical habitat units for these species.

2. PCEs will remain intact, contributing to the high conservation value of each critical habitat unit and each critical habitat as a whole, and sustaining each unit's role in the conservation and recovery of the soft bird’s-beak and Suisun thistle.

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12.0 VALLEY ELDERBERRY LONGHORN BEETLE

12.1 Status of the Species

The valley elderberry longhorn beetle was listed as threatened throughout its range and critical habitat was designated on August 8, 1980 (45 FR 52803-52807). 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. However, in the BA Reclamation states that it is not consulting on valley elderberry longhorn beetle critical habitat because the Proposed Action will avoid effects to the critical habitat; therefore, it will not be addressed further in this BiOp.

The status of the valley elderberry longhorn beetle has been assessed in the *Recovery Plan Valley Elderberry Longhorn Beetle* (Service 1984) (Recovery Plan) and the 5-year review (Service 2006). For the most recent comprehensive assessment of the range-wide status of the valley elderberry longhorn beetle, refer to the *Withdrawal of the Proposed Rule To Remove the Valley Elderberry Longhorn Beetle From the Federal List of Endangered and Threatened Wildlife* (Service 2014; 79 FR 55874) (withdrawal notice).

In 2012, the Service recommended the delisting of the valley elderberry longhorn beetle (77 FR 60238). The proposal to delist the valley elderberry longhorn beetle was withdrawn on September 17, 2014 (79 FR 55874), and further analysis has resulted in a range modification for the species (Environmental Conservation Online System (ECOS) 2016), and prompted the Service to develop a new *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (Service 2017).

12.1.1 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 (*Sambucus* spp.) grows (Service 1984). The historic distribution of the beetle closely matched the distribution of the elderberry host plant, which was patchily found throughout the Central Valley riparian forests and occasionally adjacent uplands (non-riparian). At the time of listing in 1980, the beetle was known from less than 10 locations on the American River, Putah Creek, and Merced PatterRiver (Service 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 (Figure 12-1), including the valley floor and lower foothills, and is generally found below 500 feet (152 meters) above mean sea level (Service 2017).

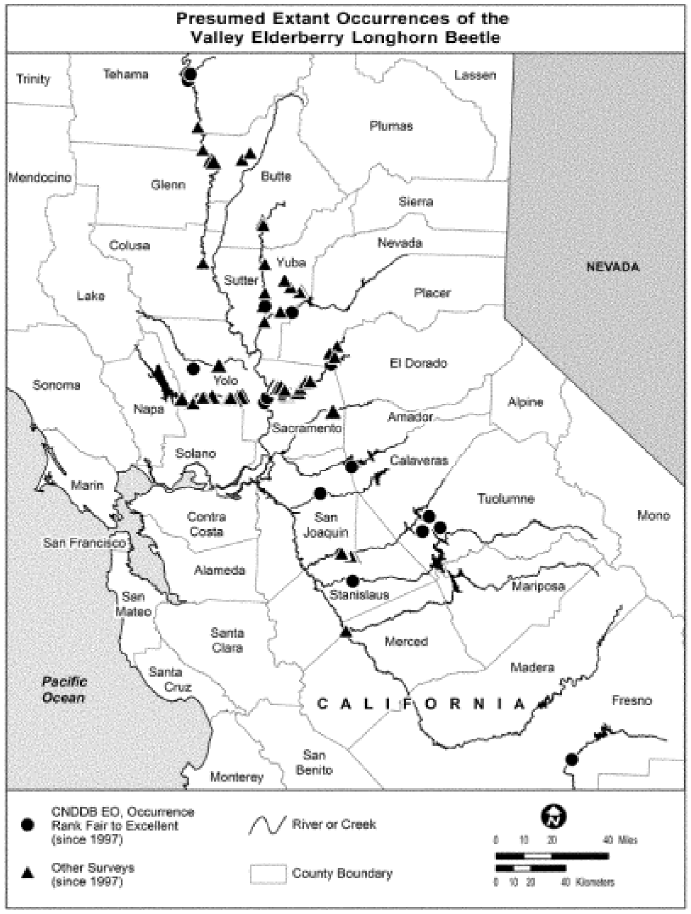

Figure 12-1. Presumed extant occurrences of the valley elderberry longhorn beetle (Service 2014). Based on observations (adult beetles and exit holes) between 1997 and 2014 within its presumed historical range. CNDDB occurrence rank of "fair, good, or excellent." Data sources: Collinge *et al.* 2001; River Partners 2007, 2010, 2011; Holyoak and Graves 2010; CDFW 2013; Collinge 2014, pers. comm.; Talley, 2014, pers. comm.; DOD 2014.

In the withdrawal notice, we reevaluated all available spatial data and provided an updated historical distribution map based on surveys conducted since 1997. The Service described the species' distribution in the context of a metapopulation structure, or discrete subpopulations that exchange individuals through dispersal or migration, and fragmented habitat (Service 2017, Collinge *et al.* 2001). The subpopulations may shift spatially and temporally within riparian drainages, resulting in a patchwork of occupied and unoccupied habitat (Service 2017e). The valley elderberry longhorn beetle remains localized in its distribution (low local numbers within a population structure), with limited dispersal ability, and we estimate it occupies less than 25% of the remaining elderberry habitat found within fragmented riparian areas. There has been nearly 90% loss of riparian vegetation in the Central Valley, and the fragmentation of this habitat that has resulted in a locally uncommon or rare and patchy distribution (clustered in regional aggregations) of the valley elderberry longhorn beetle within its remaining presumed historical range in the Central Valley (patchy distribution from Tehama County to Fresno County).

In the withdrawal notice, we reevaluated the valley elderberry longhorn beetle occurrence records, location, and occupancy data described in our proposed rule, and incorporated new information received since the proposed delisting rule was published (77 FR 60238). The valley elderberry longhorn beetle is a habitat specialist, with limited dispersal ability and a short adult lifespan, and is found in low numbers within a population structure that has become fragmented within its historical range, and continues to be fragmented further by ongoing impacts to its habitat. The valley elderberry longhorn beetle's vulnerable developmental stages (*i.e.*, exposure of eggs and larvae) and its rarity (*i.e.*, low local numbers, low occupancy within its range) are important elements of the metapopulation structure of the species. We concluded that there are extant occurrences of the valley elderberry longhorn beetle at 36 geographical locations in the Central Valley (these locations are based in large part on observations of exit holes, which may not be an accurate depiction of occupancy). However, we acknowledge that there are no current estimates of population size or trends in population numbers for the valley elderberry longhorn beetle.

12.1.2 Reproduction and Habitat Requirements

The valley elderberry longhorn beetle is closely associated with elderberry, as these plants are an obligate host plant for larvae and are necessary for the completion of the life cycle (Eng 1984; Barr 1991; Collinge *et al.* 2001). Elderberry shrubs are common in the Central Valley where they grow naturally in a variety of riparian and non-riparian vegetative communities (Vaghti and Greco 2007). Most elderberry presence within the Central Valley is determined by broad scale hydrologic regimes such as the relative elevation of floodplain and floodplain width, and secondarily by sediment texture and topography (Fremier and Talley 2009). The two main species of elderberry used by this species are the blue elderberry (*Sambucus nigra* subsp. *caerulea,* formerly *S. mexicana*) and red elderberry (*S. racemosa*). Blue elderberry is a component of riparian habitats throughout the Central Valley. Elderberry shrubs are most common on higher and older riparian terraces, where the roots of the plant are able to reach the water table and where the plants are not inundated for long periods (Talley 2005; Vaghti *et al.* 2009). Elderberry shrubs supporting the greatest beetle densities are located in areas where the shrubs are abundant and interspersed in significant riparian zones (Talley *et al.* 2006). The Service recognizes habitat for beetle as including both riparian and nonriparian areas where elderberry shrubs are present.

Adult valley elderberry longhorn beetles live for a few days to a few weeks between mid-March and mid-May, and are most active from late April to mid-May. The adult beetles feed on the elderberry foliage and possibly its flowers. During this time of activity, the beetles mate, and the female lays eggs on the living elderberry plant host. The eggs are typically placed individually or in small clusters within crevices in the bark or junctions of the stem and trunk or leaf petiole and stem. Eggs hatch within a few days and soft-bodied larvae emerge. The larvae are on the surface of the elderberry from a few minutes to several hours or a day and then bore to the center of the elderberry stems where they create a feeding gallery in the pith at the center of the stem. The larvae develop for 1 to 2 years feeding on pith. The late instar larvae chew through the inner bark, all or most of the way to the surface, then return inside plugging the holes with wood shavings. The larvae move back down the feeding gallery to an enlarged pupal chamber packed with frass. Here the larvae metamorphose into pupae between December and April (Talley *et al.* 2006).

The length of pupation is thought to be about one month with the emergent adult remaining in the chamber for up to several weeks. Adults complete the hole in the outer bark and emerge during the flowering season of elderberry shrubs. The exit holes are circular to oval and range in size from 4 to 10 millimeters in diameter (Talley *et al.* 2006).

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 (Service 2014).

12.1.3 Limiting Factors, Threats, and Stressors

Threats, such as the loss of riparian habitat due to development, infrastructure construction and land conversion to agriculture, and the effects of nonnative invasive species were evaluated during the review and discussed in the final withdrawal notice, and continue to act on the valley elderberry longhorn beetle since the withdrawal notice was published. These factors have greatly contributed to the loss and fragmentation of the valley elderberry longhorn beetle metapopulations, including the construction of roads and pipelines.

During the last 150 years California's Central Valley riparian forests have experienced extensive vegetation loss due to expansive agricultural and urban development (Katibah 1984), and in many places, have dwindled to discontinuous, narrow corridors. In recent decades, riparian areas in the Central Valley have continued to decline as a result of ongoing agricultural conversion, urban development, stream channelization and channel hardening. Due to the beetle's limited physical dispersal capability, the fragmentation of riparian forests decreases the likelihood of successful colonization of unoccupied habitat (Collinge *et al.* 2001). As a consequence, the subpopulations are more vulnerable to stochastic events (e.g. removal of vegetation for construction projects, fires, large floods, pesticide applications) that may reduce or eliminate the subpopulation. The loss of multiple subpopulations can have an adverse impact on the long-term persistence and health of the metapopulation of beetles in the Central Valley. Therefore, maintaining contiguous areas of suitable habitat is critical for the survival of the species.

Habitat loss continues to exacerbate the highly fragmented distribution of the valley elderberry longhorn beetle. Direct habitat loss irreversibly damages riparian habitat, specifically to elderberry (*Sambucus* spp.) shrubs. The alteration and destruction of habitat surrounding riparian habitat may disrupt the physical processes conducive to functional riparian ecosystems and further fragment the habitat.

12.1.4 Recovery Considerations

The Service finalized the recovery plan for the species in 1984. However, when the *Valley Elderberry Longhorn Beetle Recovery Plan* was developed, limited 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 (Service 2012). In 2012, the Service proposed delisting the beetle from its threatened status under the Act based on results of surveying efforts, as well as past and ongoing riparian vegetation restoration and the persistence of elderberry shrubs in restored areas. However, the Service withdrew the proposed delisting rule 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. Specifically, the Service concluded that the species continues to be threatened by habitat loss or degradation (*Factor A*) and predation (*Factor C*) throughout all of its range. Additional environmental factors (e.g. additional habitat loss) and other stressors (e.g. effects related to pesticide use, competition to its host plant from invasive species) are likely to influence the species' distribution and likelihood of extinction in the foreseeable future. While many riparian habitat preservation and restoration effects have taken place throughout the Central Valley since the species' listing, based on the best available data, the species has not recovered in any part of its range (Service 2014).

In the riparian habitat along the Sacramento River, a lack of blue elderberry recruitment may be affecting the quality of habitat for the beetle. Vaghti *et al.* (2009) documented that in riparian habitats there are substantial problems caused by invasive species associated with blue elderberry and the lack of small elderberry plants along dammed rivers. In the absence of large-scale riverine process restoration, horticultural restoration of elderberry shrubs and the maintenance of healthy riparian woodland ecosystems are believed to be necessary to support the recovery of valley elderberry longhorn beetle (Vaghti *et al.* 2009). Extensive elderberry replanting efforts have taken place in the Sacramento River National Wildlife Refuge (River Partners 2004) and elderberry longhorn beetles have been found occupying these restored habitats (Golet *et al.* 2008, Gilbart 2009).

The majority of the beetle's essential habitat along the Lower American River has been protected as part of the American River Parkway (Service 2012), which is managed by Sacramento County Regional Parks and California State Parks and includes both designated critical habitat and essential habitat (Service 2012). Additionally, the Corps has designed and built six sites along the lower American River as habitat for the valley elderberry longhorn beetle between RM 0.9 up to RM 21 (Service 2014).

12.2 Environmental Baseline

The riparian range of the valley elderberry longhorn beetle largely overlaps with the Action Area. However, the current distribution of species in the Action Area is largely unknown. Comprehensive surveys for the species or its host plant, elderberry (*Sambucus* spp.), have not been conducted and thus the population size and location of the species in the Action Area is unknown. Surveys to document elderberry shrubs within 165 feet (50 meters) of all Proposed Action activities will take place prior to the start of construction (Appendix E of the BA, AMM25).

The beetle's distribution is typically based on the occurrence of elderberry shrubs, which are known to occur along riparian corridors throughout the Action Area, including the Sacramento River, American River, Feather River, Stanislaus River, San Joaquin River, and along smaller natural and channelized drainages, as well as in upland habitats. Valley elderberry longhorn beetle is likely to occupy suitable habitat within the riparian areas of the Action Area. However, occupancy in the Bay-Delta watershed is anticipated to be low as few elderberry shrubs exist in the region aside from isolated patches where suitable conditions exist (Calflora 2019). There are no reported occurrences of valley elderberry longhorn beetle in the deltaic wetlands within the Action Area (CDFW 2019; Service 2014).

Valley elderberry longhorn beetle populations and their habitat within the Action Area face the same threats the species faces range-wide. Rapid and widespread development of the Central Valley beginning in the mid-19th century contributed to the loss of nearly 95% of the wooded riparian habitat in the region (Katibah 1984), resulting in the long-term loss and fragmentation of valley elderberry longhorn beetle habitat and decline of the species (Service 2017). Despite gaining protection under the Endangered Species Act in 1980, habitat loss continues to be a primary threat to survival of the species (Service 2014). The losses of riparian habitat due to development, infrastructure construction, land conversion to agriculture, stream channelization, channel hardening, and the effects of nonnative invasive species have greatly contributed to the direct loss of elderberry shrubs and the fragmentation of the valley elderberry longhorn beetle metapopulations along the major rivers of the Central Valley included in the Action Area. The alteration of riparian ecosystems due to damming and the introduction of invasive species has been found to impair blue elderberry recruitment along Action Area rivers (Vaghti *et al.* 2009).

The Service has formally consulted on 586 projects within the Action Area since 1994. These consultations were for projects within every watershed in the Action Area. These consultations were for a variety of projects, including flood control and levee improvements, transportation, utilities, housing development, and geotechnical investigation, transmission lines, and restoration.

12.3 Effects of the Proposed Action

Direct effects are the effects of the PA that directly affect the species; for example, those actions that immediately destroy or adversely affect habitat or displace animals and plants. Individual valley elderberry longhorn beetles and their larvae may be directly injured or killed by actions leading to the destruction of habitat (*i.e.*, the killing of or damage to elderberry plants) in which they live. The Service views that any ground disturbance within 20 feet of the dripline of an elderberry plant has the potential to adversely affect that plant and may cause mortality.

Indirect effects are caused by or result from a proposed action, are later in time, and are reasonably certain to occur. Implementation of species-specific conservation measures for valley elderberry longhorn beetle included in the BA (described below) will minimize indirect effects that may occur outside of the 20 foot buffer around an elderberry plant. Elderberry shrubs may be indirectly affected by actions occurring within 165 feet of the of the elderberry plant's dripline. These may include dust accumulating on plants, soil compaction, inappropriate herbicide, and fuel spills.

The life cycle of the valley elderberry longhorn beetle is such that it may be impossible to know whether an elderberry plant is occupied by larvae or not. Without visual verification of adult valley elderberry longhorn beetles being present, the only other indication of occupation is the presence of exit holes in the stems of elderberry shrubs. The presence of exit holes in elderberry shrub stems does translate to a higher likelihood that the shrubs in the general area are occupied, but the lack of exit holes does not indicate a lack of presence of the valley elderberry longhorn beetle. For that reason, the Service assumes that any elderberry plant within the range of the valley elderberry longhorn beetle might be occupied by larvae.

12.3.1 Reclamation's Proposed Conservation Measures for Valley Elderberry Longhorn Beetle

Reclamation has proposed the following measures to section "AMM25 Valley Elderberry Longhorn Beetle" (AMM-VELB) of Appendix E of the BA to avoid, minimize, and mitigate for impacts to the valley elderberry longhorn beetle and its habitat (Reclamation 2019).

Avoidance and Minimization Measures

Reclamation proposes to locate activities with flexible locations to avoid or minimize disturbance of valley elderberry longhorn beetle suitable habitat within the species' range. The following measures will be required for project components unable to avoid valley elderberry longhorn beetle habitat.

Reclamation will avoid valley elderberry longhorn beetle critical habitat during implementation of the project components.

