Incidental Take Permit Application for Long-Term Operation of the California State Water Project

State of California
Department of Water Resources

December 13, 2019

Incidental Take Permit Application
for
Long-Term Operation of the California State Water Project

Applicant:
California Department of Water Resources

Contact:
Dean Messer
Chief, Division of Environmental Services,

916-376-9700

December 13, 2019

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ACRONYMS AND OTHER ABBREVIATIONS

°C	celsius
°F	fahrenheit
AFRP	Anadromous Fish Restoration Program
AFSP	Anadromous Fish Screen Program
BiOp	Biological Opinion
BSPP	Barker Slough Pumping Plant
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CVP	Central Valley Project
CVP/SWP biological opinion	2009 NMFS Biological Opinion and Conference Opinion on the Long-term Operation of the CVP and SWP
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento–San Joaquin River Delta
DPS	distinct population segment
DWR	California Department of Water Resources
EDSM	Enhanced Delta Smelt Monitoring
EFH	essential fish habitat
EIR	Environmental Impact Report
ESA	federal Endangered Species Act
ESU	Evolutionarily Significant Unit
Fish and Game Code	California Fish and Game Code
FMWT	Fall Midwater Trawl
FR	Federal Register
FRFH	Feather River Fish Hatchery
HAB	harmful algal bloom
HEA	Habitat Expansion Agreement
HEP	Habitat Expansion Plan
HOR	Head of Old River
HORB	Head of Old River Barrier
IEP	Interagency Ecological Program
ITP	incidental take permit
LSNFH	Livingston Stone National Fish Hatchery

LSZ	low-salinity zone
MAST	Management Analysis and Synthesis Team
mm	millimeters
NBA	North Bay Aqueduct
NEP	nonessential experimental population
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Units
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCEs	primary constituent elements
PG&E	Pacific Gas and Electric Company
POD	pelagic organism decline
ppt	parts-per-thousand
psu	practical salinity units
PTM	Particle Tracking Model
RBDD	Red Bluff Diversion Dam
Reclamation	Bureau of Reclamation
ROC on LTO	Reinitiation of Consultation on the Coordinated Long-Term Operation
SFE	San Francisco Estuary
SJRRP	San Joaquin River Restoration Program
Skinner Fish Facility	John E. Skinner Delta Fish Protective Facility
SKT	Spring Kodiak Trawl
SL	standard length
SLS	Smelt Larval Survey
SWP	State Water Project
TCD	Temperature Control Device
TFCF	Tracy Fish Collection Facility
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

1 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document presents, in accordance with California Fish and Game Code (Fish and Game Code) Section 2081 and 14 California Code of Regulations (CCR) Section 783.2, *Incidental Take Permit Applications,* an application by the California Department of Water Resources (DWR) for the authorization of incidental take of Longfin Smelt (*Spirinchus thaleichthys*), Delta Smelt (*Hypomesus transpacificus*), Sacramento River Winter-run Chinook Salmon Evolutionarily Significant Unit (ESU; *Oncorhynchus tshawytscha*), and Central Valley Spring-run Chinook Salmon ESU (*O. tshawytscha*) associated with DWR's future operation of the State Water Project (SWP). These four species are subject to the rules and guidelines specified in Fish and Game Code Sections 2050–2100 and 14 CCR Sections 783 through 786.6, *Guidelines Implementing the California Endangered Species Act*.

The California Endangered Species Act (CESA) prohibits the import, export, take, possession, purchase, or sale of species listed by the State as endangered, threatened, or in specific cases, candidate species (Fish and Game Code, Sections 2080 and 2081.1). Section 86 of the Fish and Game Code defines *take* as to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill."

As provided by Section 2081(b) of the Fish and Game Code, the California Department of Fish and Wildlife (CDFW) may authorize take otherwise prohibited by Section 2080 by issuing an incidental take permit (ITP). The requirements for an application for an ITP under CESA are described in the CCR (14 CCR Section 783.2). Before issuing an ITP, CDFW must make findings based on its administrative record that the following conditions have been met:

- The take authorized will be incidental to an otherwise lawful activity.
- The applicant will minimize and fully mitigate the impacts of the take authorized.
- The measures required to meet the permit obligations will be roughly proportional in extent to the impact of the authorized taking on the species. Where various measures are available to meet this obligation, the measures required will maintain the applicant's objectives to the greatest extent possible. All required measures will be capable of successful implementation.
- The permit will be consistent with any regulations adopted pursuant to Sections 2112 and 2114 of the Fish and Game Code.
- The applicant has ensured that adequate funding is available to implement the measures required by the permit to minimize and fully mitigate the impacts of the taking, and to monitor compliance with, and the effectiveness of, the measures.
- The issuance of the permit will not jeopardize the continued existence of the species.

Table 1-1 shows the locations in this document where the application materials prescribed by 14 CCR Section 783.2(a) can be found. In addition, this section provides the following additional information, which is not required by 14 CCR Section 783.2:

- Relationship to existing Incidental Take Permit and Biological Opinions (Section 1.4)

- Duration of the requested permit (Section 1.5)
- Identification of the lead agency for purposes of the California Environmental Quality Act (CEQA) (Section 1.6)