Preconstruction surveys for elderberry shrubs will be conducted within all activity footprints and areas within 165 feet by a biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. When possible, preconstruction surveys will be conducted in the calendar year prior to disturbance and will follow the guidance of the Services' *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (Service 2017), herein referred to as the 2017 VELB Framework. Elderberry shrubs will be avoided to the greatest extent practicable. Complete avoidance (i.e., no adverse effects) may be assumed when activities occur in non-riparian habitat and elderberry shrubs are not present or within a 165-foot buffer of the activity. The Service will be consulted before any disturbances, including construction, within the 165-foot buffer area if it contains elderberry shrubs and/or riparian habitat.

- For elderberry shrubs not directly affected by construction but that occur between 20 feet and 165 feet from ground-disturbing activities, the following measures will be implemented:

- *Fencing*. All areas to be avoided during construction activities will be fenced and/or flagged as close to construction limits as feasible.
- *Avoidance area*. Activities that may damage or kill an elderberry shrub (e.g., trenching, paving, etc.) may need an avoidance area of at least 6 meters (20 feet) from the drip-line, depending on the type of activity.
- *Worker education*. A qualified biologist will provide training for all contractors, work crews, and any onsite personnel on the status of the valley elder, its host plant and habitat, the need to avoid damaging the elderberry shrubs, and the possible penalties for non- compliance.
- *Construction monitoring*. A qualified biologist will monitor the work area at project- appropriate intervals to assure that all avoidance and minimization measures are implemented. The amount and duration of monitoring will depend on the project specifics and should be discussed with the Service biologist.
- *Timing*. As much as feasible, all activities that could occur within 50 meters (165 feet) of an elderberry shrub, will be conducted outside of the flight season of the valley elderberry longhorn beetle (March - July).
- *Trimming*. Trimming may remove or destroy valley elderberry longhorn beetle eggs and/or larvae and may reduce the health and vigor of the elderberry shrub. In order to avoid and minimize adverse effects to valley elderberry longhorn beetle when trimming, trimming will occur between November and February and will avoid the removal of any branches or stems that are ≥ 1 inch in diameter. Measures to address regular and/or large-scale maintenance (trimming) should be established in consultation with the Service.
- *Chemical Usage*. Herbicides will not be used within the drip-line of the shrub. Insecticides will not be used within 30 meters (98 feet) of an elderberry shrub. All chemicals will be applied using a backpack sprayer or similar direct application method.
- *Mowing*. Mechanical weed removal within the drip-line of the shrub will be limited to the season when adults are not active (August - February) and will avoid damaging the elderberry.
- *Erosion Control and Revegetation*. Erosion control will be implemented and the affected area will be revegetated with appropriate native plants.
- *Dust Control*. 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.

- Elderberry shrubs with stems greater than 1 inch that are directly affected by construction should be transplanted under the following conditions: 1) if the elderberry shrub cannot be avoided; 2) if indirect effects will result in the death of stems or the entire shrub.
  - The removal may either include the roots or just the removal of the aboveground portion of the plant. When possible, the entire root ball will be retained and the elderberry shrub will be transplanted as close as possible to their original location. Elderberry shrubs will be relocated adjacent to the project footprint if: 1) the planting location is suitable for elderberry growth and reproduction; and 2) the project proponent is able to protect the shrub and ensure that the shrub becomes reestablished. If these criteria cannot be met, the shrub may be transplanted to an

appropriate Service-approved mitigation site. Any elderberry shrub that is unlikely to survive transplanting because of poor condition or location, or a shrub that would be extremely difficult to move because of access problems, may not be appropriate for transplanting. The following transplanting guidelines shall be used by Reclamation in developing their valley elderberry longhorn beetle conservation measures:

- *Monitor*. A qualified biologist will be on-site for the duration of transplanting activities to assure compliance with avoidance and minimization measures and other conservation measures.
- *Exit Holes*. Exit-hole surveys will be completed immediately before transplanting. The number of exit holes found, GPS location of the plant to be relocated, and the GPS location of where the plant is transplanted will be reported to the Service and to the CNDDB.
- *Timing*. Elderberry shrubs will be transplanted when the shrubs are dormant (November through the first two weeks in February) and after they have lost their leaves. Transplanting during the non-growing season will reduce shock to the shrub and increase transplantation success.
- *Transplanting Procedure*. Transplanting will follow the most current version of the ANSI A300 (Part 6) guidelines for transplanting (http://www.tcia.org/).
- *Trimming Procedure*. Trimming will occur between November and February and should minimize the removal of branches or stems that exceed 1 inch in diameter.

Compensation to Offset Unavoidable Impacts

Reclamation proposes to coordinate with the Service to offset impacts on elderberry shrubs by either creating valley elderberry longhorn beetle habitat or by purchasing the equivalent credits at a Service approved conservation bank with a service area that overlaps with the Action Area. Compensatory mitigation will be coordinated with the Service to determine the appropriate type and amount of compensatory mitigation and follow criteria in the 2017 VELB Framework.

12.3.2 Sacramento River

Seasonal Operations

Implementation of the PA is unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the upper Sacramento watershed. There is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles.

Salmonid Spawning and Rearing Habitat Restoration

During placement of gravel and other measures to enhance spawning habitat, Reclamation will avoid disturbance of elderberry shrubs consistent with AMM-VELB, including but not limited to, avoiding siting restoration projects in areas with elderberry shrubs to the extent practical, implementing avoidance areas and fencing around elderberry shrubs, and adjusting construction timing to avoid work within 165 feet of elderberry shrubs from March to July. 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 the Bay Delta Conservation Plan, 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* (Service 2017).

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 (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 Holyoak 2006). 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 Holyoak (2006) 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 construction activities will occur during nighttime hours in the vicinity of habitat for federally listed species.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

North Delta Food Subsidies/Colusa Basin Drain Study

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass. The proposed flows will not exceed current local flooding levels. Flows are proposed in July, August and/or September for approximately 4 weeks, which would potentially kill elderberry shrubs from excessive saturated soil conditions or competition from other plants that may benefit from the change in hydrology (Vaghti *et al.* 2009), although the extent to which these effects might occur is uncertain based on the information provided in the BA. If elderberry shrubs are damaged or die due to the proposed flows taking place in July at the end of breeding season, adult valley elderberry longhorn beetles may be injured or killed. Flows during the breeding season may also potentially affect the behavior of adult beetles. Flooding in July or August may result in killing eggs laid on elderberry leaves below the flood elevation. Flooding may result in the scouring of elderberry shrubs and breaking off limbs occupied by beetle larvae resulting in the death of those individuals. By transplanting elderberry shrubs likely to be killed or injured by the proposed flows or mitigating at a minimum of 3:1 for unavoidable adverse impacts in accordance with the measures in AMM-VELB and the Service's (2017) *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle*, Reclamation can minimize adverse effects from this activity.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

<u>12.3.3 American River</u>

Seasonal Operations

Implementation of the PA is unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the American River watershed. There is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles.

Salmonid Spawning and Rearing Habitat Restoration

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB by implementing such measures as establishing avoidance areas and fencing around elderberry shrubs for temporary construction access, educating workers, and adjusting the timing of work to avoid killing or injuring adult beetles. 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* (Service 2017), or through the purchasing of mitigation credits. Construction-related effects associated with Spawning and Rearing Named Projects in the American River Watershed are similar to those effects described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

12.3.4 Stanislaus River

Seasonal Operations

Implementation of the PA is unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the Stanislaus River watershed. There is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles.

Salmonid Spawning and Rearing Habitat Restoration

Creation of spawning habitat will avoid disturbance of valley elderberry longhorn beetle habitat, consistent with AMM-VELB by implementing such measures as establishing avoidance areas and fencing around elderberry shrubs for temporary construction access, educating workers, and adjusting the timing of work to avoid killing or injuring adult beetles. 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* (Service 2017), or through the purchasing of mitigation credits.

Construction-related effects associated with Spawning and Rearing Named Projects in the Stanislaus River Watershed are similar to those effects described above for Spawning and Rearing Named Projects in the Upper Sacramento River Watershed.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

12.3.5 San Joaquin River

Proposed Flow Changes

In the lower San Joaquin watershed, the PA is unlikely to produce any measurable change in quantity or quality of valley elderberry longhorn beetle habitat in the San Joaquin River watershed. There is no apparent mechanism by which these changes could result in harm to individual valley elderberry longhorn beetles.

Lower San Joaquin River Habitat Restoration

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* (Service 2017).

Construction-related effects associated with *Lower San Joaquin Rearing Habitat Restoration* are as described above for *Spawning and Rearing Habitat Restoration* in the Upper Sacramento River Watershed.

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.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

12.3.6 Bay-Delta

Intertidal and Associated Subtidal Habitat Restoration

The component projects and approach used in Tidal Habitat Restoration have been described previously. Tidal Habitat Restoration could affect valley elderberry longhorn beetle via direct effects of construction, or through conversion of habitat, as described below. Incidental take of valley elderberry longhorn beetles resulting from restoration at these sites will be addressed in subsequent consultations for individual restoration projects.

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 the *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (Service 2017).

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 (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 Holyoak 2006). 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 Holyoak (2006) 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.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

12.4 Effects to Recovery

For a species like the valley elderberry longhorn beetle that has lost much of its former known occupied habitat, recovery would necessitate the conservation of much of the remaining habitat that still supports it. Reclamation is proposing to minimize the adverse effects of the loss of suitable habitat by implementing actions to promote the recovery of the affected species in a manner where the conservation measures are commensurate with the adverse effect. Reclamation has proposed to preserve, create or enhance habitat to offset the total loss of suitable habitat associated with the Proposed Action. This habitat will be protected and managed for the conservation of the species in perpetuity and will provide habitat for breeding, feeding and sheltering and will help maintain the geographic distribution of the species and will contribute to the recovery of the species by increasing the amount of habitat that is secure from development threats and the other factors that threaten the species that can be addressed by habitat protection and management. Since habitat loss and degradation are contributing factors to the decline of the valley elderberry longhorn beetle; preservation, creation and enhancement of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the valley elderberry longhorn beetle.

12.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect valley elderberry longhorn beetle throughout the Action Area. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis for the valley elderberry longhorn beetle.

12.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the valley elderberry longhorn beetle.

12.6.1 Reproduction

The valley elderberry longhorn beetle is closely associated with elderberry, as these plants are an obligate host plant for larvae and are necessary for the completion of the life cycle. 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* (Service 2017). Therefore, no permanent loss of habitat is anticipated. Therefore, the PA is not expected to negatively affect valley elderberry longhorn beetle reproduction, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

12.6.2 Numbers

Comprehensive population surveys for the valley elderberry longhorn beetle, or its host plant, have not been conducted and thus the population size and location of the species in the Action Area is unknown. Therefore, estimating the number of valley elderberry longhorn beetles in the

Action Area that may be affected by the PA is difficult. Reclamation has proposed to preserve, create and enhance suitable habitat that will provide habitat for breeding, feeding and sheltering and would implement AMMs to further reduce potential impacts to the species. Despite the proposed protection measures, we anticipate the PA may still result in effects to the valley elderberry longhorn beetle; however, the number of valley elderberry longhorn beetles affected would be low. This is especially true relative to the range-wide numbers. Therefore, the PA will not significantly reduce the number of valley elderberry longhorn beetles and we conclude the overall number of valley elderberry longhorn beetles throughout the species' range would not decline.

12.6.3 Distribution

The remaining presumed historical range of the valley elderberry longhorn beetle in the Central Valley consists of patchy distribution from Tehama County to Fresno County. The current distribution of valley elderberry longhorn beetles within the Action Area is largely unknown. The distribution that could be affected by the Proposed Action could be relatively large compared to the total range-wide distribution and the Proposed Action covers many of the rivers in the species' range. However, Reclamation is not proposing to implement activities expected to result in permanent loss of suitable habitat by implementing AMMs and the transplantation of affected shrubs and planting of new shrubs and associated riparian vegetation consistent with the *Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle* (Service 2017). We conclude that the valley elderberry longhorn beetles will continue to survive in the Action Area regardless of the activities. Consequently, the water operations and restoration activities will not alter the overall distribution of the valley elderberry longhorn beetle and we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition.

12.7 Conclusion

After reviewing the current status of the valley elderberry longhorn beetle, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The area of potential effect to the valley elderberry longhorn beetle is small and will not reduce the reproduction, numbers, and distribution of the species.

2. The number of valley elderberry longhorn beetles that will likely be affected is relatively small.

3. Reclamation has proposed measures to avoid and minimize potential effects.

4. Reclamation proposes to protect, create, and enhance habitat that could support the valley elderberry longhorn beetle.

5. The proposed action is being implemented in a manner that will minimize damage to areas that could support the valley elderberry longhorn beetle.

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13.0 RIPARIAN BRUSH RABBIT

13.1 Status of the Species

The Service listed riparian brush rabbit (*Sylvilagus bachmani riparius*) as endangered on February 23, 2000. Currently, no critical habitat has been designated for the riparian brush rabbit. The *Final Rule to List the Riparian Brush Rabbit and the Riparian, or San Joaquin Valley, Woodrat as Endangered* (Federal Register 65: 8881-8890; https://www.gpo.gov/fdsys/pkg/FR-2000-02-23/pdf/00-4207.pdf#page=1) provides the most comprehensive assessment of the range-wide status of the riparian brush rabbit at the time of its listing. Since that time, additional private lands in San Joaquin County (referred to as the South Delta population) have been identified as having extant rabbit populations, and a re-introduced population has been established on the SJRNWR (Phillips *et al.* 2013). Currently, there are three known populations of riparian brush rabbits:

1. Caswell Memorial State Park – Caswell Memorial State Park is located at the confluence of the Stanislaus River and the San Joaquin River;
2. South Delta populations – these populations include the Paradise Cut, Faith Ranch, etc.; and,
3. SJRNWR – the SJRNWR is south of the Legal Delta. The population that exists within the SJRNWR is primarily made up of re-introduced individuals and their progeny.

13.1.1 Historical and Current Distribution

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 (Service 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 (Service 1998).

There are two remaining populations of riparian brush rabbits in San Joaquin County. One population is present on approximately 258 acres (104 hectares) in Caswell Memorial State Park on the Stanislaus River, 147 acres of which are considered riparian habitat. The other population is located at several small, isolated or semi-isolated patches immediately west and southwest of Lathrop, totaling approximately 270 acres (109 hectares) along Paradise Cut and Tom Paine Slough, and channels of the San Joaquin River in the south Delta (Kelly 2015 pers comm. 2015; Kelly *et al.* 2011; Williams *et al.* 2002). In January of 1997, Caswell Memorial State Park flooded, submerging most of the habitat of the riparian brush rabbit. Evidence of only three riparian brush rabbits was seen immediately following this flooding episode (D. Williams 1997). In 1998, only one riparian brush rabbit was live-trapped (D. Williams 1998a,b). In addition, a captive breeding program has established a population on the Faith Ranch, which is owned by the wine-making Gallo family (Service 2007).

The SJRNWR encompasses approximately 7,000 acres in Stanislaus County 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 (Service 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. Additionally, a wildfire event in 2004 and major flood events in 2006 and 2011 may have significantly affected the SJRNWR riparian brush rabbit population (Kelly *et al.* 2011).

The SJRNWR population of riparian brush rabbit is just outside of or adjacent to the Action Area with existing, but limited, connectivity. The most recent CNDDB record of riparian brush rabbits within the Action Area, dated 2008, was a result of trapping efforts located at Caswell Memorial State Park, between 1993 and 2008 (CDFW 2018). More recently, continued trapping efforts resulted in the capture of two rabbits in 2012 (Matocq *et al.* 2015). In addition, re-establishment efforts have been conducted south of the Delta on the SJRNWR, with 49 captive-bred rabbits released in 2002 and 187 released in 2003. The rabbit population on the SJRNWR was supplemented annually from 2005 to 2010. As a result of these re-establishment efforts as well as the on-site efforts to restore the contiguous riparian woodland habitat, the largest population of rabbit now resides on the SJRNWR.

13.1.2 General Life History and Habitat

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 typically remain hidden under protective shrub cover and seldom venture more than a few feet from cover. Their response to a threat is to retreat back into cover rather than to be pursued in open areas (Service 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 (Service 1998). Kelt *et al.* (2014) found that rabbits on the SJRNWR consistently preferred vegetation communities dominated by sandbar willow (*Salix exigua*) and mixed with dense shrubs, such as California blackberry and rose, and exhibited secondary preferences for open grassland and dense riparian; home ranges of rabbits on the SJRNWR ranged from approximately 3.68 to 5.21 acres.

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 grass 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 (Service 1998).

13.1.3 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 and stochastic events.

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; Service 1998). Climate change is likely to increase the severity of flooding, impacting riparian brush rabbit populations.

Periodic flooding events are likely to continue to occur along all major rivers in the Central Valley (Kindel 1984). With behavioral restrictions on its freedom of movement (low dispersal behavior) and the shortage of habitat that is suitably protected from frequent floods downstream of Caswell Memorial State Park, there are limited opportunities that individuals escaping drowning or predation would be able to find mates or reproduce successfully following dispersal events (Service 1998).

Wildfire poses 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 wildfire that would cause both high mortality and further loss of habitat.

The riparian brush rabbit is subject to a variety of contagious, and potentially fatal diseases that may be transmitted from neighboring populations of desert cottontails. For the small remnant brush rabbit populations, a disease event could result in extirpation of the entire population (Williams 1988; Service 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, and feral dogs and cats (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.

13.1.4 Recovery Considerations

The Service 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.

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, California wild rose, and low-growing willows, or other dense shrub species;
- Ecotone edges of brushy habitat 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; and,
- High-ground refugia from flooding.

13.1.5 Monitoring and Research Programs

River Partners have been working on the SJRNWR to establish a self-sustaining population of riparian brush rabbit on the SJRNWR. Their restoration actions are continuing 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 SJRNWR, creating the largest block of contiguous riparian woodland in the San Joaquin Valley. Riparian brush rabbits have been reintroduced to this restored habitat from captive-reared populations. Matocq *et al.* (2017) found that the re-introduced population on the SJRNWR represented high levels of genetic diversity with a unique genetic composition, which was likely the result of its complex history of population declines, repeated translocations, and natural gene flow from nearby semi-isolated populations. The goal of the restoration effort is to increase the available habitat for the riparian brush rabbit by more than 30 times its 1997 extent. The restored habitat is intended to protect the population from inevitable future flood events.

In 2015, Reclamation provided additional funds to the River Partners to restore 175 acres of historic floodplain forest habitat at Dos Rios Ranch, in Stanislaus County, to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, least Bell's vireo, and western yellow-billed cuckoo. 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 listed species to seasonally flooded land (River Partners 2018).

13.2 Environmental Baseline

The factors described in the *Status of the Species* section above, including habitat loss, fragmentation, and degradation due to urban and agricultural development, are factors which have in the past and still continue to affect the species within the Action Area.

The Caswell Memorial State Park population along the Stanislaus River is within the southern boundary of the Action Area. The south Delta populations of riparian brush rabbit, which includes Paradise Cut and Tom Paine Slough, are within the Action Area. There is little information available as to the status of these populations.

Although no rabbit surveys were conducted specifically for the Proposed Action, riparian woodland habitat is located within the Action Area and numerous sightings have been made in close proximity to the West Stanislaus Irrigation District intake canal. Approximately 0.84 acre of riparian woodland with thickets of willows and shrubs occur within the Action Area, with ruderal habitat comprising the majority of the balance of the upland areas within the Action Area. It is reasonable to assume that the riparian woodland present overlaps the home range of at least one rabbit.

The Service has formally consulted on two projects within the Action Area since 2015 that may adversely affect the rabbit; the West Stanislaus Fish Screen Intake Project, in Stanislaus County, (08ESMF00-2018-F-0976) and the State Route 99 Ripon Bridge Rehabilitation Project in San Joaquin County (08ESMF00-2015-F-1164).

13.3 Effects of the Proposed Action

The riparian brush rabbit occurs in the Stanislaus River and San Joaquin River watershed, and Proposed Action components within these watersheds may affect this species as follows.

13.3.1 Stanislaus River Watershed

Flow and Operations

Operations under the Proposed Action will 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 caused by implementation of the PA. Implementation of the Proposed Action generally will result in minor changes to flow and likely will be small relative to normal month-to-month and year-to-year variability in the system. Any changes in the natural flow regime of the river will likely result in an increase in non-native and invasive plant species and a reduction in native riparian vegetation recruitment. Lower flows in the spring under the Proposed Action are likely to result in less riparian vegetation recruitment which could result over the duration of the PA in less habitat used for cover for riparian brush rabbit. The Proposed Action will likely result in flows being generally more stable timing-wise as compared to the current operations scenario. Lower flows in the spring and a more stable regime are likely to reduce the amount of surrounding suitable habitat over time. Any changes to the habitat surrounding existing populations of riparian brush rabbits may adversely affect their ability to disperse and colonize new areas beyond the current habitats occupied. The changes in flow and operations are unlikely to directly affect individual riparian brush rabbits, but may result in indirect impacts over time through negative changes in riparian habitat resulting in unsuitable habitat for the species. However, it is not expected that the magnitude and rate of this impact will affect breeding, feeding, or sheltering during the timeframe of the PA.

Spawning and Rearing Habitat

Spawning gravel placed in-stream will not result in loss or disturbance of riparian brush rabbit habitat. However, access to the enhancement site by vehicles, workers, and equipment may temporarily disturb habitat or disrupt normal behavioral patterns of riparian brush rabbits in the vicinity of the activity. 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 may result in loss of riparian brush rabbit habitat. 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 proposes to implement AMM-RBR/RWR to avoid occupied riparian brush rabbit habitat. Reclamation proposes to remove no more than 10 acres of suitable, but unoccupied, riparian brush rabbit habitat, therefore minimizing the effect to the species by limiting the amount of suitable habitat that can be removed and reducing or avoiding direct injury or mortality to individual riparian brush rabbits. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a 3:1 ratio as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian brush rabbit; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian brush rabbit.

Spawning and Rearing Habitat actions are addressed programmatically in this consultation, so further detail about effects and incidental take will be addressed in subsequent consultation prior to implementation.

13.3.2 Lower San Joaquin River Watershed

Proposed Flow Changes

The anticipated changes from the current operations scenario in flows resulting from the implementation of the Proposed Action in the lower San Joaquin watershed would be almost nonexistent and have little to no change in quantity or quality of riparian brush rabbit habitat in the lower San Joaquin watershed. Additionally, there is little to no risk that these changes will result in direct harm to individual riparian brush rabbits.

Lower San Joaquin Spawning and Rearing Habitat

Permanent Habitat Loss

The Proposed Action will include large-scale floodplain habitat restoration in the Lower San Joaquin River. Levee construction may result in removal or conversion of potential 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. Per the BA, “Reclamation will ensure that potential riparian brush rabbit habitat permanently removed does not exceed the maximum allowable habitat loss for this species.” Reclamation did not define “maximum allowable habitat loss” but did quantify the acreage amounts described above in Appendix E of the BA. Reclamation’s proposed conservation measure AMM-RBR/RWR requires avoidance of habitat occupied or assumed to be occupied by riparian brush rabbit. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a 3:1 ratio as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian brush rabbit; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian brush rabbit.

Temporary Habitat Loss

Based on Reclamation's proposed draft 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, a number of years will be required for restored riparian habitat to functionally replace habitat that has been affected. Most of the riparian vegetation within the species' range is early- to mid-successional, 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.

Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The inundated areas may consist of suitable riparian brush rabbit habitat. Floodplain restoration will result in periodic inundation of riparian habitat and associated grassland habitat. These habitats that are proposed to be periodically inundated have the potential to provide habitat for the riparian brush rabbit. 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.

The proposed AMM-RBR/RWR 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 side of the newly constructed levees (Kelly *et al.* 2011).

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. Reclamation will avoid disturbance of occupied riparian brush rabbit habitat and therefore will avoid construction-related injury or mortality of this species. 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 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.

These actions associated with the Lower San Joaquin Spawning and Rearing Habitat are addressed programmatically in this consultation, so further detail about expected benefits and adverse effects, and any incidental take, will be addressed in subsequent consultation prior to implementation.

13.4 Effects to Recovery

Reclamation is proposing to minimize the adverse effects from the loss of suitable habitat by implementing actions to promote the recovery of the affected species in a manner where the conservation measures are commensurate with the adverse effect. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian brush rabbit; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian brush rabbit. Therefore, we conclude that the Proposed Action will not interfere with the recovery of the riparian brush rabbit.

13.5 Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the Action Area and are considered in this biological opinion. Future Federal actions unrelated to the Proposed Action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act.

The overwhelmingly predominant land use within the Action Area is some form of agriculture, whether that be row crops, orchards, dry farming, livestock grazing, etc. It is reasonable to assume that all effects to federally listed species that are associated with the agricultural activities that currently occur in the Action Area will continue to occur. The Service assumes that these ongoing, background effects from agricultural practices within the Action Area will remain throughout the life of the Proposed Action and would be very difficult to quantify or predict the nature that they will take throughout the life of the Proposed Action. These agricultural practices do constitute a cumulative effect. Beyond these ongoing agricultural activities, we are unaware of any specific future State, Tribal, local, or private actions that may affect the riparian brush rabbit and are reasonably certain to occur in the Action Area.

13.6 Summary of the Effects from the Action

In determining whether a Proposed Action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to the reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the Proposed Action on the riparian brush rabbit.

13.6.1 Reproduction

The riparian brush rabbit is a secretive and hard-to detect species that is limited within the Action Area. There are no proposed actions within known occupied riparian brush rabbit habitat. Therefore, the Proposed Action is not expected to negatively affect riparian brush rabbit reproduction, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

13.6.2 Numbers

The number of riparian brush rabbits in the Action Area is relatively low, based on recent and past records (Kelly 2015; Kelly *et al.* 2011; Williams *et al.* 2002). Additionally, Reclamation has proposed measures to avoid and minimize the effects of the Proposed Action on the species. Despite the proposed protection measures, the Service anticipates that the Proposed Action may result in effects to the riparian brush rabbit; however, the number of riparian brush rabbits affected would be very low. This is especially true relative to the range-wide numbers. Therefore, the Proposed Action is not expected to reduce the number of riparian brush rabbits throughout the species' range.

13.6.3 Distribution

The Service anticipates the number of riparian brush rabbits likely to be affected by the Proposed Action will be very low. We do not expect that any riparian brush rabbits will be directly killed by any of the described restoration actions associated with the Proposed Action. We also conclude that riparian brush rabbits will continue to survive in the Action Area regardless of the activities. Consequently, the proposed restoration projects will not alter the distribution of the riparian brush rabbit and we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition.

13.7 Conclusion

After reviewing the current status of the riparian brush rabbit, the Environmental Baseline for the Action Area, the effects of the PA and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of riparian brush rabbits likely to be affected by the PA will be very low.
2. Reclamation has proposed adequate measures to avoid and minimize potential effects.
3. Reclamation proposes to restore or protect habitat that could support the riparian brush rabbit.

13.8 Riparian Brush Rabbit Literature Cited

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14.0 RIPARIAN WOODRAT

14.1 Status of the Species

The Service listed riparian woodrat (*Neotoma fuscipes riparia*) as an endangered species under the ESA on February 23, 2000 (65 FR 8881). No critical habitat has been designated for the riparian woodrat.

The *Final Rule to List the Riparian Brush Rabbit and the Riparian, or San Joaquin Valley, Woodrat as Endangered* (Federal Register 65: 8881-8890; https://www.gpo.gov/fdsys/pkg/FR-2000-02-23/pdf/00-4207.pdf#page=1) provides the most comprehensive assessment of the range-wide status of the riparian woodrat at the time of its listing. The most recent comprehensive assessment of the range-wide status of the woodrat is the *Riparian Woodrat 5-Year Review: Summary and Evaluation* (Service 2012). No change in the species' listing status was recommended in this 5-year review.

14.1.1 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 1988). 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). There are two remaining extant populations. The first population is restricted to about 250 acres (100 hectares) of riparian forest on the Stanislaus River in Caswell Memorial State Park, and the second population is approximately five miles away within the SJRNWR (Kelly *et al.* 2009, Kelly *et al.* 2011). In 1993, Williams (1993) estimated the size of the Caswell Memorial State Park population at 437 individuals. In January of 1997, Caswell Memorial State Park flooded, submerging most of the habitat of the riparian woodrat. Evidence of only six riparian woodrats was seen immediately following this flooding episode (D. Williams 1997). In 1998, only nine riparian woodrats were live-trapped at Caswell Memorial State Park (D. Williams 1998a,b).

The Caswell Memorial State Park population along the Stanislaus River is within the southern boundary of the Action Area. No research has been conducted on the spatial distribution and habitat use of the riparian woodrat, but it likely has similar spatial distribution patterns of the dusky-footed woodrat, of which it is a subspecies. Territories of dusky-footed woodrats in the mixed conifer forests of the northern Sierra Nevada, California ranged from 0.14 to 18 acres (Innes *et al.* 2009).

The SJRNWR population may be quite vulnerable: only 34 individuals have been captured (at different times) and no stick lodges have been observed anywhere on the refuge, although riparian woodrats are known to use downed trees, snags, or even buildings in place of constructing stick lodges (Kelly *et al.* 2011). Additionally, a wildfire event in 2004 and major flood events in 2006 and 2011 may have significantly reduced the SJRNWR riparian woodrat population (Kelly *et al.* 2011).

The specimens from which the subspecies designation was described were collected about 2 miles (3 km) northeast of Vernalis, west of Modesto in Stanislaus County, California, approximately 6 miles (10 km) from Caswell Memorial State Park. Analysis of DWR land use maps indicate that there were approximately 50 acres (20 hectares) of "natural vegetation" present along the San Joaquin River near the locality in 1988, though no woodrats have been seen in that area. Today there is no habitat for riparian woodrats around El Nido, which is located about 5.5 miles (8.9 km) east of the San Joaquin River.

14.1.2 General Life History and Habitat

Riparian woodrats are most numerous where shrub cover is dense and least abundant in open areas. In riparian areas, the 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, and terminal shoots of twigs, flowers, nuts, and fungi (Service 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. No woodrat houses have been found at SJRNWR (Kelly *et al.* 2011). Houses are usually placed on the ground or against/straddling a log or exposed roots of a standing tree, and typically located in dense brush. Houses 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 events.

Riparian woodrats live in loosely cooperative societies and have a matrilineal 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, the effective population size is generally much smaller than the actual population size. This breeding system in combination with the small size of the only known extant populations suggests that the riparian woodrat could be at an increased risk of extinction because of inbreeding depression.

14.1.3 Limiting Factors, Threats, and Stressors

Loss, fragmentation, and degradation of habitat are the principal reasons for the decline of the riparian woodrat (Service 2000). Threats evaluated in the 5-year review have continued to act on the species, with effects of stochastic events, inbreeding, disease, and predation posing the most significant. The most immediate threats to the two, small populations include naturally occurring events, such as drought, flooding, and wildfires. The lack of remnant habitat also continues to restrict and isolate the remaining two populations of riparian woodrat. All of these environmental stressors are likely to increase in severity with climate change as California's snowpack decreases and watersheds move toward more rain driven hydrology. In addition, riparian woodrats are threatened by disease, predation, competition, clearing of riparian vegetation, use of rodenticide, and loss of genetic variability.

14.1.4 Recovery Considerations

The Service 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 plans for the riparian brush rabbit at the Caswell Memorial State Park and SJRNWR.

14.1.5 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 and Quinn1992; 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 riparian 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 habitat at Dos Rios Ranch, in Stanislaus County, to benefit riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, least Bell's vireo, and western yellow-billed cuckoo. After successful pilot studies, two berms were strategically notched and removed from the landscape in 2018, which reconnected the endangered riparian woodrat and nine other listed species to seasonally flooded land (River Partners 2018).

14.2 Environmental Baseline

The Caswell Memorial State Park population is within the Action Area. The factors described in the *Status of the Species* section above, including habitat loss, fragmentation, and degradation due to urban and agricultural development, are factors which have in the past and still continue to affect the species within the Action Area.

The Service has formally consulted on one project within the Action Area since 2015 that may adversely affect the riparian woodrat; the State Route 99 Ripon Bridge Rehabilitation Project in

San Joaquin County (08ESMF00-2015-F-1164). Surveys were not conducted for that project but presence was assumed due to high quality habitat along the banks of the Stanislaus River within dispersal distance to Caswell Memorial State Park.

14.3 Effects of the Proposed Action

The riparian woodrat occurs in the Stanislaus River and San Joaquin River watershed, and Proposed Action components within these watersheds may affect this species as follows.

14.3.1 Stanislaus River Watershed

Flow and Operations

Operations under the Proposed Action will 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 will result in minor changes and likely will be small relative to normal month-to-month and year-to-year variability in the system. Any changes in the natural flow regime of the river will likely result in an increase in non-native and invasive plant species and a reduction in native riparian vegetation recruitment. Lower flows in the spring under the Proposed Action are likely to result in less riparian vegetation recruitment which could result over the duration of the PA in less habitat used for cover for riparian woodrat. The Proposed Action will likely result in flows being generally more stable timing-wise as compared to the current operations scenario. Any changes to the habitat surrounding existing populations of riparian woodrats may adversely affect the population's ability to disperse and colonize new areas beyond the current habitats occupied. The changes in flow and operations are unlikely to result in direct harm to individual riparian woodrats, but may result in indirect impacts through changes in riparian habitats resulting in unsuitable habitat for the species over time.

Spawning and Rearing Habitat

Spawning gravel placed in-stream, will not result in loss or disturbance of riparian woodrat habitat. However, access to the enhancement site by vehicles, workers, and equipment may disturb habitat or disrupt normal behavioral patterns of riparian woodrats in the vicinity of the activity. 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 may result in loss of riparian woodrat habitat. 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 proposes to implement AMM18 Riparian Woodrat and Riparian Brush Rabbit to assume presence or conduct protocol-level surveys in order to avoid occupied riparian woodrat habitat. According to the BA, Reclamation will remove no more than 10 acres of suitable, but unoccupied, riparian woodrat habitat, therefore minimizing the effect to the species by limiting the amount of suitable habitat that can be removed and reducing or avoiding direct injury or mortality to individual riparian woodrats. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a 3:1 ratio as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian woodrat; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian woodrat.

Spawning and Rearing Habitat actions are addressed programmatically in this consultation, so further detail about effects and incidental take will be addressed in subsequent consultation prior to implementation.