Table 1-1. Location in this Document of Required Application Materials

Code Citation	Requirement	Location
14 CCR Section 783.2(a)(1)	Applicant's full name, mailing address, and telephone number(s)	Section 1.2
14 CCR Section 783.2(a)(2)	Common and scientific names of the species to be covered by the permit and the species' status under CESA	Section 1.1
14 CCR Section 783.2(a)(3)	Complete description of the project or activity for which the permit is sought	Section 3.3
14 CCR Section 783.2(a)(4)	Location where the project or activity is to occur or to be conducted	Section 1.3
14 CCR Section 783.2(a)(5)	Analysis of whether and to what extent the project or activity for which the permit is sought could result in the taking of species to be covered by the permit	Sections 4.2 – 4.3
14 CCR Section 783.2(a)(6)	Analysis of the impacts of the proposed taking on the species	Sections 4.2 – 4.3
14 CCR Section 783.2(a)(7)	Analysis of whether issuance of the incidental take permit would jeopardize the continued existence of a species	Sections 6.1 – 6.4
14 CCR Section 783.2(a)(8)	Proposed measures to minimize and fully mitigate the impacts of the proposed taking	Sections 5.1 – 5.5
14 CCR Section 783.2(a)(9)	Proposed plan to monitor compliance with the minimization and mitigation measures and the effectiveness of the measures	Section 7
14 CCR Section 783.2(a)(10)	Description of the funding source and the level of funding available for implementation of the minimization and mitigation measures	Section 8
14 CCR Section 783.2(a)(11)	Certification	Section 9

Notes: CCR = California Code of Regulations; CESA = California Endangered Species Act

1.2 PERMIT APPLICANT

The permit applicant is the California Department of Water Resources located at P.O. Box 942836, Sacramento, CA 94236-0001. The responsible agent, Dean Messer, (916) 376-9700, or his designee, has the authority to accept service of process.

1.3 PROJECT LOCATION

The project location is defined by the following geographic area:

- Sacramento River from its confluence with the Feather River downstream to the legal Delta boundary at the I Street Bridge in the city of Sacramento;
- Sacramento-San Joaquin Delta (i.e., upstream to Vernalis and downstream to Chipps Island); and
- Suisun Marsh and Bay.

The project location overlaps the historical and current range of Longfin Smelt, Delta Smelt, Sacramento River Winter-run Chinook Salmon ESU, and Central Valley Spring-run Chinook Salmon ESU

(Figures 1-1 through 1-4). SWP facilities that are located within the project location, as described in this document, are shown in Figure 1-5.

1.4 RELATIONSHIP TO EXISTING INCIDENTAL TAKE PERMIT AND BIOLOGICAL OPINIONS

DWR operates the SWP in compliance with the following existing ITPs and biological opinions that address CESA-listed species:

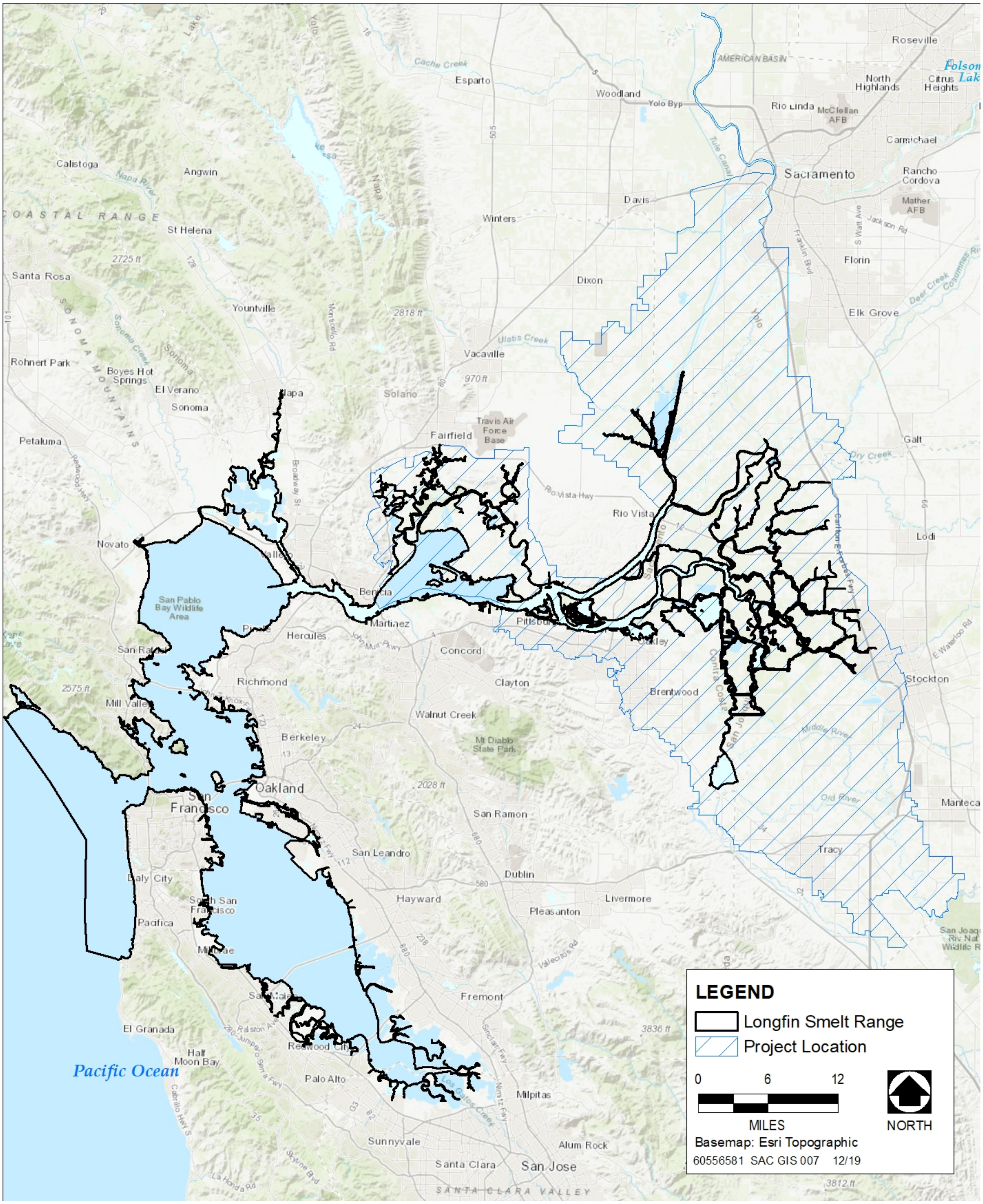
- California Department of Fish and Game (CDFG) 2009 Incidental Take Permit for Longfin Smelt;
- National Marine Fisheries Service (NMFS) 2009 Biological Opinion and Conference Opinion on the Long-Term Operation of the Central Valley Project and State Water Project
- U.S. Fish and Wildlife Service (USFWS) 2008 Biological Opinion on the Coordinated Operations of the Central Valley Project and State Water Project
- CDFG Fish and Game Code Section 2080.1 consistency determinations under CESA based on the conclusions of the two federal biological opinions.

1.5 REQUESTED PERMIT DURATION

The requested duration of the ITP is 10 years.

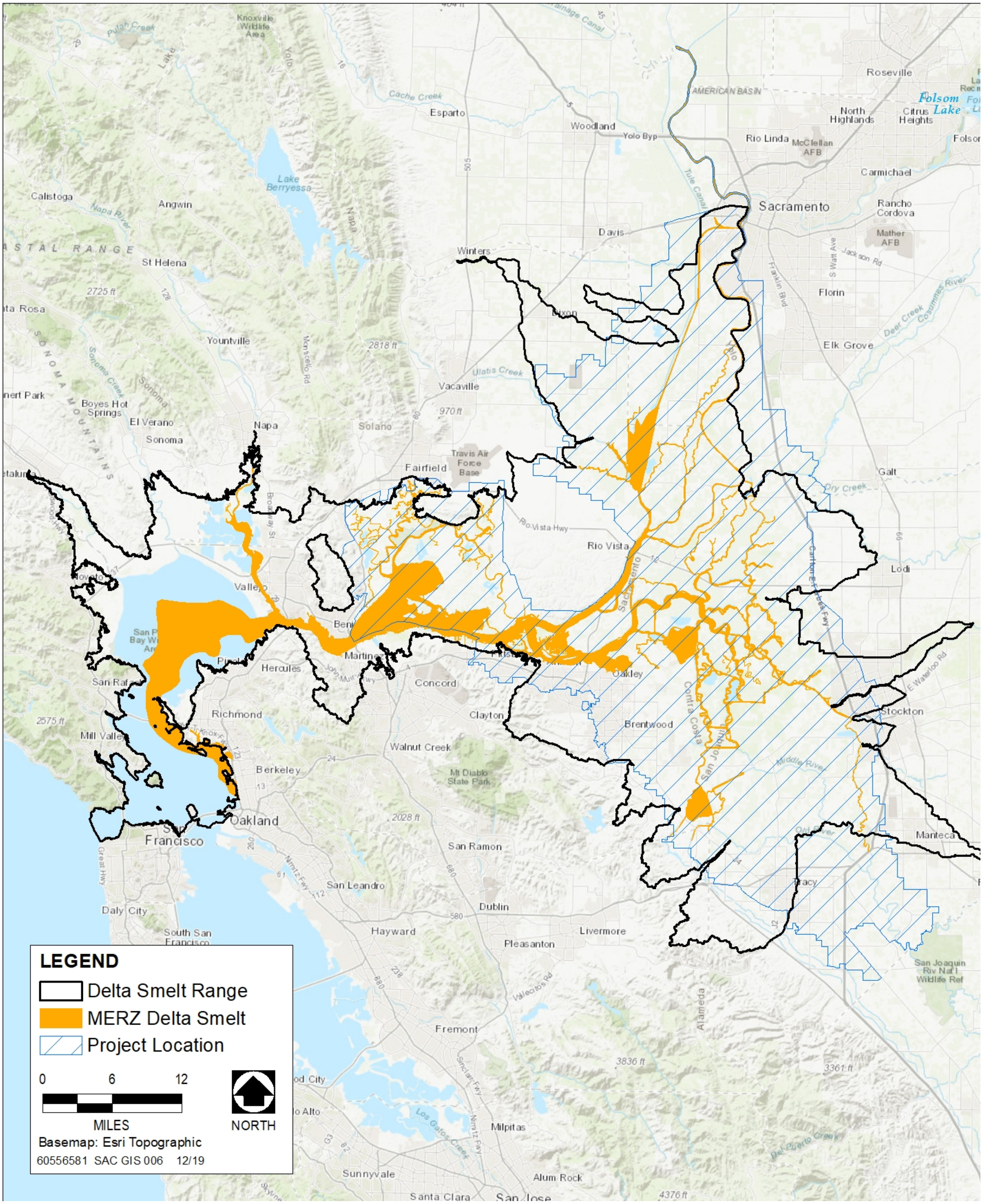
1.6 CEQA LEAD AGENCY

The CEQA lead agency is DWR. DWR prepared an Initial Study (IS), which concluded that effects of the Proposed Project could potentially be significant for water quality and aquatic resources. DWR subsequently prepared a Draft Environmental Impact Report (EIR), which was circulated for public review on November 21, 2019 (State Clearinghouse Number 2019049121).



Sources: The Bay Institute et al. 2007, as cited in DWR 2009; Merz et al. 2013

Figure 1-1. Project Location and the Historical and Current Range of Longfin Smelt



Source: California Department of Fish and Wildlife BIOS Database 2019; Merz et al. 2011