14.3.2 Lower San Joaquin River Watershed

Proposed Flow Changes

The anticipated changes from current conditions in flows resulting from the implementation of the Proposed Action in the lower San Joaquin watershed would be almost nonexistent and have little to no change in quantity or quality of riparian woodrat habitat in the lower San Joaquin watershed. Additionally, there is little to no risk that these changes will result in direct harm to individual riparian woodrats.

Lower San Joaquin Spawning and Rearing Habitat

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. Levee construction may result in the permanent removal of approximately 41 acres of riparian woodrat habitat along the lower San Joaquin River. Per the BA, "Reclamation will ensure that riparian woodrat habitat permanently removed does not exceed the maximum allowable habitat loss for this species". Reclamation did not define "maximum allowable habitat loss" but did quantify an amount in Appendix E of the BA. Reclamation's proposed AMM18 Riparian Woodrat and Riparian Brush Rabbit requires avoidance of habitat occupied or assumed to be occupied by riparian woodrat. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat at a 3:1 ratio as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian woodrat; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian woodrat.

Temporary Habitat Loss

Based on Reclamation's proposed draft 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, as much as 20 years may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected.

Periodic Inundation

Existing levees will be breached for floodplain restoration and the newly constructed setback levees will allow inundation through seasonal flooding. The inundated areas may consist of suitable riparian woodrat habitat. Floodplain restoration will result in periodic inundation of riparian woodrat habitat. 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.

The proposed AMM18 Riparian Woodrat and Riparian Brush Rabbit 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* (Service undated, available at: https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/).

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. Reclamation will avoid disturbance of occupied riparian woodrat habitat and therefore will avoid construction-related injury or mortality of this species. 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 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.

These actions associated with the Lower San Joaquin Spawning and Rearing Habitat are addressed programmatically in this consultation, so further detail about expected benefits and adverse effects, and any incidental take, will be addressed in subsequent consultation prior to implementation.

14.4 Effects to Recovery

Reclamation is proposing to minimize the adverse effects from the loss of suitable habitat by implementing actions to promote the recovery of the affected species in a manner where the conservation measures are commensurate with the adverse effect. Reclamation has proposed to restore or protect suitable habitat to offset the total loss of suitable habitat as described in Appendix E of the BA. Habitat loss and degradation are contributing factors to the decline of riparian woodrat; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the riparian woodrat. Therefore, we conclude that the Proposed Action will not interfere with the recovery of the riparian woodrat.

14.5 Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions unrelated to the Proposed Action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act.

The overwhelmingly predominant land use within the Action Area is some form of agriculture, whether that be row crops, orchards, dry farming, livestock grazing, etc. It is reasonable to assume that all effects to federally listed species that are associated with the agricultural activities that currently occur in the Action Area will continue to occur. The Service assumes that these ongoing, background effects from agricultural practices within the Action Area will remain throughout the life of the Proposed Action and would be very difficult to quantify or predict the nature that they will take throughout the life of the Proposed Action. These agricultural practices do constitute a cumulative effect. Beyond these ongoing agricultural activities, we are unaware of any specific future State, Tribal, local, or private actions that may affect the riparian woodrat and are reasonably certain to occur in the Action Area.

14.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to the reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the Proposed Action on the riparian woodrat.

14.6.1 Reproduction

The riparian woodrat is a secretive and hard-to detect species that is limited within the Action Area. Reclamation proposed to avoid occupied habitat (assumed or verified by surveys). Therefore, the Proposed Action is not expected to negatively affect riparian woodrat reproduction, and we conclude that the effects would not reduce the range-wide reproductive capacity of the species.

14.6.2 Numbers

The number of riparian woodrat in the Action Area is relatively low, based on recent and past records (Kelly *et al.* 2009; Kelly *et al.* 2011; Williams 1986). Additionally, Reclamation has proposed measures to avoid and minimize the effects of the Proposed Action on the species. Despite the proposed protection measures, the Service anticipates that the Proposed Action may result in effects to the riparian woodrat; however, the number of riparian woodrats affected would be very low. This is especially true relative to the range-wide numbers. Therefore, the Proposed Action is not expected to reduce the number of riparian woodrats throughout the species' range.

14.6.3 Distribution

The Service anticipates the number of riparian woodrats likely to be affected by the Proposed Action will be very low. We do not expect that any riparian woodrats will be directly killed by any of the described restoration actions associated with the Proposed Action. We also conclude that riparian woodrats will continue to survive in the Action Area regardless of the activities. Consequently, the proposed restoration projects will not alter the distribution of the riparian woodrat and we do not expect Reclamation's actions will reduce the species' distribution relative to its range-wide condition.

14.7 Conclusion

After reviewing the current status of the riparian woodrat, the Environmental Baseline for the Action Area, the effects of the PA and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The number of riparian woodrats likely to be affected by the PA will be very low.

2. Reclamation has proposed adequate measures to avoid and minimize potential effects.

3. Reclamation proposes to restore or protect habitat that could support the riparian woodrat.

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15.0 WESTERN YELLOW-BILLED CUCKOO

15.1 Status of the Species

15.1.1 Current Legal Status

The Service listed the western distinct population segment (DPS) of the yellow-billed cuckoo as threatened on October 3, 2014 (79 FR 59992). Critical habitat was proposed on August 15, 2014 (79 FR 48547, Service 2014a), and the proposed rule identified sections of the Action Area along the Sacramento River from south of Red Bluff in Tehama County to Colusa, California. A final critical habitat determination has not been made for this species, and Reclamation did not request a conference opinion on the effects of the PA on proposed critical habitat. The Service initiated a 5-year status review of the species in June 2018, but it is not yet completed. The information in this section is from the final listing rule, the proposed critical habitat rule, review of the best available scientific and commercial information, and the ROC on LTO BA.

15.1.2 Description and Life History

The western yellow-billed cuckoo (cuckoo) is a medium sized bird (Family Cuculidea) measuring approximately 12 inches (30 centimeters) in length and weighing about 2.1 ounces (60 grams). The plumage consists of a grayish-brown back and white chest, the tail is black and quite long with white spots. The upper mandible is dark, and the lower is typically yellow with a black tip. Cuckoos are fairly secretive in nature and call infrequently with “kowlp”, “coo”, “kuk” or “knocking” vocalizations.

Cuckoos are Neotropical migrant birds that winter in South America east of the Andes, primarily south of the Amazon Basin in southern Brazil, Paraguay, Uruguay, eastern Bolivia, and northern Argentina (Service 2013). Following migration from South America, cuckoos arrive in the southwest United States and northwestern Mexico in late May/early June with some as late as early July. They move about their breeding range in search of a riparian habitat block of sufficient size that has an abundance of prey. Breeding occurs when prey is sufficiently abundant to feed and fledge their precocial chicks. Breeding can occur from June through August with most cuckoos migrating south by mid-September. Nesting activity typically occurs between late June and late July and nest clutch size is typically between two and four eggs (Halterman *et al.* 2015). Cuckoos have a very short breeding season (14 to 20 days from nest construction to fledge) that is based on the availability of large insects that provide nutrition for quick growth. Fledglings are dependent on adults until 28-32 days old.

15.1.3 Habitat

Throughout this section, the terms ‘territory’ and ‘site’ are used to help describe cuckoo population biology. A territory is the area occupied by a pair or a pair accompanied by an additional ‘helper male’ or juvenile male cuckoo throughout the breeding season. Territories are the unit of measurement used by the Service in determining population status and trends. Detections at a ‘site’ consist of individual locations where a cuckoo was identified either by aural or visual observation either during migration or during the breeding period. Such information may not signify a breeding territory, but rather a location used for foraging, resting, or perhaps, breeding activities (Carstensen *et al.* 2015). Within an area of suitable or moderately suitable habitat cuckoo territories may overlap and are not typically defended. The term 'suitable or moderately suitable habitat' refers to habitat patches where cuckoos would be suspected to potentially use as a breeding or nesting area.

The Service's current estimates of territory size for cuckoo are based on telemetry studies and modeling from Arizona and New Mexico, which found 'suitable or moderately suitable habitat' used for breeding consists of a core area of dense cottonwood-willow vegetation of at least 12 acres (4.5 hectares) in area and surrounded by large expanses of vegetation of at least 178 acres (72 hectares) for foraging that may be of lower quality than the core area (Johnson *et al.* 2017; Halterman *et al.* 2015; Sechrist *et al*. 2009). Similar telemetry studies to determine the average size of core areas used for breeding by cuckoos in California have not been completed. Past studies in California found cuckoos are most likely to be found in patches of willow–cottonwood riparian habitat greater than 200 acres (80 hectares) in size (Service 2014a), and the species rarely uses small patches of habitat (under 50 acres [20 hectares] in size), particularly when patches were distant from other patches of riparian habitat (Laymon and Halterman 1989).

Breeding cuckoos are riparian obligates and nest in low to moderate elevation riparian woodlands with dense vegetation providing a thick canopy cover. Cuckoo habitat is dynamic and can change rapidly due to riverine processes of flooding, erosion, sediment deposition, and drought. Nesting habitat can mature as quickly as 2-3 years depending on conditions and vegetative species (Halterman *et al.* 2015). Cuckoos primarily use willow species such as Gooding's black willow (*Salix gooddingii*), red willow (*S. laevigata*), and coyote willow (*S. exigua*) for nesting and have open saucer type nests (similar to that of a Dove). Other tree species are occasionally used, including Fremont cottonwood (*Populus fremontii*) and alder. Along the Sacramento River, orchards of English walnut (*Juglans regia*), prune, and almond trees have also been reportedly used for nesting (Laymon 1980). Occupied habitat in Butte County was described by Halterman (1991) as great valley cottonwood riparian forest and great valley mixed riparian forest, including willows, box elder, and white alder. Potential habitat also occurs in valley marshland with willow riparian corridors, such as that found in the Llano Seco area of Butte County. Nests are built from 4 to 73 feet above the ground, and nest trees range from 10 to 98 feet in height (Service 2014a).

Although cuckoos nest primarily in willow trees, Fremont cottonwood trees are important foraging habitat, particularly as a source of insect prey. All studies indicate a highly significant association with relatively expansive stands of cottonwood-willow forests; however, cuckoos will occasionally occupy a variety of marginal habitats, particularly at the edges of their range (Laymon 1998). Cottonwood trees have specific habitat needs to successfully germinate and grow. Cottonwood seedling roots grow from between 0.2 to 0.4 inch (0.5 to 1.0 cm) per day (Mahoney and Rood 1998), to a maximum growth of 1 inch (2.5 cm) per day (Stella et al. 2010) under cultivation. At 1 inch (2.5 cm) per day, recruitment begins to diminish (Rood et al. 1988). Adequate flow recessions are necessary for cottonwood germination and seedling survival.

Continuing habitat succession has also been identified as important in sustaining breeding populations (Laymon 1998). Riparian vegetation succession is dependent upon dynamic riverine processes (Service 2014a). It is important to recognize that in order to support or provide for dynamic riverine processes, riparian habitats must be dynamic, with natural processes that create, recycle, and maintain riparian habitat. Riparian habitat can quickly change and vary in suitability, location, use, and occupancy by cuckoo over time (Service 2014a). Meandering streams with regular riparian floodplain activation that allows for constant erosional and depositional processes creates habitat for new rapidly growing young stands of willow, which create preferred nesting habitat conditions for cuckoo. Lateral channel migration and point bar deposition that create new floodplains and channel bend cut-offs that create floodplain lakes are important processes that create viable cuckoo habitat (Greco 2013). Loss of riparian floodplain activation and other factors can destroy or degrade breeding habitat, such that any given breeding habitat cannot be expected to remain suitable in perpetuity. In order to manage breeding habitat over time, it is necessary to have additional suitable habitat available to which cuckoos, displaced by such habitat loss or change, can readily move into and breed. If short-term losses of habitat and floodplain activation were never to occur, habitat would simply senesce or over-mature and no longer have the structure and foliage cover to accommodate nesting activity (Service 2016a).

Cuckoos have a certain degree of breeding site fidelity. Where banding studies have taken place, returning cuckoos one or more years after initial capture were typically recaptured within 80 feet to 50 miles from their original banding location (McNeil *et al.* 2013; Halterman 2009; Halterman *et al.* 2015). Breeding pairs of banded cuckoos along the Lower Colorado River were found occupying the same territory for up to three years (Laymon 1998; Halterman *et al*. 2015). However, dramatic fluctuation in breeding pairs at long-term study sites at the South Fork Kern River and Bill Williams River indicates that year-to-year movement between potential breeding areas also occurs (Service 2013). Geolocator studies have found that cuckoos can make long-distance movements during the breeding season (Sechrist *et al.* 2012). Limited radio telemetry work has been conducted on the cuckoo populations in California and the findings were largely inconclusive. However, one cuckoo tagged in the Sacramento River Valley was later found breeding in the Kern River Valley (Seavy 2019, personal communication). It is likely that cuckoos return to sites of previous successful breeding, but if the conditions are not suitable that year, they move to other potential breeding sites (Service 2013). The maximum distance individual cuckoos will travel from their natal habitat to find a new suitable breeding site is uncertain given the limited number of studies conducted to date.

Cuckoos may be found in a variety of vegetation types during migration, including coastal scrub, secondary growth woodland, hedgerows, humid lowland forests, and forest edges from sea level to 8,125 feet in elevation (Hughes 2015). Additionally, during migration they may be found in smaller riparian patches than those in which they typically nest. This variety of vegetation types suggests that the habitat needs of the cuckoo during migration are not as restricted as their habitat needs when nesting and tending young.

15.1.4 Numbers

The number of cuckoos in the western United States has “declined by several orders of magnitude over the past 100 years” (Service 2013), coincident with the widespread loss of riverine riparian woodlands as a result of the construction of dams, mining of groundwater, and development of urban and agricultural areas in the United States. This decline is continuing throughout the range of the species. Surveys over the past 15 years have documented losses of breeding pairs in smaller isolated sites and at core breeding areas. The Service estimated the current breeding population at 680 to 1,025 pairs, with 350 to 495 pairs north of the Mexican border and the remainder in Mexico. The estimated population in California once exceeded 15,000 pairs (Hughes 2015), declined to 122-163 pairs in 1977 (Gaines and Laymon 1984), further declined to an estimated 100 pairs in 2000 (Halterman *et al*. 2001), and was estimated to be 40-50 pairs state-wide in 2013 (Service 2013).

Limited information is available regarding the current distribution and abundance of cuckoos range-wide. The estimated range-wide cuckoo population was summarized by the Service in 2013 and is provided in Table 15-1 below. Since the publication of the proposed listing of the cuckoo (Service 2013), the number of cuckoo territories in Arizona and New Mexico is estimated to be higher than in 2013 (Ryan 2019, personal communication; Sferra 2019, personal communication). While the species is responding positively to habitat restoration efforts in some areas, populations in other areas have decreased in size. In California, population declines in the Sacramento River Valley (Dettling *et al.* 2015) and Kern River Valley (Southern Sierra Research Station 2018) have been documented.

Table 15-1. Estimated range-wide cuckoo territory numbers (Service 2013)

State	**Estimated number of territories**
Arizona	170-250
California	40-50
Colorado	<10
Idaho	10-20
Nevada	<10
New Mexico	100-155
Northwestern Mexico	330-530
Utah	10-20
Western Texas	<10
Wyoming	<5
Total	**680-1025**

15.1.5 Distribution

The cuckoo formerly bred in California, Arizona, New Mexico, Oregon, Washington, western Colorado, western Wyoming, Idaho, Nevada, Utah, northwestern Mexico, and probably southern British Columbia, Canada (Figure 15-1). The species is now absent through much of the western range, including British Columbia, Oregon, and Washington (Hughes 2015). Very few incidental sightings have occurred in the Pacific Northwest over the last 30 years (Toochin and Cecile 2014; Teachout and Wiles 2016). The possibility of a vestigial breeding population in Washington exists (Wahl *et al.* 2005); however, if cuckoos still breed in the state, their numbers are extremely low, with pairs numbering in the single digits (Service 2015).

The species' current confirmed breeding range reaches its northwestern limit in the Sacramento Valley, California (although a small, potentially breeding population exists in coastal northern California on the Eel River). The northeastern portion of the breeding range is in southeastern Idaho on the Snake River. They breed at several sites in California, Arizona, New Mexico, and Mexico. Arizona, New Mexico, and northwestern Mexico, where some cuckoo populations are stable or growing, are recognized as the current core breeding areas for the cuckoo (Sferra 2019, personal communication). While California historically hosted a large portion of the breeding population and the species nested at numerous sites primarily in coastal areas from San Diego to Sonoma County, the Central Valley from Kern County to Shasta County, and the lower Colorado River, the California population has decreased to less than 1 % of its estimated historical size (Service 2013). Today, there are only three regions in California with confirmed breeding populations: the Sacramento River between Red Bluff and Colusa, the Kern River immediately upstream of Lake Isabella, and the Lower Colorado River along the border between Arizona and California (Service 2013). The Lower Colorado River breeding population is relatively stable (McNeil *et al.* 2014; Parametrix and Southern Sierra Research Station 2018). The Kern River population is experiencing a drastic decline and the area may not currently support a viable breeding population (Southern Sierra Research Station 2017). While cuckoo still occupy the Sacramento River Valley, the population has declined by at least 80 percent over the last 40 years, with a major continuing decline in the most recent 10 years (Service 2013). In 2013, the Sacramento River Valley population was found to be between 27 and 28 breeding pairs (Dettling *et al.* 2015).