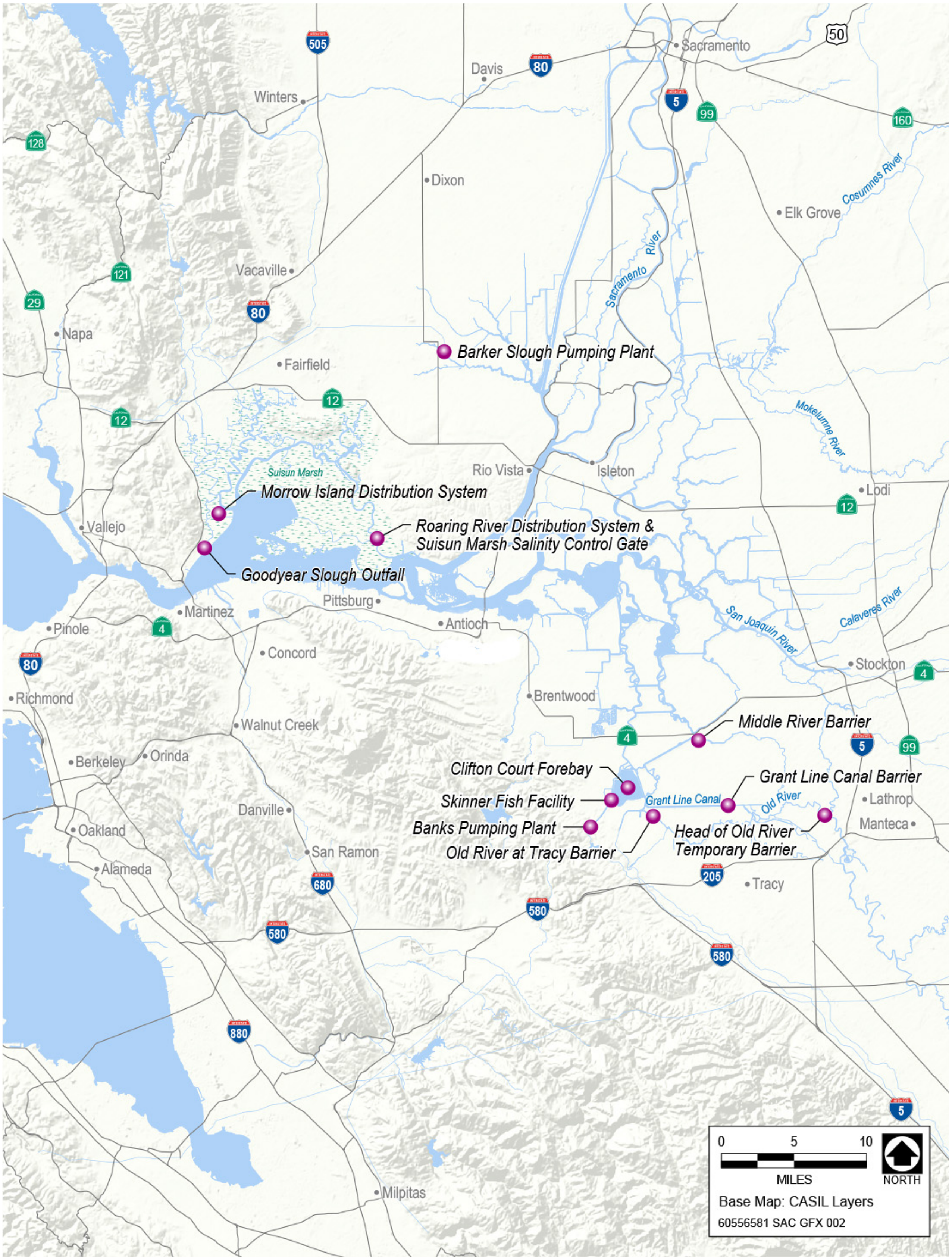
Figure 1-2. Project Location and the Historical and Current Range of Delta Smelt

Source: California Department of Fish and Wildlife BIOS Database 2019

Figure 1-3. Project Location and the Historical and Current Range of Sacramento River Winter-run Chinook Salmon ESU

Source: California Department of Fish and Wildlife BIOS Database 2019

Figure 1-4. Project Location and the Historical and Current Range of Central Valley Spring-run Chinook Salmon ESU



Source: Data compiled by AECOM in 2017

Figure 1-5. State Water Project Facilities within the Project Location

2 COVERED SPECIES

The following sections present the legal status, life history and habitat requirements, distribution and abundance and threats for each life stage of the four CESA-listed fish species included in the ITP application.

2.1 DELTA SMELT

2.1.1 LEGAL STATUS

Delta Smelt was listed as a threatened species under the CESA in 1993. An emergency petition was filed in February 2007 with the California Fish and Game Commission to elevate the status of Delta Smelt from threatened to endangered under CESA (Bay Institute et al. 2007). On March 4, 2009, the California Fish and Game Commission elevated the status of Delta Smelt to endangered under CESA. A 12-month finding on a petition to reclassify the Delta Smelt as an endangered species was completed on April 7, 2010. After reviewing all available scientific and commercial information, the USFWS determined that reclassifying the Delta Smelt from threatened to endangered was warranted but was precluded by other higher priority listing actions (USFWS 2010).

2.1.2 LIFE HISTORY AND GENERAL ECOLOGY

Delta Smelt are endemic to the San Francisco Bay–Delta where the species primarily occupies open-water habitats in Suisun Bay, Suisun Marsh, and the Sacramento–San Joaquin Delta. On occasion, Delta Smelt distribution can extend 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 the Napa River and San Francisco Bay. The Delta Smelt is primarily an annual species, completing its life cycle in 1 year, which typically occurs from April to the following April. In captivity, Delta Smelt can survive to spawn at 2 years of age (Lindberg et al. 2013), but age 2 Delta Smelt are now rare in the wild (Bennett 2005; Damon et al. 2016).

Delta Smelt complete their entire life cycle within the low salinity zone (LSZ) of the upper estuary, in the tidal freshwater region of the Cache Slough Complex or move between the two regions of freshwater and low salinity (Bennett 2005; Sommer and Mejia 2013; Hobbs et al. 2019)[1]. Komoroske et al. (2016) found that Delta Smelt can acclimate to salinities greater than 6 parts-per-thousand (ppt) in the laboratory, but observations of Delta Smelt presence in waters having salinities exceeding 6 ppt are rare in the wild. This is likely because the osmoregulatory costs at such high salinities are too high to support growth and survival (Komoroske et al. 2016).

Delta Smelt spawning likely occurs at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005). Although preferred spawning substrate is unknown, spawning habits of the Delta Smelt's closest relative, the Surf Smelt (*Hypomesus pretiosus*), in addition to unpublished experimental trials, suggest that sand or small pebbles may be the preferred substrate

[1] The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 parts per thousand (Kimmerer 2004).

(Bennett 2005). Hatching success peaks at water temperatures of 15 degrees Celsius (°C) to 16°C, ceasing when water temperatures exceed 20°C (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of March to May, but ripe female Delta Smelt have been observed as early as January and larvae have been collected as late as July (Damon et al 2016). Delta Smelt appear to have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. Spawning locations can vary with the water year. During higher flows, spawning may be centered downstream of the Delta, whereas during drier years, spawning is centered in the Delta. The length of the spawning season varies with variation in water temperature (Bennet 2005).

Although adult Delta Smelt can spawn more than once, most adults senesce by May (Polansky et al. 2018). The egg stage averages about 10 days before the embryos hatch into larvae (Bennett 2005). The larval stage averages about 30 days. Metamorphosing post-larvae appear in monitoring surveys from April into July of most years (Bennett 2005). By July, most Delta Smelt have reached the juvenile life stage. Delta Smelt collected during the fall are considered subadults. By Delta Smelt are considered adults by January 1. Many Delta Smelt disperse to landward habitats sometime after the first significant precipitation event of the winter, staging while sexual maturity is completed (Grimaldo et al. 2009; Sommer et al. 2011; Polansky et al. 2018). Some adult Delta Smelt exhibit very limited dispersal during the spawning season (Murphy and Hamilton 2013; Polansky et al. 2018).

In the wild, larval Delta Smelt are presumed to be surface-oriented, exhibiting greater dispersion during the night (Bennett 2005). In the laboratory experiments, newly hatched larval Delta Smelt are able to manipulate their position in tanks but there is no evidence to suggest that they can swim against net currents. Juvenile Delta Smelt vary their position in the water column with respect to tides, water quality and bathymetry; presumably these movements facilitate maintenance in favorable habitats (Feyrer et al. 2013). Adult Delta Smelt appear to use tidal migration and/or move horizontally towards shore during spawning migrations to upstream habitats (Bennett and Burau 2015).

From March through June, larval Delta Smelt rely heavily first on juvenile, then adult stages of the calanoid copepods *Eurytemora affnis* and *Pseudodiaptomus forbesi*, as well as cladocerans (Nobriga 2002; Hobbs et al. 2006; Slater and Baxter 2014) and *Sinocalanus doerrii*. Nobriga (2002) found that Delta Smelt larvae expressed positive selection for *E. affnis* and *P. forbesi*, consuming these prey species in greater proportion than available in the environment. Such selection was not noted for other zooplankton prey. Regional differences in food use occurs, with *E. affnis* and *P. forbesi* being major prey items downstream in the low salinity zone with a transition to *S. doerrii* and cyclopoid copepods as major prey items upstream into the Cache Slough Complex. Juvenile Delta Smelt (June through September) rely extensively on calanoid copepods such as *E. affnis* and *P. forbesi*, especially in freshwater (salinity < 1 ppt) and the Cache Slough Complex, but there is great variability among regions (Interagency Ecological Program [IEP] 2015). Larger fish are also able to take advantage of mysids, cladocerans, and amphipods (Moyle et al. 1992; Lott 1998; Feyrer et al. 2003). The presence of several epibenthic species in diets therefore indicates that food sources for this species are not solely connected to pelagic pathways.

2.1.3 DISTRIBUTION AND ABUNDANCE

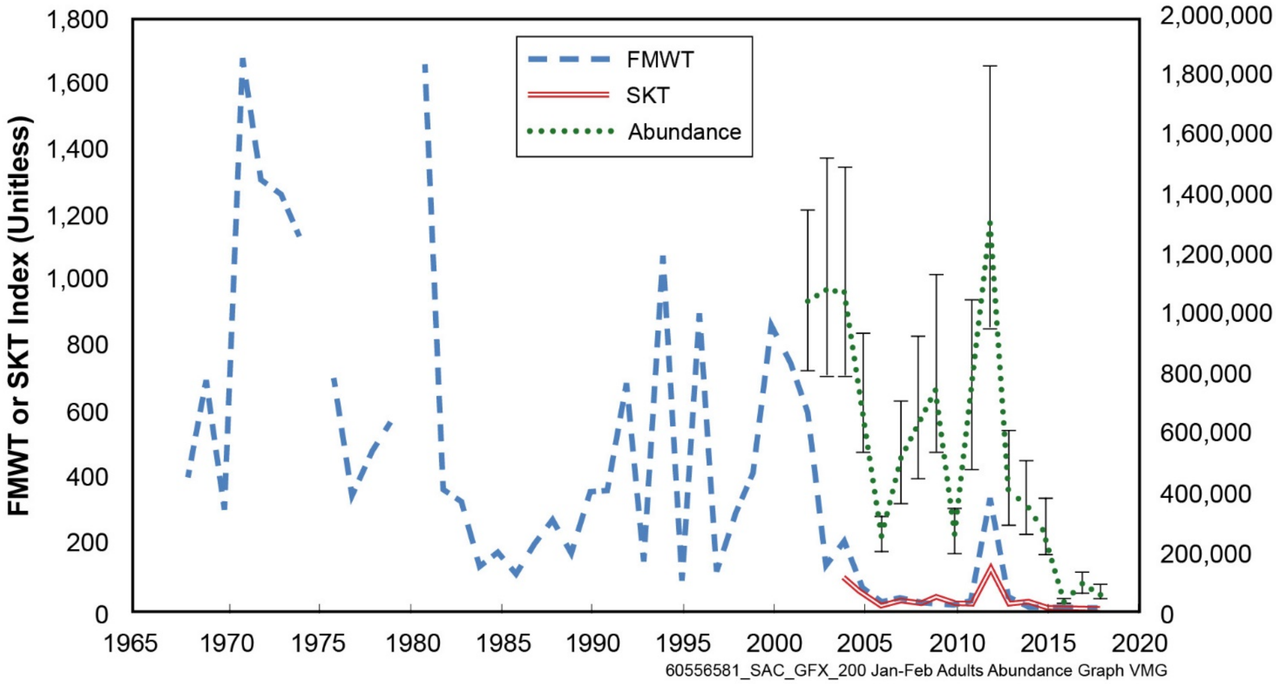
The California Department of Fish and Wildlife (CDFW) conducts four fish surveys from which it develops indices of Delta Smelt's relative abundance. Each survey has variable capture efficiency (Mitchell et al. 2017), and in each, the frequency of zero catches of Delta Smelt is very high, largely due to the species' rarity (Latour 2016; Polansky et al. 2018) or because the surveys are carried out independent of other factors that affect catch, such as tide (Bennett and Burau 2015) and channel location (Feyrer et al. 2013). Information for Delta Smelt distribution and abundance can also be ascertained from other surveys that target salmonids. The U.S. Fish and Wildlife Service (USFWS) implemented a new smelt monitoring program in 2016, called the Enhanced Delta Smelt Monitoring (EDSM) program. This new program is used to measure the abundance and distribution of all life stages of Delta Smelt using a generalized random tessellation stratified (GRTS) design. Delta Smelt population estimates are derived from this survey and may be featured more prominently and in conjunction with CDFW trawls data in the future.