Figure 15-1. Current Breeding Range of the Western Yellow-Billed Cuckoo. Source: Reclamation (2018) *Lower Rio Grande Yellow-billed Cuckoo Survey Results 2017*.
Note: Figure 15-1 depicts the most recently published map of the western yellow-billed cuckoo breeding range, but that map is based on 1987 data. Current data for New Mexico confirm a cuckoo population on the Lower Rio Grande that is not depicted on this map.

The metapopulation dynamics of the cuckoo are largely unknown at this time. Given the limited scope of banding and geolocator studies for cuckoo, it is unknown if the exchange of individuals among geographically separated populations is common, or if there is a core population from which individuals may disperse out into other populations.

The available information on the winter range of the western DPS of the cuckoo comes from two studies: Sechrist *et al.* 2012 and McNeil *et al.* 2015. A single cuckoo from the breeding population on the middle Rio Grande River in New Mexico wintered in eastern Bolivia, southwestern Brazil, Paraguay, and northeastern Argentina, spending 5 months from late November through late April moving around an area 1,243 miles in length and 373 miles in width (Sechrist *et al.* 2012). Another study documented a similar loop migration route in another cuckoo breeding in the lower Colorado River in Arizona, but reversed in direction from the New Mexico bird. During fall migration the bird flew ~5,903-5,959 miles (~9,500–9,900 km), passing through the Caribbean region. It wintered from mid-November to late April in the Gran Chaco of central South America, around the junction of Paraguay, Bolivia, and Argentina. The more direct spring route back to the breeding grounds passed through Peru and Central America (McNeil *et al.* 2015).

15.1.6 Limiting Factors, Threats, and Stressors

The primary threats to cuckoos are the loss of extensive contiguous riparian habitat due to dams and the alteration of downstream channels by surface and groundwater diversion; encroachment of levees and flood control and bank stabilization structures into the river channel and floodplain; transportation systems; gravel mining; agriculture including ranching; and conversion to non-native invasive plant communities (Service 2014b). Other threats come from the use of pesticides that reduce or eliminate prey during the breeding season. Very little is known about threats to cuckoos and their wintering habitat in South and Central America.

Dams and their ongoing operations are a threat to the cuckoo over most of its range. The initial damming damages riparian structure and functioning due to habitat displacement from dam construction and permanent flooding of upstream riparian areas. Current and future releases of water downstream from dams at flow rates or timing that differ from preconstruction hydrologic circumstances may lead to flooding or desiccation beyond the tolerance limits of the native riparian vegetation, resulting in habitat loss. Downstream effects include changes in sediment transport due to sediment retention behind dams so that channels become increasingly "sediment starved." This situation causes vertical erosion (downcutting), which can lead to loss of river terraces that sustain riparian vegetation (Service 2014b).

The operation of dams result in a diminishment or loss of the natural hydrograph that provides the conditions needed for riparian vegetation growth, establishment, and succession. In California, winter and spring storms historically activated the riparian floodplain. The Sacramento River is lacking in the hydrograph components of winter mobilization flows, spring floodplain inundation, and spring snowmelt recession. The dampening of the magnitude of normal high flows can prevent cottonwood germination and the dewatering of downstream reaches causes declines of riparian forests. These impacts are happening now and are likely to continue without changes to water release strategies and management (Service 2014b).

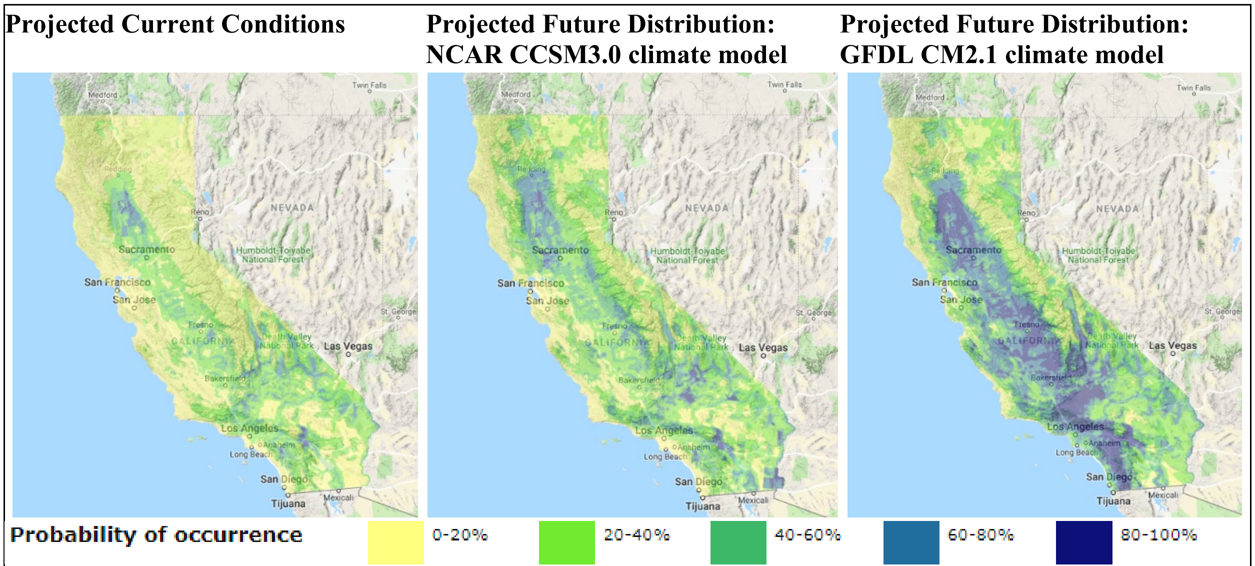
Conversion of native or mixed native and nonnative riparian woodlands to nearly monotypic stands of saltcedar (*Tamarix* spp.) and other nonnative vegetation, coupled with the inability of native vegetation to regenerate under altered hydrological conditions, is a significant threat to the cuckoo (Service 2014b). Exotic vegetation does not appear to be preferred habitat by cuckoos, but will be utilized if available. From 2009-2014 along the Middle Rio Grande River, nearly 40% of the cuckoo detections were located in areas with canopy, understory or both dominated by 75% or more exotic species cover (Carstensen *et al.* 2015). However, in Arizona on the lower Colorado River, the odds of cuckoo occurrence decreased rapidly as saltcedar presence increased (Johnson *et al.* 2012). In central California, giant reed (*Arundo donax*), common edible fig (*Ficus carica*), and Himalayan blackberry (*Rubus discolor*) are some of the more conspicuous nonnative plants widely established along the Sacramento River. Cuckoo are far less likely to be detected in areas with an understory dominated by Himalayan blackberry and nesting has not been documented in areas dominated by these species that lack at least some native canopy trees (Service 2014b).

Cuckoos prey on katydids, caterpillars, cicadas, and other large insects (Halterman *et al.* 2015). Targeted insecticide applications on agricultural land have reduced the cuckoo's preferred food resources such as sphinx moth caterpillars, giant grasshoppers, cicadas, and tree frogs. There have not been any studies directly linking cuckoo decline to the use of common pesticides. However, the global decline in insect biomass (Hallman *et al.* 2017) is a threat to many insectivorous bird species (Hallman *et al.* 2014). Pesticides, whether applied directly to riparian habitat or sprayed on adjacent areas, may affect the reproductive success of the cuckoo (Service 2014b). A reduction in the availability of suitably sized prey may lead to nest failure and the abandonment of nesting areas.

The proposed critical habitat rule described a study along the Snake River in Idaho and noted that, "compared to habitat patches surrounded by natural habitat, patches near agricultural lands supported more avian nest predators that prosper in human-altered landscapes and have a greater effect on the smaller, fragmented habitats" (Service 2014a). The increase in predators can result in an increase in the loss of nests; repeated nest failures may cause cuckoos to abandon suitable habitat.

Climate change also poses threats to the cuckoo through changes in the availability and distribution of suitable habitat. In the cuckoo's range, climate change is generally predicted to result in an overall warmer, drier climate, with periodic episodic precipitation events. California has a recurring drought cycle that can result in loss of riparian trees from reduced river flows and lowering water tables. The most recent drought is suspected to be a major contributing factor to the decline of the Kern River Valley cuckoo population (Stanek 2019, personal communication).

Long-term climate trends are likely to have an overall negative effect on the available habitat throughout the breeding range of the cuckoo (Service 2014b). However, there is a potential that future conditions in the major riparian corridors of California may result in better habitat suitability for cuckoo than future conditions in the species' current stronghold in the Southwest (Sferra 2019, personal communications; Point Reyes Bird Observatory (PRBO) 2012). In 2012, PRBO Conservation Science (now called Point Blue Conservation Science) produced distributional models for potential habitat for riparian birds, including cuckoo, under current conditions and two different climate scenarios (Figure 15-2). Despite potential changes in the frequency, timing, and severity of storm events in the future, the model predicted an increase in potential habitat for cuckoo. The models are coarse estimates of potential habitat availability and do not represent potential occupied habitat under potential future climate scenarios (Seavy 2019, personal communication).



Variables in order of importance for yellow-billed cuckoo: 1. Precipitation seasonality, 2. Vegetation, 3. Precipitation of driest quarter, 4. Annual precipitation, 5. Distance to stream, 6. Mean temperature of the warmest quarter, 7. Temperature seasonality, 8. Annual mean temperature, 9. Mean diurnal range, 10. Isothermality.

Figure 15-2. Modeled western yellow-billed cuckoo distribution responses to climate change. Source: California Avian Data Center (PRBO 2012).

In the arid southwest, models based on projected climate change predict that saltcedar will become more dominant in this region over the next 100 years (Service 2014b). In degraded habitat with saltcedar the threat of fire may be greater. Saltcedar ignites quickly, further increasing the incidence of periodic fires. Wildfires are likely to become more common with climate change, further exacerbating the saltcedar problem in cuckoo habitat in places such as New Mexico and Arizona (Service 2014b).

15.1.7 Recovery and Management

A recovery plan has not yet been developed for this species. In the absence of a recovery plan, we default to the general conservation needs of the species. For a species like the cuckoo that has lost much of its former known occupied habitat, recovery would necessitate the conservation of much of the remaining habitat that supports the species. In addition, restoration of suitable habitat that has been disturbed, but otherwise remains undeveloped, would be a priority. Lastly, efforts to establish the species in unoccupied, but otherwise suitable habitat, would contribute to its recovery.

15.2 Environmental Baseline

The cuckoo is known to have been historically common in riparian habitat throughout the Central Valley, from Kern County north to Redding (Laymon 1998). While the species has been detected in multiple watersheds throughout the Action Area, only the Sacramento River Valley is believed to currently sustain breeding populations at isolated sites along the Sacramento River and Sutter Bypass between Red Bluff and Colusa (Laymon and Halterman 1989; Laymon 1998;

Halterman 2001; Hammond 2011; Dettling *et al*. 2014; Stanek 2014; Parametrix Inc. and Southern Sierra Research Station 2015). Table 15-2 contains a summary of occurrences at locations throughout the Action Area from the 1960s to the present. No surveys for cuckoo were conducted for the BA.

Table 15-2. Watersheds occupied by western yellow-billed cuckoo based on recent records in counties in or abutting the Action Area since 1960.

Location	Dates	Notes	Source
Sacramento River (between Red Bluff and Colusa)	through 2018	Believed to be the only active breeding location within the Central Valley. No large-scale surveying efforts since 2013.	CDFW, Ebird, Dettling *et al.* 2015
Sutter Bypass and East Canal (Sacramento River Valley)	1992, 1999, 2000, 2008, 2010, 2015, 2016, 2018	Six pairs detected by Sutter NWR staff in 2000.	CDFW, Ebird, Service Sutter NWR staff
Feather River	1976, 1977, 1985, 1986, 1987, 2016	Occurrences near Yuba City and Lake of the Woods State Wildlife Area. PRBO surveys 2012 and 2013 detected no individuals in the watershed.	CDFW, Ebird
American River (between Nimbus Dam and convergence with Sacramento River)	August 2013, August 2015	Two reports in 2013 of a single bird; one report in 2015 of a single bird.	Ebird
Stanislaus River (between Ripon and convergence with the San Joaquin River)	1962, 1965, June 1973, July 1982, July 2018	Numerous observations near the mouth of the Stanislaus River from 1962-1973.	CDFW, Ebird
San Joaquin River-Old River	June 2012	Water Treatment Plant	Ebird

Bay-Delta (Lower Sacramento River)	July 2009, August 2010	Snodgrass Slough	CDFW
Bay-Delta (Lower San Joaquin River)	June 2005	Dow Wetlands Preserve	Ebird

The cuckoo population within the Action Area has been in decline since the time when the first phases of the CVP were implemented, and likely prior to that time given the extensive loss of riparian habitat since the Gold Rush. The steep decline in the cuckoo population in the Sacramento Valley was first noted by Grinnell and Miller in 1944, who concluded that the loss of large areas of riparian forest was the cause of the decline. By the 1980s, 95% of riparian forest in California's Central Valley had been lost (Katibah 1984). The breeding cuckoo population throughout California was estimated to be approximately 15,000 pairs before extensive development (Hughes 2015). The Service estimates between 40 and 50 breeding pairs remain in California, down from approximately 280 pairs in 1977 (Service 2013). Approximately half of the statewide population in 2013 is within the Sacramento River Valley area. The most recent estimate of the breeding population within the Action Area is no more than 28 pairs in 2013 (Dettling *et al.* 2015) and may be less in 2019 given the ongoing downward trend. Since 1977, the number of cuckoos detected per survey hour has been declining (Figures 15-3 and 15-4). Detections per survey hour are an indication of the density of individual birds occupying a particular area. Trends in the detection rate of a species are indicative of the general trend in the species' population, supporting the conclusion that the population in the Sacramento River Valley continues to decline (see Figure 15-4).

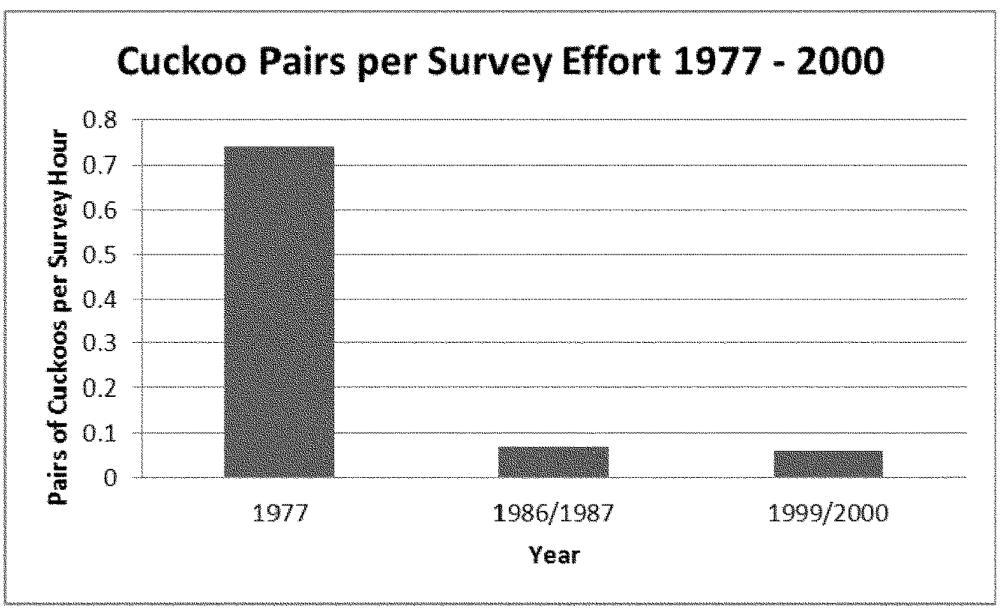


Figure 15-3. Yellow-billed cuckoo pairs per survey effort on California statewide surveys 1977-2000. Source: *Proposed Threatened Status for the Western Population Segment of the Yellow-billed Cuckoo* (Service 2013).

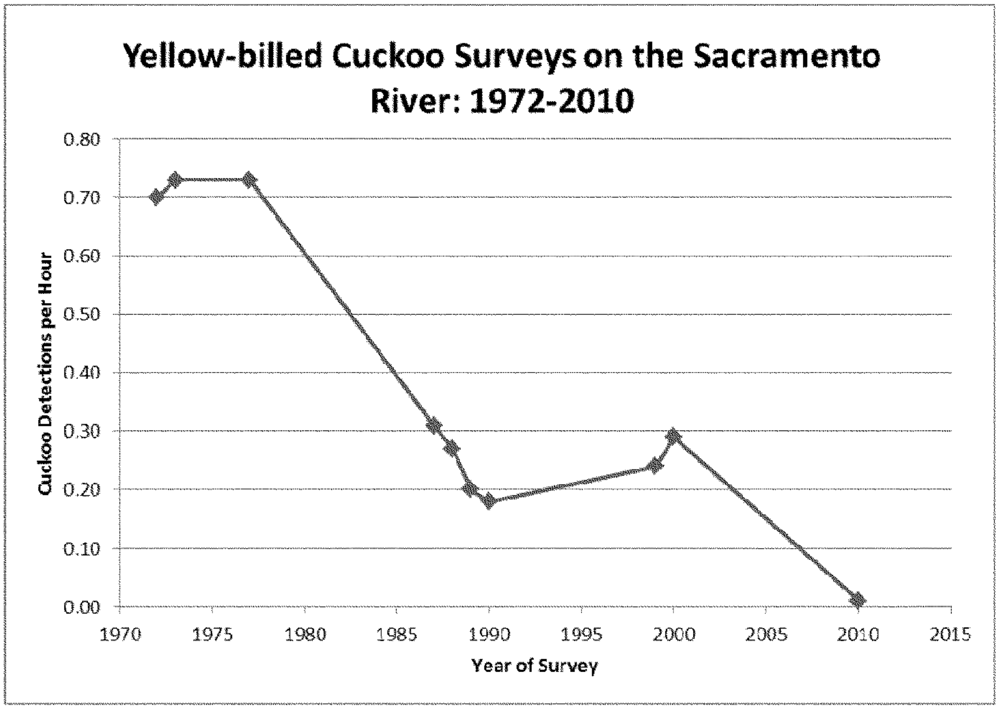


Figure 15-4. Yellow-billed cuckoo detections during surveys on the Sacramento River on 10 separate years from 1972 to 2010. Source: *Proposed Threatened Status for the Western Population Segment of the Yellow-billed Cuckoo* (Service 2013).

Cuckoo detections have occurred most frequently in the upper Sacramento River where levees are setback from the river or do not exist, allowing for larger patches of active floodplain riparian habitat. Additionally, the last 20 years has seen a large amount of riparian restoration occur in the upper Sacramento River (Gilot *et al.* 2008). The Sacramento River from Red Bluff to Colusa has a highly dynamic mosaic of habitat patches of varying ages that form, disappear, and re-form in response to active river channel processes that operate over decades (Greco 2008; Greco 2012). Although this section of the Sacramento River is affected by altered hydrology, it is far enough below Shasta Dam and below several major undammed tributaries, such as Cottonwood Creek and Battle Creek, that it still has flood events every few years that help support riparian habitat processes (Werner 2012, pers. comm.). The river provides habitat characteristics that Laymon (1998) indicated were important for the cuckoo in California, such as a meandering system with young riparian habitat that, compared to mature woodlands, provides preferred nesting sites, high productivity of invertebrate prey, and reduced predator abundance (Laymon 1998).

Most other riparian habitat in the Action Area tends to be more narrow and linear than in the mainstem Sacramento River between Red Bluff and Colusa. The American River has a wider floodplain due to levees being setback from the channel. There are some patches large enough to support nesting cuckoos, though cuckoos have not been observed nesting along the American River. In 2013, there were two unconfirmed audible occurrences along the American River Parkway approximately five miles from the Action Area. These two occurrences were less than five miles apart along the river and heard on the same day (EBird 2019). In 2015, there was a confirmed visual sighting along the American River located in proximity to both the 2013 occurrences and approximately five miles from the Action Area (EBird 2019). Insufficient prey base from extensive application of insecticides to control mosquitoes and disturbance from recreational activities and homeless encampments along the American River may deter cuckoos from nesting. Based on these sightings, cuckoos likely use locations throughout the Action Area as stop-over habitat for feeding, resting, and sheltering during their migration from Mexico to the Upper Sacramento River. These stop-over areas also include the Stanislaus River, San Joaquin River, the Delta, Yolo Bypass, and Sutter Bypass.

A habitat model developed by Gaines (1974) for the cuckoo in the Sacramento Valley includes the following elements: patch size of at least 25 acres, at least 330 feet wide and 990 feet long, within 330 feet of surface water, and dominated by cottonwood/willow gallery forest with a high-humidity microclimate. Laymon and Halterman (1989) further refined the model by classifying habitat patch sizes for suitability. A willow-cottonwood forest patch greater than 1,980 feet wide and greater than 200 acres (81 hectares) is classified as optimum habitat; a patch 660 to 1,980 feet wide and 102.5 to 200 acres (41.5 to 81 hectares) is suitable; a patch 330 to 660 feet wide and 50 to 100 acres (20 to 40 hectares) is marginal, and smaller patches are unsuitable. Most riparian corridors in the Action Area do not support sufficiently large riparian patches or the natural, geomorphic processes that provide suitable cuckoo breeding habitat (Greco 2013).

Largely due to restoration efforts, there is currently estimated to be a total of 20,100 acres (8,134 hectares) of potential cuckoo habitat along the Sacramento River and 5,070 acres (2,052 hectares) along the Feather River, for a total of 25,170 acres (10,186 hectares) in the species current breeding area in the Central Valley (Dettling *et al.* 2015). Despite the restoration efforts in the Sacramento River Valley, the amount of forest restored so far may not be enough to slow the decline of the species that was already in motion (Dettling *et al.* 2015). Dybala *et al.* (2017) determined an additional 8,377 acres (3,390 hectares) of riparian vegetation in the Sacramento River Valley would need to be restored within the next 10 years to stop the trend of steep population decline for cuckoo. A total of 151,670 acres (61,379) hectares would have to be restored within the next 100 years to make the cuckoo population resilient (Dybala *et al.* 2017).

The decline of the cuckoo is primarily the result of the loss and degradation of riparian habitat within its breeding range (Laymon 1984). The first major human disturbance to riparian habitat historically used by cuckoo within the Action Area came from hydraulic mining in the mid-1800s. The bed of the Sacramento River returned to its original elevation after the end of hydraulic mining in 1884. However, the plan view of the river was permanently altered. Before the river established a new pattern of stability, dams and levees were built to control floods and restricted the river's natural hydraulic processes. Levee construction and reclamation of levee lands further destroyed large amounts of riparian vegetation and began the conversion of riparian lands to croplands which continued through the 1980s (Scott and Marquiss 1984). The few remaining riparian areas used for breeding by the cuckoo within the Action Area were included in the proposed critical habitat rule (Service 2014a).

15.2.1 Factors Affecting Western Yellow-billed Cuckoo Within the Action Area

Many factors have contributed to the current status of the cuckoo in the Action Area. Agriculture, construction of flood control infrastructure, levee construction, and riprapping have contributed to historic loss of riparian and floodplain habitat, and which constrain or prevent ecosystem function to allow for riparian habitat regeneration in the Action Area. Flood control efforts in the Sacramento Valley have a history dating back to the Gold Rush, and resulted in a fragmented system of levees and other structures (James and Singer 2008). Reclamation did not provide information on how past and current water operations has affected cuckoo, nor was habitat suitability modeling provided for the Action Area. Long-term operations of the CVP and SWP have been occurring for many decades and have contributed to the current condition of the species in the Action Area, along with the other factors listed above. The effects of the PA will be imposed on an already degraded, fragmented, and ecologically constrained riparian system.

The operation of large dams have significant downstream hydrologic and geomorphic effects on rivers (Graf 1999; Graf 2006), and recent studies have modeled the effects of dams and diversions on the Sacramento River (Fremier *et al.* 2014; Michalková *et al.* 2010). The changes in channel dynamics resulting from the operation of water storage and conveyance facilities in the Sacramento River are major factors in the reduction of suitable cuckoo habitat (Greco 2013). Multiple models have been developed to explain how water operations have changed hydrogeomorphic processes in the Sacramento River since the implementation of the CVP (Greco 1999, Greco 2013; Greco *et al.* 2007). Additionally, hydrologic and ecological models have been developed and tested to predict how proposed changes in flows may result in different degrees of hydrologic alteration (Richter *et al.* 1996), changes in channel migration potential (Fremier *et al.* 2014), floodplain activation (Bovee *et al.* 1998; Millsap and Gard 2017), general ecological health (Sommer *et al.* 2004; Alexander *et al.* 2014; The Nature Conservancy *et al.* 2008; Alexander *et al.* 2018), and particularly applicable to cuckoo habitat needs, Fremont cottonwood regeneration (ESSA 2017; Alexander *et al.* 2014).

The continued operation of dams and diversions will likely have compounding effects on riparian habitats into the future. Continued shifts in vegetation community composition in terms of dominant species, age, canopy height, and patch sizes (Greco *et al.* 2007; Greco 2013) and changes in channel morphology (Michalková *et al.* 2010) have been documented in recent decades. The effects of dam-induced reduction of mean annual peak discharge flow (CALFED 2000), reduction of flood discharge volume (Greco 2013), reduction in stream power (Fremier 2003), sediment starvation (Michalková *et al.* 2010), and reduced bank erosion rates and overbank deposition (Buer *et al.* 1989) all contribute to changes in successional riparian forest ecosystems. As the ability of the river channel to migrate laterally is restricted (Larsen *et al.* 2006) and the quantity of new land production reduces, the amount of new pioneer riparian forests is subsequently decreased (Greco *et al.* 2007).

In addition to the management of riparian habitat within the Service's wildlife refuges within the Action Area, there are restoration projects that have occurred or are planned to occur. Substantial riparian restoration and floodplain reestablishment through levee setbacks are occurring on the Sacramento and San Joaquin Rivers, and some major tributaries.

The Service has formally consulted on 32 projects within the Action Area. These include projects such as bridge replacements, river bank protection, channel rehabilitation, habitat restoration, Corps flood control manual updates, and transmission line installation. A consultation with the Corps was completed in 2018 for the Folsom Dam Water Control Manual Update. In this consultation, it was found that flood flows were expected to result in a reduction in the amount of habitat, or lowering of the quality of the remaining habitat, but this reduction was deemed to be of insufficient duration, intensity, and severity to adversely affect the cuckoo. Another notable consultation is with the Corps on the construction of the Hamilton City Flood Damage Reduction and Ecosystem Restoration Project to setback the levee along the Sacramento River near Hamilton City, Glenn County. This project is expected to result in temporary adverse effects to cuckoo during construction, but will improve riparian habitat quality long-term. Once completed, the setback levee will allow for the return of dynamic riverine processes to 1,415 acres on the landside of the existing levee that will be reconnected to the active floodplain, and restoration of 420 acres of riparian forest suitable for cuckoo breeding.

15.3 Effects of the Proposed Action

As noted in the *Environmental Baseline* section above, the effects of the PA will be against a backdrop of a highly degraded, constrained riparian system. The following description of the effects of the PA is broken out by watershed and PA element.

15.3.1 Sacramento River

Seasonal Operations

Reclamation's PA includes proposed flow changes in the Sacramento River resulting in less than 5% percent decrease in average flows in November and less than 5% increase in average flows in May and June from the current condition. Reclamation stated in their BA that the proposed "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." Periodic flooding and erosion are important to maintaining successional riparian ecosystems. Without detailed ecological flow modeling, like SacEFT, it can be assumed that seasonal operations will on average maintain current vegetation, resulting in habitat similar to the current condition with limited floodplain activation to stimulate regeneration. Since the average flows are similar overall to the current operations scenario, it can be expected that implementation of the PA will result in similar habitat conditions from now until 2030.

Spring Pulse Flows

The spring pulse flows in the PA may benefit cuckoo by supporting the recruitment of important riparian tree species, primarily willows. The PA does not describe the incorporation of flow recession during the germination and seedling establishment for riparian over-story species (particularly Fremont cottonwood). Additionally, the BA did not include ecological flow modeling (such as SacEFT) that would support a quantitative assessment of how much these flows will actually benefit riparian plant communities and sustain cuckoo habitat. We assume that the proposed spring pulse flows could benefit the cuckoo to an unknown amount from now until 2030.

Operations of a Shasta Dam Raise

Reclamation does not propose to change the operations of Shasta Dam after construction of the dam raise and during the timeframe of the PA until 2030. If operational changes are proposed, Reclamation will reinitiate consultation. See the Reinitiation Notice (Section 18.0) at the end of this BiOp for more information.

Salmonid Spawning and Rearing Habitat Restoration

Reclamation proposes to restore 40-60 acres of side channel habitat at approximately 10 sites in Shasta and Tehama County by 2030. Although Reclamation will minimize removal of riparian habitat to the extent feasible through implementation of AMM24 (AMM-WYBC), up to 58 acres of cuckoo habitat may be removed. Removal of riparian vegetation, potential reduction in the size of intact patches of suitable riparian habitat, and potential fragmentation of habitat will result in injury to the cuckoo through the reduction of reproductive potential and recruitment associated with the loss of nesting and foraging habitat. Side channel habitat can serve as cuckoo habitat and habitat restoration projects may provide some benefit to cuckoos through improving habitat suitability. Reclamation will complete subsequent consultations on each of their proposed restoration projects individually as previously described in the *Consultation Approach* section of this BiOp.

Construction-related effects on the cuckoo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction. Reclamation proposes to avoid disturbance of occupied cuckoo habitat through implementation of AMM-WYBC. However, cuckoos are secretive birds and not easily detected through pre-construction surveys. As such, potential adverse effects to cuckoos from construction may not be fully avoided by implementing the measures in AMM-WYBC, but we expect implementation of these measures to minimize the likelihood of construction-related effects to the cuckoo.
These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

North Delta Food Subsidies/Colusa Basin Drain Study

High water levels (flows of 200 to 500 cfs) are proposed to pass through the Yolo Bypass which includes a disjunctive 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 likely. 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. The proposed flows are unlikely to result in direct harm to individual cuckoos, and may result in indirect beneficial impacts through improvement in habitat conditions and prey base.

15.3.2 American River

Seasonal Operations

In the American River watershed, the PA will result in the potential of a few percent decrease in flow in December, February and March, and a few percent increase in July and September. Similar to the Sacramento River, it can be assumed that seasonal operations will on average maintain current vegetation, resulting in habitat similar to the current condition with limited floodplain activation to stimulate regeneration. Since the average flows are similar overall to the current operations scenario, it can be expected that implementation of the PA will result in similar habitat conditions from now until 2030.

Salmonid Spawning and Rearing Habitat Restoration

Construction-related effects on the cuckoo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction. Reclamation proposes to avoid disturbance of occupied cuckoo habitat through implementation of AMM-WYBC. However, the cuckoo are secretive birds and not easily detected through pre-construction surveys. As such, potential adverse effects to cuckoo from construction may not be fully avoided by implementing the measures in AMM-WYBC, but we expect implementation of these measures to minimize the likelihood of construction-related effects to the cuckoo.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

15.3.3 Stanislaus River

Seasonal Operations

Lower flows in the spring under the PA could potentially result in less riparian vegetation recruitment. The PA will likely result in flows being generally more stable, which will reduce riparian over-story tree regeneration. Since the average flows are similar overall to the current operations scenario, it can be expected that implementation of the PA will result in similar habitat conditions from now until 2030.

Salmonid Spawning and Rearing Habitat Restoration

Reclamation proposed to create side channels requiring the removal of riparian habitat within the range of cuckoo. Although Reclamation proposes to minimize removal of riparian habitat to the extent feasible through implementation of AMM-WYBC, up to 43 acres of riparian cuckoo habitat may be removed.

Construction-related effects on the cuckoo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction. Reclamation proposes to avoid disturbance of occupied cuckoo habitat through implementation of AMM-WYBC.

However, the cuckoo are secretive birds and not easily detected through pre-construction surveys. As such, potential adverse effects to cuckoo from construction may not be fully avoided by implementing the measures in AMM-WYBC, but we expect implementation of these measures to minimize the likelihood of construction-related effects to the cuckoo.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

15.3.4 San Joaquin River

Proposed Flow Changes

In the lower San Joaquin watershed, differences between the PA and COS are almost nonexistent. While baseline conditions for cuckoo in the lower San Joaquin River are impaired by decades of hydrologic alteration, agricultural activities, and habitat loss, the Service does not foresee any subsequent harm to cuckoos in terms of changes in quantity or quality of cuckoo habitat in the lower San Joaquin watershed during the PA timeframe.

Lower San Joaquin River Habitat Restoration

Permanent Habitat Loss

The restoration of floodplain habitat in the Lower San Joaquin River would result in the permanent removal of up to 11 acres of cuckoo habitat. Reclamation states the habitat is of moderate value as it consists primarily of small patches in proximity to other habitat along the San Joaquin River or adjacent to existing conservation lands and that when restoration sites are selected, they will be selected to minimize effects on cuckoo habitat.

Temporary Habitat Loss

If Reclamation incorporates multi-species restoration methods to create and maintain large patches of riparian forests that provide for the breeding and foraging needs of cuckoo, the loss of 11 acres of cuckoo habitat due to construction could be minimized by the creation or restoration of suitable cuckoo habitat as part of this habitat restoration program. Under this potential scenario, what would otherwise be considered a permanent loss of habitat would be a temporary loss instead.

Periodic Inundation

Based on a hypothetical floodplain restoration, this activity will periodically inundate an estimated 70 acres of habitat for the 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). While frequent intense flooding in the lower elevation portions of the floodplain may result in excessive scouring of riparian vegetation, occasional large floods are expected to have a beneficial rather than an adverse effect on the species by promoting vegetation succession. If large floods are operated with a moderated recession flow of less than 1 inch per day, they could provide for better cottonwood and willow recruitment and seedling survival. However, the loss of semiannual floods may result in less understory vegetation, which responds positivity to low-intensity frequent flooding. Dense understory vegetation provides cover for cuckoo nest located in over-story trees and habitat for the large insects cuckoo prey upon. Therefore, periodic inundation is likely to result in some loss of prey base for the cuckoo.