The distribution of the Delta Smelt population varies with life stage, season and environmental conditions (Bennett 2005; Sommer and Mejia 2011; Hobbs et al. 2019). Sub-adult and adult Delta Smelt typically make landward movements soon after first flush periods when turbidities elevate over 10 Nephelometric Turbidity Units (NTU) (Grimaldo et al. 2009). During extreme wet years, some adults may move seaward into San Francisco Bay and the Napa River. Larval Delta Smelt can be broadly distributed depending on the freshwater flow during March and April. During wet years, larval Delta Smelt are generally distributed seaward. In contrast, during drier years, larval Delta Smelt are concentrated in the Delta. Juvenile Delta Smelt distribution is generally centered in the North Delta Arc, which extends from Cache Slough to Suisun Bay and Suisun Marsh.

The relative abundance of Delta Smelt has declined substantially since the 1980s (Sommer et al. 2007). The recent relative abundance reflects decades of habitat change and marginalization by non-native species that prey on and outcompete Delta Smelt. The observed decline in Delta Smelt abundance is consistent with declines of other pelagic species in the Delta (Sommer et al. 2007; Baxter et al. 2010).

Data derived from the Fall Midwater Trawl surveys are used for detecting and roughly scaling interannual trends in Delta Smelt abundance. The indices derived from the Fall Midwater Trawl closely mirror trends in catch per unit effort (Kimmerer and Nobriga 2008), but do not, at present, support statistically reliable population abundance estimates, though substantial progress has recently been made in this regard (Newman 2008). The Fall Midwater Trawl indices have ranged from 1,673 in 1970 to 0 in 2018, the lowest index on record. Summer Townet Survey-derived indices peak high and low values have occurred in different years from the Fall Midwater Trawl; Summer Townet indices have ranged from a low of 0.3 in 2005 and 2009 to a high of 62.5 in 1978. Indices from the two surveys show a similar pattern of Delta Smelt relative abundance that is higher prior to the mid-1980s and very low in the past decade.

The CDFW Spring Kodiak Trawl (SKT) monitors the adult spawning stock of Delta Smelt and serves as an indication for the relative number and distribution of spawners in the system. The 2018 SKT Abundance Index was 2.1, the second lowest on record. All CDFW relative abundance indices show a declining trend since the early 2000s (Figure 2-1). Significantly more Delta Smelt have been recorded in a sampling area on the flood tide as opposed to the ebb tide (Reclamation 2019).



Source: Reclamation 2019

Figure 2-1. Fall Midwater Trawl Index, Spring Kodiak Trawl Index, and January-February Spring Kodiak Trawl Abundance Estimate (with 95% Confidence Interval), Water Years 2002–2018

The 2018 absolute abundance estimate is the second lowest; however, the confidence intervals overlap so strongly that it cannot be stated that 2018had higher adult abundance than 2016. The January through February 2016 point estimates are the lowest since the SKT survey began in 2002 and suggest Delta Smelt experienced increased natural mortality during the extreme drought conditions during 2013–2015. While the estimate may have increased slightly in 2017, it appears to have decreased again in 2018. The continued low spawning stock of Delta Smelt relative to historical estimates suggest the population would continue to be vulnerable to key threats (described below), especially when these stressors are occurring in consecutive years (e.g., drought) or across sequential life stages (e.g., high water temperatures).

2.1.4 Species Threats

Delta Smelt are believed to be limited by a number of stressors, including entrainment at water diversions, increasing frequency and duration of droughts, poor water quality, prey availability, contaminants, water temperature, water, and predation (Sommer et al. 2007; Miller et al. 2012; Wagner et al 2011; Baxter et al. 2015). Since 2010, several conceptual models (IEP 2015) and empirical models (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a; Hamilton and Murphy 2018) have explored life cycle models for the Delta Smelt to identify and describe the reasons for the population decline. Some of these models have recreated a trend observed in abundance indices, but each model has applied different methodology and predictive covariates.

Collectively, these modeling efforts generally support water temperature, water clarity, and prey availability as key factors that limit Delta Smelt populations, but water diversions and predation may also have significant impacts as well. The threats discussed below may be directly or indirectly affected by the Proposed Project.

2.1.4.1 ENTRAINMENT

All life stages of Delta Smelt are vulnerable to entrainment. In general, Delta Smelt salvage increases with increasing net Old and Middle river Flow (OMR) flow reversal (i.e., more negative net OMR flows) and when turbidity exceeds 10 to 12 NTU (USFWS 2008; Grimaldo et al. 2009). Based on field and salvage data, Kimmerer (2008) calculated that from near 0% to 25% of the larval and juvenile Delta Smelt population and 0% to 50 % of the adult Delta Smelt population can be entrained at the CVP and SWP annually, in years with periods of high exports. Although methods to calculate proportional loss estimates have since been debated (Kimmerer 2011; Miller 2011), modeling efforts suggest that entrainment losses can adversely affect the Delta Smelt population (Kimmerer 2011; Maunder and Deriso 2011; Rose et al. 2013a, 2013b).

Delta Smelt are most vulnerable to entrainment when, as adults, they move from brackish water into freshwater or as larvae, when they move from freshwater in the southern and central Delta into the brackish water of Suisun Bay. While some Delta Smelt live year-round in freshwater far from the CVP and SWP, most rear in the low-salinity regions of the estuary, also at a relatively safe distance from the SWP and CVP pumps. The timing, direction, and geographic extent of the spawning movements of adult Delta Smelt affect their entrainment risk (Sweetnam 1999; Sommer et al. 2011). Unlike the years prior to the 1990s when high salvage of adult and juvenile Delta Smelt occurred at high, intermediate, or low export levels, the risk of entrainment for fish that move into the Central Delta and South Delta is currently highest when net Delta outflow is at intermediate levels (~20,000 to 75,000 cfs) and OMR flow is more negative than -5,000 cfs (USFWS 2008). In contrast, when adult Delta Smelt move upstream to the Sacramento River and into the Cache Slough region or do not move upstream at all, entrainment risk is appreciably lower. During extreme wet years, very few Delta Smelt (all life stages) are salvaged because the distribution shifts seaward away from the footprint of the SWP and CVP (Grimaldo et al. 2009).

2.1.4.2 FLOW

The IEP Management Analysis and Synthesis Team (MAST) report found a relationship between Delta outflow and spring Delta Smelt recruitment (spring to summer) for the post-Pelagic Organism Decline (POD) (Sommer et al. 2007) era, but the mechanisms underlying this relationship are unknown and warrant further investigation (IEP 2015).

During the late summer and fall, Delta outflow affects the distribution of low salinity habitat within the upper estuary landscape. Higher Delta outflows (or low X2) expand the LSZ, while lower outflows constrict the extent of low salinity habitat (Feyrer et al. 2011; Bever et al. 2016). During the summer and fall, it has been hypothesized that environmental conditions such as prey supply, improved water temperature, and turbidity improve for Delta Smelt as X2 moves seaward and the LSZ expands habitat area (IEP 2015). Recent work suggests that increased Delta outflow during the summer and fall can affect prey subsidies from the Delta to the LSZ (Kimmerer et al. 2019), but the loss rate of new zooplankton production in the LSZ as a result of these subsidies is likely rapid, due to clam grazing. Variability in water temperature and turbidity are primarily driven by climate, but in general, Suisun Bay and Suisun Marsh tend to support more suitable levels of water temperature and turbidity than the Delta.

2.1.4.3 Habitat

Delta Smelt is primarily considered a pelagic species, and their habitat is generally defined by water quality (Bennett 2005; Feyrer et al. 2007; Nobriga et al. 2008) with some association to bathymetric features (Feryer et al. 2013) and velocities (Bever et al. 2016). Researchers have assumed that Delta Smelt primarily occupy the upper 2 meters of the water column, but recent work shows that juvenile Delta Smelt will occupy the lower bottom half of the water column or move horizontally during ebb tides (Feyrer et al. 2013). After first flush and initial dispersal, adult Delta Smelt appear to hold their position geographically (Polansky et al. 2018).

Multiple field and modeling studies have established the association between elevated turbidity and the occurrence and abundance of Delta Smelt. Sommer and Mejia (2013) and Nobriga et al. (2008) found that late larval and juvenile Delta Smelt are strongly associated with turbid water, a pattern that continues through fall (Feyrer et al. 2007). Long-term declines in turbidity may also be a key reason that juvenile Delta Smelt now rarely occur in the South Delta during summer (Nobriga et al. 2008). Thomson et al. (2010) found that turbidity was a significant predictor of Delta Smelt decline in abundance over time. Grimaldo et al. (2009) found that the occurrence of adult Delta Smelt at the fish salvage facilities was linked, in part, with high turbidity associated with first flush events. Turbidity may also serve as a behavioral cue for small-scale (lateral and vertical movements in the water column) and larger-scale (migratory) Delta Smelt movements (Bennett and Burau 2014).

Upper water temperature limits for juvenile Delta Smelt survival are based on laboratory studies and corroborated by field data. Based on the critical thermal maximum, CT_{max}, juvenile Delta Smelt acclimated to 17 °C could not tolerate temperatures higher than 25.4 °C (Swanson et al. 2000). However, for juvenile Delta Smelt acclimated to 11.9°C, 15.7°C, and 19.7°C, consistently higher CT_{max} values were estimated—27.1°C, 28.2°C, and 28.9°C, respectively (Komoroske et al. 2014), which corresponded closely to the maximum water temperatures recorded in the Summer Townet and Fall Midwater Trawl (FMWT). Swanson et al. (2000) used wild-caught fish, while Komoroske et al. (2014) used hatchery-reared fish, which may have contributed to the differences in results. Based on the Summer Townet Survey (Nobriga et al. 2008) and the 20 mm Survey (Sommer and Mejia 2013), most juvenile Delta Smelt were predicted to occur in field samples when water temperature was below 25°C. In a multivariate autoregressive modeling analysis with 16 independent variables, MacNally et al. (2010) found that high summer (June through September) water temperature had a negative effect on Delta Smelt subadult abundance in the fall. Water temperature was also one of several factors affecting Delta Smelt life stage dynamics in the state-space model of Maunder and Deriso (2011) and in an individual-based Delta Smelt life cycle model (Rose et al. 2013 a, b).