Construction-Related Effects

Construction-related effects on the cuckoo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction. The threats of construction-related effects are 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. Reclamation proposes to avoid disturbance of occupied cuckoo habitat through implementation of AMM-WYBC. However, the cuckoo are secretive birds and not easily detected through pre-construction surveys. As such, potential adverse effects to cuckoo from construction may not be fully avoided by implementing the measures in AMM-WYBC, but we expect implementation of these measures to minimize construction-related effects to the cuckoo.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

15.3.5 Bay-Delta

Intertidal and Associated Subtidal Habitat Restoration

Construction-related effects on the cuckoo include the potential for injury or mortality and noise and visual disturbance to individuals in the vicinity of construction. Reclamation proposes to avoid disturbance of occupied cuckoo habitat through implementation of AMM-WYBC. Since cuckoos are not expected to nest in intertidal and subtidal habitats, the implementation of the measures in Appendix E of the BA are expected to avoid impacts to cuckoo.

These actions are addressed programmatically in this consultation, so further detail about expected adverse effects and benefits, and any incidental take, will be addressed in subsequent consultation prior to implementation.

15.4 Effects to Recovery

A recovery plan has not been developed for the cuckoo. In the absence of a recovery plan, we default to the general conservation of the species. For a species like the cuckoo that has lost much of its habitat, recovery would necessitate the conservation of much of the remaining habitat that still supports breeding, feeding, and sheltering.

Reclamation and DWR have proposed to avoid and minimize impacts from construction to occupied suitable habitat; however, it is possible that their proposed avoidance and minimization measures will not prevent the loss of habitat and effects to individuals. Habitat loss and degradation are contributing factors to the decline of the cuckoo; consequently, restoration or protection of additional suitable habitat is a reasonable means of offsetting the adverse effects and may benefit the recovery of the cuckoo. Multi-species habitat restoration methods could be employed that would result in additional suitable habitat for cuckoo. The PA contains no specific project elements, as described in the BA, likely to contribute to the recovery of the cuckoo, and there are no proposed measures in the PA to address the degraded condition of the habitat in the Action Area. Given the lack of information on metapopulation dynamics of this species, it is unknown how or if the effects of the PA will affect the recovery of the cuckoo range-wide.

15.5 Cumulative Effects

The activities described in Section 5.5 for delta smelt are also likely to affect cuckoo. These include agricultural practices, recreation, urbanization and industrialism, and greenhouse gas emissions, and are similar to activities occurring in the other parts of the Action Area outside of the Delta. Therefore, the effects described in Section 5.5 are incorporated by reference into this analysis of cumulative effects for the cuckoo throughout the Action Area.

Additional activities that are reasonably certain to occur in the Action Area include creation of recreation trails, conversion of riparian habitat to agriculture, and flood maintenance activities. Recreational trails can disturb or harass cuckoos when trails are located adjacent or within cuckoo breeding habitat. Construction equipment that is used for creation of the trail has the potential to disrupt nesting cuckoos. While a lot of the conversion of riparian to agriculture occurred early in the 20th century, there are still instances of landowners converting riparian habitat to agriculture, particularly when certain crops such as nuts become more profitable. Agriculture adjacent to riparian habitat that could be used by the cuckoo has the potential to affect the cuckoo and its habitat through the use of pesticides and drift of pesticides damaging both the riparian vegetation as well as the prey base of the cuckoo. Vector control activities in riparian habitat near urban areas that could be used by the cuckoo also has the potential to affect the cuckoo and its habitat through the use of mosquito-control pesticides and drift of those pesticides damaging both the riparian vegetation as well as the prey base of the cuckoo through the non-targeted killing other insect species. Flood maintenance activities that primarily affect cuckoo include vegetation removal and suppression. DWR is responsible for keeping the floodways clear and open to maintain capacity and will remove vegetation or suppress vegetation in areas of limited capacity. This will likely result in discontinuous riparian habitat throughout the river systems in the Action Area.

15.6 Summary of the Effects from the Action

In determining whether a proposed action is likely to jeopardize the continued existence of a species, we consider the effects of the action with respect to the reproduction, numbers, and distribution of the species. We also consider the effects of the action on the recovery of the species. In that context, the following paragraphs summarize the effects of the PA on the cuckoo.

15.6.1 Reproduction

The Sacramento River Valley between Red Bluff and Colusa is one of the few remaining riparian areas used for breeding by cuckoos in the western United States and the largest and historically most productive breeding area in California. Other riparian areas within the Action Area may be used for nesting, but are certainly used during migration. It is unknown to what degree cuckoo populations recruit adults from other breeding locations or if the species is likely to recolonize breeding habitat if a population fails. Cuckoos are believed to have some level of site fidelity, with documented returns of birds to breeding grounds where they were raised or where they have nested in the past. There are no other known breeding populations of cuckoo in the Central Valley of California. The next closest population is located in the Kern River Valley over 300 miles away from Colusa; however, that population has declined drastically in recent years and may no longer support breeding cuckoos (Stanek 2019, personal communication). Maintaining multiple breeding populations is critical for the long-term resilience of species. Particularly given that cuckoo populations in Arizona, New Mexico, and Mexico may face greater threats from climate change through increased water demands, shifting weather patterns, and the resulting loss of suitable habitat than cuckoo populations in the California Central Valley (Sferra 2019; Douglas 2019, personal communications), maintaining the population along the Sacramento River would provide redundancy through multiple breeding populations across the range of the species to insure long-term reproductive success.

The quantity of riparian habitat in the Action Area and its suitability for cuckoo breeding has declined significantly in part due to the construction of dams and operation of CVP and SWP (Katibah 1984; Scott and Marquiss 1984; Greco *et al.* 2007; Greco 2008; Greco 2013). Other causes of riparian habitat decline include conversion to agriculture, residential development, and flood control infrastructure. This loss of suitable habitat has been paired with a decline of approximately 80% of the breeding cuckoo population in northern and central California in the last 40 years (Service 2013).

The effects of the PA are added to this highly degraded Environmental Baseline to determine effects to reproduction. The Sacramento River supports the only known breeding population of cuckoos in the Action Area. Reclamation's PA includes proposed flow changes in the Sacramento River resulting in less than 5% percent decrease in average flows in November and less than 5% increase in average flows in May and June. In the absence of a thorough analysis of breeding habitat suitability in the BA, the Service assumes the PA will continue operations that will not cause loss of breeding pairs over the course of the action (until 2030). Restoration activities could remove or modify riparian habitat, but this effect to occupied cuckoo habitat will be minimized through implementation of proposed conservation measures and ultimately may benefit breeding cuckoos through improved habitat over time. Therefore, no measurable effects of the PA on reproduction of cuckoo are expected to occur.

15.6.2 Numbers

The number of cuckoos in the Action Area is relatively high compared to the state-wide population estimate (approximately 50% of the population), but low compared to the range-wide numbers (approximately 2 – 4%). Based on the current degraded condition of the cuckoo's habitat in the Action Area and the overall declining trend of the species as described in the Status of the Species and Environmental Baseline and cumulative effects from a number of factors including agricultural activities, it is reasonable to conclude numbers will continue to decline in the Action Area and range-wide between now and 2030. Further declines in the Sacramento

River Valley breeding population are likely to reduce the range-wide resiliency of the species - its ability to maintain survival and reproduction in spite of stochastic disturbances.

Reclamation and DWR have proposed measures to avoid and minimize the effects of the PA on the species as they relate to construction of restoration projects. The proposed flow changes on the Sacramento and American rivers are, on average, comparable to flows under the current operations scenario. The remaining water courses are expected to also experience similar conditions under the PA. The North Delta Food Subsidies/Colusa Basin Drain Study may benefit cuckoos migrating through the Yolo Bypass and Delta by improving prey base. Therefore, the effects of the PA are not anticipated to measurably reduce the number of cuckoos.

15.6.3 Distribution

The distribution of the species has been greatly reduced throughout its entire range. The Action Area includes large areas of breeding, foraging, and migratory habitat for the cuckoo. The riparian corridors associated with the major rivers of the California Central Valley – the Sacramento, American, Feather, Stanislaus, and San Joaquin Rivers – are part of the historical breeding habitat of the cuckoo and the remnant patches of suitable habitat support the remaining breeding populations of the species in Action Area. The current distribution of the species across the Action Area has not been quantified, and no surveys were conducted to support the BA. Outside of the Sacramento River and Feather River (Dettling *et al.* 2015), there have been no large-scale survey efforts for cuckoo in the Action Area by other organizations in recent decades. Based on anecdotal observations, it is believed that cuckoos use other water courses in the Action Area as migratory stop-over habitat for feeding, resting, and sheltering.

Based on the proposed conservation measures, we expect that the potential for injury to cuckoos from restoration projects will be minimized. On average, the operational scenario included in the PA is expected to be comparable to the current operations scenario, resulting in similar habitat conditions. Therefore, the species' distribution is unlikely to be reduced relative to its range-wide distribution as a result of implementation of the PA.

15.7 Conclusion

After reviewing the current status of the western yellow-billed cuckoo, the Environmental Baseline for the Action Area, the effects of the PA, and the cumulative effects, it is the Service's biological opinion that the PA is not likely to jeopardize the continued existence of the species. We have reached this conclusion because:

1. The habitat conditions are highly degraded. The effects of the PA, when added to these baseline conditions, are not expected to cause additional loss of cuckoos over the timeframe of this consultation.

2. Reclamation has proposed to implement avoidance and minimization measures designed to avoid affecting occupied habitat from the construction activities, and ultimately may benefit cuckoos through improved habitat over time.

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16.0 INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed wildlife species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking incidental to and not the purpose of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by Reclamation and/or DWR, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation and DWR have a continuing duty to comply with this ITS. If Reclamation and DWR fail to assume and implement the terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation and/or DWR must report the progress of the action and its impact on the species to the Service as specified in the ITS [50 CFR §402.14(i)(3)].

The Service has determined that the PA presents a mixed programmatic action, as defined in 50 CFR 402.02 (i.e., the proposed action includes elements that will not be subject to further section 7 consultation and elements that will be subject to future consultation). Some of the project elements of the PA are analyzed in this BiOp at a site-specific level for near-term implementation with no future Federal action required. For other project elements, Reclamation proposed to initiate subsequent consultations for future Federal actions that will be authorized, funded, or carried out at a later time, and this BiOp uses a programmatic approach to evaluate those elements of the PA. Therefore, consistent with our regulations at 50 CFR 402.14(i)(6), this ITS only covers those standard consultation elements of the PA for which incidental take is reasonably certain to occur. The incidental take exemptions provided for in this ITS are effective only upon Reclamation’s issuance of the Record of Decision.

Amount or Extent of Anticipated Take

In the BiOp, the Service has determined that incidental take is reasonably certain to occur as follows:

The Service anticipates that the PA will result in the incidental take of individual delta smelt due to hydrodynamic effects caused by the operation of the CVP and SWP export facilities in the south Delta, the fish facilities in the south Delta, and other CVP or SWP water diversion and water distribution systems in other parts of the Delta and Suisun Marsh. Regarding the CVP and SWP export of water from the Delta, the Service anticipates take in the form of kill or harm of all delta smelt within the south Delta affected by water operations and other areas of the Delta affected by reduced habitat quality.

Incidental take associated with this action is expected in the following forms: mortality and harm of delta smelt adults, juveniles, and larvae. It is difficult to determine the number of individuals that could be injured or killed (including harm as a result of significant habitat modification) because free-swimming aquatic animals are difficult to observe in large water bodies and because delta smelt have become very rare in recent years. The Service anticipates injury and mortality of individual delta smelt will occur as a result of entrainment and whenever habitat conditions do not support the successful completion of the species' full life cycle.

Surrogate Approach

In accordance with 50 CFR 402.14(i)(1)(i), a surrogate may be used to express the amount or extent of anticipated incidental take if the BiOp or ITS describes the causal link between the surrogate and anticipated take, explains why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals, and sets a clear standard for determining when the level of anticipated take has been exceeded.

Surrogates are used for this ITS because, as described throughout this BiOp, it is impossible to accurately quantify and monitor the amount or number of individuals that are expected to be incidentally taken as a result of the PA due to the variability associated with the effects of the PA, the declining population size of delta smelt, difficulty in detecting individuals entrained or impinged, annual variations in the timing of various parts of the species' life cycle, and variation in how individual fish use habitat within the Action Area.

The Service is using the ecological conditions described below as the incidental take surrogates for individual delta smelt.

<u>*Take from South Delta Entrainment*</u>

The Service has determined for the purposes of this BiOp that delta smelt that enter the Old and Middle river corridors are entrained whether or not they survive long enough to reach the CVP or SWP fish facilities. Adult delta smelt have substantial capacity to control their distribution in the Bay-Delta. Thus, some adult delta smelt may 'entrain' themselves during their winter dispersal, while others may cue on hydrodynamics resulting from the export of water while moving up the San Joaquin River and be entrained due to project operations. Delta smelt larvae have some ability to control their distribution but less than older, more competently swimming life stages, making them more vulnerable to tidal currents and the net displacement (or flow) of water over multiple tidal cycles. No delta smelt life stage is known to seek cover in beds of aquatic vegetation, such as those that have proliferated around much of the shallower waterways in Delta, and particularly in the south Delta and its associated flooded islands. Rather, delta smelt are attracted to turbidity in open-water habitats. The hydrodynamic conditions indexed by net negative flow in Old and Middle rivers can affect the dispersal of turbidity into and through the South Delta. During winter dispersal and spring spawning, when turbidity of more than 12 NTU is present in Old and Middle rivers, adult delta smelt may be more likely to move into these channels, become entrained, and become subject to the reduced quality habitat in the channels, adjoining canals, and associated flooded islands (e.g., Mildred Island) due to operations, or be injured or killed as a result of entering the export facilities. Additionally, entrained adult delta smelt may spawn in areas where their progeny will be lost to the population due to some unquantifiable combination of predation loss associated with submerged vegetation or eventual transport to the CVP and SWP facilities.

Therefore, the level of turbidity present in the South Delta can be causally linked to the level of incidental take of adult delta smelt and some of their offspring due to entrainment caused by operations. The analysis of effects in this BiOp is based, in part, on the PA avoiding the formation of a continuous band of turbidity from the Sacramento River to the export facilities to minimize the number of adult delta smelt that disperse into unfavorable habitat conditions, thus minimizing entrainment of pre-spawning adult delta smelt and the subsequent loss of larval and juvenile delta smelt later in the spring. In addition to potential losses of larvae that may hatch from locations in the south Delta, current information indicates that the hydrodynamic conditions indexed by net negative flow in Old and Middle rivers are one factor that can affect the dispersal of delta smelt larvae spawned outside the south Delta into the channels, adjoining canals, and associated flooded islands of the south Delta (e.g., Mildred Island) where the Service has determined they are considered entrained for the purposes of this BiOp.

The following specific ecological conditions reflect the conditions commensurate with the level of incidental take through entrainment that is anticipated in this BiOp.

1. During the early winter, if and when the single annual, system-wide first flush has been identified pursuant to the criteria identified in the PA, net negative flow in Old and Middle rivers should be held to no greater than a 14-day averaged OMR of -2000 cfs for 14 days to prevent turbidity from being pulled into the south Delta and creating a continuous band of turbidity from the Sacramento River to the export facilities.
2. During the winter and early spring, net negative OMR flows should be held at levels no more negative than a 14-day averaged OMR of -2000 cfs, for at least 5 days, when turbidity at the Bacon Island monitoring station (OBI) is a daily average of 12 NTU or greater. To avoid triggering an OMR flow action during a sensor error or a localized turbidity spike that might be caused by local flows or a wind-driven event, Reclamation and DWR will consider and review data from other locations. In the event that the daily average turbidity at OBI is 12 NTU (or greater) and Reclamation and DWR believe that a Turbidity Bridge Avoidance action is not warranted based on additional data sources (isolated and/or wind-driven turbidity event at OBI), Reclamation and DWR will take no additional action and provide the supporting information to the Service within 24 hours.
3. During March-June, negative OMR flows should be managed at no more negative than -5000 cfs on a 14-day moving average or at the flow determined through use of Service-approved life cycle models to limit recruitment to stable levels.

Injury and mortality of adult, larval, and juvenile delta smelt are anticipated to be minimized due to active real-time management of OMR flow and turbidity in the south Delta as described in the PA. Incidental take resulting from operations of all south Delta CVP and SWP facilities is addressed in the ecological conditions described above consistent with the index equation approach to OMR Management described in the PA. If the conditions described above are not maintained, the amount or extent of the anticipated level of incidental take will be considered exceeded and reinitiation will be required pursuant to 50 CFR 402.16.

Take from Rock Slough Intake Operation

The Service's analysis in this BiOp assumes that all delta smelt that are entrained into the south Delta are lost to the population. The Service considers the injury or mortality of delta smelt due to operation of the Rock Slough Intake to have already been analyzed under entrainment effects in this BiOp. The Rock Slough intake is within the south Delta and the intake does not divert enough water to contribute to the likelihood that additional delta smelt not already accounted for in *Take from South Delta Entrainment* will be entrained at this intake.

Additionally, the Service anticipates very little observable take at the Rock Slough intake, as Rock Slough has a positive barrier fish screen making injury or mortality of adult and juvenile delta smelt unlikely, and monitoring information at the Rock Slough intake indicates that delta smelt are very rarely present (1 larval delta smelt and 1 adult delta smelt detected from 1999 through 2018). Therefore, because delta smelt are rarely present around the Rock Slough Intake and the effects are already accounted for, injury or mortality of all delta smelt due to operations of the Rock Slough Intake is exempted.

Hydrodynamic conditions related to the rate of diversion at the Rock Slough intake influence the likelihood of delta smelt being drawn into the intake. As the diversion rate increases, the likelihood of entrainment increases. The maximum pumping capacity of the Rock Slough intake is 350 cfs, and the diversion at the intake is generally at capacity except during periods specified for fisheries protection in other biological opinions that provides for minimal pumping to address water quality needs. The current diversion pattern has been demonstrated through monitoring to substantially limit take of delta smelt. Therefore, the diversion rate can be causally linked to the level of incidental take of delta smelt due to impingement or entrainment caused by operations of the Rock Slough intake, and the following specific ecological conditions reflect the conditions commensurate with the level of incidental take anticipated in this BiOp.

> A diversion rate of no more than 350 cfs will be utilized at the Rock Slough intake, except during fishery protection periods, when minimal diversions occur.

If the conditions described above are not maintained, the amount or extent of the anticipated level of incidental take will be considered exceeded and reinitiation will be required pursuant to 50 CFR 402.16.

Take of Delta Smelt at the North Bay Aqueduct

Delta smelt are attracted to turbidity and the sloughs and canals of the Cache Slough Complex have turbid water conditions that are believed to be one reason delta smelt inhabit this region all year long. Although the exact locations are unknown, delta smelt are also believed to spawn in the Cache Slough complex every year. The operation of the Barker Slough Pumping Plant can result in the hydrodynamic conditions indexed by net negative flow of turbid water into Barker Slough. These hydrodynamic conditions can entrain larval delta smelt. The Service anticipates that incidental take of delta smelt larvae will occur at the Barker Slough Pumping Plant and North Bay Aqueduct (NBA). Incidental take is expected to be low since Barker Slough Pumping Plant has positive barrier fish screens making injury or death of adult and juvenile delta smelt unlikely. However, a small number of larval delta smelt may be killed through impingement, entrainment, or sediment and aquatic weed removal.

Hydrodynamic conditions related to the rate of diversion at the NBA influence the likelihood of delta smelt being drawn into the NBA. As the diversion rate increases, the likelihood of entrainment increases. The CalSim II modeling in support of the PA suggested that the maximum cumulative water diversion into the NBA would not exceed 30 TAF during the months of March, April, and May, which is the months of the year that operations could potentially result in take of larval delta smelt. Therefore, the diversion rate can be causally linked to the level of incidental take of delta smelt due to impingement, entrainment, or sediment and aquatic weed removal caused by operations of the Barker Slough Pumping Plant and NBA, and the following specific ecological conditions reflect the conditions commensurate with the level of incidental take anticipated in this BiOp.

> A cumulative total of no more than 30 TAF of water will be diverted through the NBA diversions during the months of March, April, and May.

If the conditions described above are not maintained, the amount or extent of the anticipated level of incidental take will be considered exceeded and reinitiation will be required pursuant to 50 CFR 402.16.

Take of Delta Smelt at the Roaring River and Morrow Island Distribution Systems

Delta smelt frequently reside in the larger sloughs of Suisun Marsh and less frequently reside in the marsh's smaller sloughs. It is anticipated that the PA will increase the use of Suisun Marsh by delta smelt via the Summer-Fall Habitat Action. The Roaring River Distribution System (RRDS) and the Morrow Island Distribution System (MIDS) are used to deliver fresh water flowing into Montezuma and Suisun sloughs to adjacent wetlands and to drain water off of these wetlands. The use of these distribution systems entrains fish. Thus, the Service anticipates that incidental take of delta smelt larvae will occur at the RRDS and take of delta smelt larvae, juveniles, and adults will occur at the MIDS, which is unscreened. Incidental take is expected to be low since RRDS has positive barrier fish screens and the approach velocity is generally low. Therefore, the presence of the screen and approach velocities maintained can be causally linked to incidental take from operation of the RRDS and MIDS.

The following specific ecological conditions reflect the conditions commensurate with the level of incidental take through operation of RRDS and MIDS that is anticipated in this BiOp.

> Approach velocity at the screens is limited to 0.2 ft/second except during mid-September – mid October, when RRDS diversion rates are controlled to maintain a maximum approach velocity of 0.7 ft/second for fall flood up operations.

If the conditions described above are not maintained, the amount or extent of the anticipated level of incidental take will be considered exceeded and reinitiation will be required pursuant to 50 CFR 402.16.

Effect of the Take

In the accompanying biological opinion, the Service determined that the level of anticipated take is not likely to result in jeopardy to the delta smelt.

Reasonable and Prudent Measures

The Service has determined that the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of the delta smelt:

1. Minimize the adverse effects of the south Delta pumping facilities on delta smelt.

2. Minimize the adverse effects of habitat degradation in summer and fall by studying the effectiveness of the Summer-Fall Habitat Action implementation. As appropriate, representatives from Reclamation, DWR, CDFW, NMFS and the Service will participate in the Delta Coordination Group as part of this planning process.

3. Minimize the adverse effects of the FCCL supplementation program on delta smelt.

4. Minimize the adverse effects of the operation of the North Bay Aqueduct.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, Reclamation and DWR shall comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

The following Terms and Conditions implement Reasonable and Prudent Measure Number 1:

1. Reclamation and DWR shall ensure the frequency of sampling for the south Delta export facilities (Banks and Jones) will be at least 25% of the time the export facilities are in operation. If this cannot be achieved, the Service shall be notified on a real-time basis.

2. Reclamation and DWR shall update and provide fish salvage protocols for Skinner Fish Facility and the Tracy Fish Collection Facility to the Service within 1 year of the issuance of this biological opinion. Annual reports of salvage activities will be submitted to the Service documenting the operation and monitoring activities of the fish salvage facilities.

3. If it is determined that an independent panel is necessary to determine the efficacy of the

proposed OMR Management actions, Reclamation shall seek technical assistance from the Service on development of the charter for that panel.

4. If Reclamation or DWR determine that a Turbidity Bridge Avoidance action is not necessary because the event is not believed to be related to an actual turbidity bridge, they will provide the supporting information, including the reason why the action is not warranted, within 24 hours, and the Service will respond within 24 hours. The action will be initiated until Reclamation, DWR, and the Service are in agreement that an action is not necessary.

5. Reclamation and DWR shall monitor OMR flow and turbidity levels (the surrogate parameter identified in the *Amount or Extent of Anticipated Take* section) at locations identified in the PA on a real-time basis. Reclamation and DWR shall ensure monitoring stations have appropriate redundancy to reduce the likelihood of data collection failure due to malfunction. This information shall be made available to the Service on a real-time basis to document the management of the system. This can be done through Bay Delta Live or a similar system. If the Service determines that conditions have led to the exceedance of anticipated take, reinitiation would be required.

6. Reclamation and DWR shall use Service life cycle models or other Service-approved models when available for the purposes of estimating proportion of the population affected by entrainment.

7. Reclamation shall seek technical assistance from the Service on the development of the charter for the independent panel for the proposed Four-Year Review of the "OMR management and measures to improve survival through the south Delta".

8. Reclamation and DWR will comply with all monitoring and reporting requirements as identified in the *Reporting Requirements* section, below.

The following Terms and Conditions implement Reasonable and Prudent Measure Number 2:

1. Reclamation and DWR, in coordination with the Service and Delta Coordination Group, will define specific parameters for implementation of the Summer-Fall Habitat Action. Additionally, mutually agreeable methods for determining parameters for successful recruitment of delta smelt will be developed. These parameters shall include habitat acreages and population trends. This method shall be in place prior to implementation of the Summer-Fall Habitat Action.

2. Reclamation and DWR shall provide annual reports documenting the planning, implementation, and monitoring of the Summer-Fall Habitat Action. In years that an action will be implemented, Reclamation shall provide a draft of the implementation plan to the Service by May 1 and a final report of the action by May 1 of the following year.

3. Reclamation and DWR shall develop a monitoring plan to assess the efficacy of

implementing the Summer-Fall Habitat Action. The plan shall be vetted by the Delta Coordination Group and included in the annual implementation plan. A full report of results shall be provided within one year of the completion of the action.

4. Reclamation shall seek technical assistance from the Service on the development of the charter for the independent panel for the proposed Four-Year Review of "Delta Smelt Summer and Fall Habitat Actions".

5. Reclamation and DWR will comply with all monitoring and reporting requirements as identified in the *Reporting Requirements* section, below.

The following Terms and Condition implement Reasonable and Prudent Measure Number 3:

1. Reclamation shall ensure development of a supplementation strategy for the FCCL supplementation program as described in the PA. This strategy will be in place one year from the issuance of the BiOp.

The following Term and Condition implements Reasonable and Prudent Measure Number 4:

1. DWR shall ensure that regular fish screen maintenance is performed at the North Bay Aqueduct. This maintenance is necessary to avoid incidental take of juvenile and adult delta smelt and to avoid exceeding the incidental take of larvae. DWR shall annually report to the Service with details on fish screen maintenance at these facilities.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the PA. If, during the course of the action, this level of incidental take is exceeded, reinitiation of consultation and review of the reasonable and prudent measures provided is required. Reclamation must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Reporting Requirements

In order to monitor whether the amount or extent of incidental take anticipated from implementation of the PA is approached or exceeded, Reclamation shall adhere to the following reporting requirements. Should this anticipated amount or extent of incidental take be exceeded, Reclamation must reinitiate formal consultation as per 50 CFR 402.16.

1. Comply with reporting requirements included in the above Terms and Conditions.

2. For the Summer-Fall Habitat Action, if Reclamation does not accept the recommended action provided through the structured decision making process, Reclamation must notify the Service prior to implementing activities associated with this action to determine if the effects are consistent with the analysis in this BiOp.

3. The Service must be notified within 24 hours of the finding of any injured or dead delta

smelt or any unanticipated damage to its habitat associated with the PA. Notification will be made to the contact below and must include the date, time, and precise location of the individual/incident clearly indicated on a U.S. Geological Survey 7.5 minute quadrangle or other maps at a finer scale, as requested by the Service, and any other pertinent information. When an injured or dead individual of the delta smelt is found, Reclamation and DWR shall follow the steps outlined in the *Disposition of Individuals Taken* section below.

Disposition of Individuals Taken

Injured or dead delta smelt observed in salvage should be preserved in a container of at least 70% Ethanol containing a paper with the date and time when the animal was found, fork length, the location where it was found, and the name of the person who collected the specimen. The preserved delta smelt are then to be evaluated by an onsite Service-approved biologist who verifies species identification and examines the fish for reproduction maturity and stage. A second fish identification verification is provided by staff of the CDFW or alternatively DWR or Reclamation staff, if needed. Fish specimens confirmed as delta smelt must be stored until custody is transferred to the CDFW for archiving. Annually, a catalog of archived samples transferred from Reclamation and DWR salvage facilities will be provided to Jana Affonso, Assistant Field Supervisor of the Endangered Species Division of the San Francisco Bay-Delta Office.

17.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service recommends the following actions:

1. The Service recommends that Reclamation and DWR participate in recovery planning and implementation of conservation actions consistent with recovery planning documents. In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.
2. Design restoration projects to provide suitable for multiple species dependent upon riparian habitat for breeding, feeding, and sheltering, such as the least Bell's vireo, western yellow-billed cuckoo, and valley elderberry longhorn beetle.
3. Restore habitat in tributaries of large rivers with altered hydrology, such as those included in the Action Area, which may have more natural hydrologic conditions to enhance available nesting habitat for riparian birds such as least Bell's vireo and the western yellow-billed cuckoo.
4. Develop a program for the monitoring of least Bell's vireo in potentially suitable habitat within the Action Area to assist in tracking the recovery of the species in the Central Valley.
5. During the implementation of future planned projects within the Central Valley, enhance on-site riparian habitat for the least Bell's vireo by planting native riparian shrubs and trees.
6. During the implementation of future planned projects within the Central Valley, enhance onsite riparian habitat for valley elderberry longhorn beetle.
7. Develop and implement restoration measures in areas designated in the *Valley Elderberry Longhorn Beetle Recovery Plan*.
8. Include elderberry shrubs as part of riparian planting mix when revegetating for temporary impacts from restoration project construction.
9. Directly conduct or fund research projects to address current information gaps in the western yellow-billed cuckoo life history, migration routes, conservation strategies, and recovery needs in the Central Valley.
10. Develop multi-species riparian habitat restoration techniques for the Central Valley that would create benefits for Federally-listed species.
11. Encourage adaptive management of storage, flows and conservation of water to benefit Federally-listed species.
12. Work to secure long-term water sources to support riparian habitat restoration activities in Refuges.
13. Work to further conduct process-based ecosystem restoration projects to create or enhance suitable western yellow-billed cuckoo breeding habitat along the Sacramento River, Feather River, American River, San Joaquin, and Stanislaus River by collaborating with Service Refuges, CDFW, State Parks, Corps, Tribal governments,

and other stakeholders.

14. Monitor, maintain, and expand existing riparian habitat restoration areas to benefit western yellow-billed cuckoo.
15. Establish a 500-foot pesticide-free and non-GMO zone around all known, historical western yellow-billed cuckoo habitat. Explore partnerships with landowners along rivers in the Action Area to improve available prey base for western yellow-billed cuckoos during breeding and migration.
16. Develop and implement a riverine ecosystem mitigation and adaptive management plan to avoid and compensate for the long-term impacts of altered flow regimes on riparian and wetland communities to benefit a broad range of threatened and endangered species in the Action Area.

18.0 REINITIATION—CLOSING STATEMENT

This concludes formal consultation on the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any additional take may not be exempt from the prohibitions of section 9 of the Act, pending reinitiation.

This BiOp uses a programmatic approach to evaluate the elements of the PA that will be subject to future project-specific consultations because of the need for future Federal approvals. The analysis in this BiOp allows for a broad-scale examination of the potential impacts to listed species and designated critical habitat, and examines how the parameters of the PA align with the survival and recovery needs of listed species occurring in the action area. The remainder of the project elements not addressed programmatically are addressed as a standard, project-level consultation because they are not subject to future Federal approvals. Some project elements and their effects on the species and critical habitat addressed in this BiOp may change as Reclamation and DWR continue to develop the PA through collaborative processes, and, therefore, may require reinitiation if there are effects to listed species or critical habitat that were not analyzed herein.

Shasta Dam Raise Operations

Reclamation is proposing to raise the existing Shasta Dam by 18.5 feet. The effects of the construction of this dam raise are being addressed under a separate section 7 consultation with the Service. According to Reclamation, filling of the reservoir behind Shasta Dam above the current maximum storage capacity of 4.55 MAF to 5.19 MAF (634,000 acre-feet additional storage capacity) would not likely occur before 2025. During construction of the dam raise, Reclamation is not proposing any changes to operations of Shasta Dam and Reservoir beyond what is proposed in the PA of this BiOp. Operations of Shasta Dam would continue in accordance with authorizing statutes and amendments, State Water Resources Control Board water rights permits and orders, and the ROC BiOps (Reclamation 2019). The inundation of the expanded reservoir is expected to result in water levels 20.5-feet higher than the existing full pool elevation.

Filling Period

It will take approximately 2 years for the expanded reservoir to fill behind the dam raise (Figure 3 in Reclamation 2019). Reclamation is not currently proposing changes to operations as a result of filling the expanded reservoir that could affect timing or amount of downstream riparian or floodplain inundation or water reaching the Delta. Therefore, this BiOp only analyzes operations pursuant to the current ROC PA.

Post-filling Period

After the initial filling period is complete, if operations are modified as a result of the additional reservoir storage, Reclamation shall assess whether modified operations will result in effects in a manner or to an extent not considered in this BiOp. Effects that shall be considered include, but are not necessarily limited to, the following:

1. reduced riparian, floodplain and channel margin habitats at certain times of years and locations that have not been analyzed;

2. reduced inflow to delta in winter and spring and higher Delta inflow in summer and fall;

3. reoperation of reservoirs and delta pumping facilities to deliver the newly stored water.

If changes to operations are proposed in the future to account for the filling and/or post-filling periods that may affect the amount or timing of how Shasta Dam and Reservoir are operated, reinitiation of this consultation is required if any of the triggers in 50 CFR 402.16 are met.

Suisun Marsh Salinity Control Gate Operations

The Suisun Marsh Salinity Control Gates are being proposed to direct more fresh water in the Suisun Marsh to improve habitat conditions for delta smelt in the region. Depending on the timing of the proposed operations, these activities could overlap with the breeding season when federally-listed species may be present in the vicinity of the gates and/or shift prey availability due to temporary lowering of marsh salinities. Current information does not demonstrate adverse effects to occur from SMSCG operations. If through planning and implementation of the project-level activities, adverse effects to federally-listed species are likely to occur and were not analyzed herein, reinitiation of this consultation is required if any of the triggers in 50 CFR 402.16 are met.

18.1 Reinitiation Literature Cited

(Reclamation). United States Bureau of Reclamation. 2019. Threatened, Endangered, and Proposed Species that May be Affected by the Shasta Dam Raise Project. Biological Assessment, Shasta County, California. Mid-Pacific Regional Office, Sacramento, CA.