While recent research has resulted in improved understanding of the factors influencing the quantity, toxicity, and location of harmful algal blooms (HABs), there are still many uncertainties about their direct and indirect effects on Delta Smelt relative to other factors and about what can be done to prevent them. Furthermore, and despite their importance to ecosystem and human health, there is still no routine quantitative monitoring program in place that specifically targets harmful algae. The Summer Townet and Fall Midwater Trawl surveys now include qualitative, visual assessment of *Microcystis*, but more quantitative techniques and techniques that detect additional harmful species and their toxicity would likely provide greater insights. Such techniques are increasingly available (e.g., solid phase adsorption tracking; Wood et al. 2011), and some focused studies that quantify and provide distributions of HABs have been conducted or are underway. These studies should be continued in order to address hypotheses related to the effects of HABs in the conceptual model and to evaluate the utility of these techniques for routine monitoring applications.

2.1.4.4 PREY SUPPLY

Changes in phytoplankton production and phytoplankton species abundances observed and the invasion of *P. amurensis* may have had important consequences for consumer species preyed upon by Delta Smelt. For example, there has been a decrease in mean zooplankton size (Winder and Jassby 2011) and a long-term decline in calanoid copepods, including a major step-decline in the abundance of the copepod *E. affinis*. These changes are possibly due to predation by the overbite clam (Kimmerer et al. 1994) or to indirect effects of clam grazing on copepod food supply. Predation by *P. amurensis* may also have been important for other zooplankton species (Kimmerer 2008).

In addition to a long-term decline in calanoid copepods and mysids (Orsi and Mecum 1984) in the upper SFE, there have been numerous copepod species introductions (Winder and Jassby 2011). *P. forbesi*, a calanoid copepod that was first observed in the estuary in the late 1980s, has replaced *E. affinis* as the most common Delta Smelt prey during the summer. It may have a competitive advantage over *E. affinis* due to its more selective feeding ability. Selective feeding may allow *P. forbesi* to utilize the remaining high-quality algae in the system while avoiding increasingly more prevalent low-quality and potentially toxic food items such as *M. aeruginosa* (Mueller-Solger et al. 2006; Ger et al. 2010a). After an initial rapid increase in abundance, *P. forbesi* declined somewhat in abundance from the early 1990s in the Suisun Bay and Suisun Marsh regions, but maintained its abundance, with some variability, in the central and southern Delta (Winder and Jassby 2011).

The abundance of a more recent invader, the cyclopoid copepod *Limnoithona tetraspina*, significantly increased in the Suisun Bay region beginning in the mid-1990s. It is now the most abundant copepod species in the Suisun Bay and confluence region of the estuary (Bouley and Kimmerer 2006, Winder and Jassby 2011). Gould and Kimmerer (2010) found that it grows slowly and has low fecundity. Based on these findings they concluded that the population success of *L. tetraspina* must be due to low mortality and that this small copepod may be able to avoid the visual predation to which larger copepods are more susceptible. It has been hypothesized that *L. tetraspina* is an inferior food for pelagic fishes, including Delta Smelt, because of its small size, generally sedentary behavior, and ability to detect and avoid predators (Bouley and Kimmerer 2006; Gould and Kimmerer 2010). Nevertheless, this copepod has been found in the guts of Delta Smelt when *Limnoithona* spp. occurs at extremely high densities relative to other zooplankton (Slater and Baxter 2014). Recent experimental studies addressing this issue suggest that larval Delta Smelt will consume and grow on *L. tetraspina*, but growth is slower than with *P. forbesi* (Kimmerer et al. 2011). It remains unclear if consuming this small prey is energetically beneficial for Delta Smelt at all sizes or if there is a breakpoint above which larger Delta Smelt receive little benefit from such prey. *Acartiella sinensis*, a calanoid copepod species that invaded at the same time as *L. tetraspina*, also reached considerable densities in Suisun Bay and the western Delta over the last decade (Hennessy 2010), although its suitability as food for Delta Smelt remains unclear.

2.1.4.5 PREDATION AND COMPETITION

Recent modeling efforts show that Delta Smelt declines are negatively associated with metrics assumed to reflect the abundance of predators in the estuary (Maunder and Deriso 2011; Miller et al. 2012). These metrics are composites of the relative abundance of Mississippi Silverside (*Menidia audens*), Largemouth Bass (*Micropterus salmoides*) and other centrarchids; these species are potential predators of concern because of their increasing abundance (Bennett and Moyle 1996; Brown and Michniuk 2007; Thomson et al. 2010) and because of inverse correlations between Largemouth Bass abundance and Delta Smelt abundance (Nobriga and Feyrer 2007; Thomson et al. 2010; Maunder and Deriso 2011). These correlations could represent predation on Delta Smelt by Largemouth Bass or, alternatively, the very different responses of the two species to changing habitat within the Delta (Moyle and Bennett 2008). Largemouth Bass will readily eat Delta Smelt when the opportunity exists (Ferrari et al. 2014). However, there is little evidence that Largemouth Bass are major consumers of Delta Smelt due to low spatial co-occurrence (Nobriga et al. 2005; Baxter et al. 2010). Thus, the inverse correlations between these species may not be mechanistic. Rather, they may reflect adaptation to, and selection for, different environmental conditions.

During the period from 1963 through 1964, Stevens (1966) also evaluated seasonal variation in the diets of juvenile Striped Bass (*Morone saxatilis*) throughout the Delta; only age 2 and age 3 Striped Bass contained more than trace amounts of Delta Smelt. The highest reported predation on Delta Smelt was 8% of the age 2 Striped Bass diet by volume during the summer. Thomas (1967) reported on spatial variation in the Striped Bass diet composition based on collections throughout the San Francisco Estuary and the Sacramento River above tidal influence. Delta Smelt accounted for 8% of the spring diet composition and about 16% of the summer diet composition in the Delta.

Moyle et al. (2016) suggested that Mississippi Silversides currently are the most important predators of Delta Smelt early life stages, as reflected in recent studies of Delta Smelt DNA in the prey consumed by silversides (Baerwald et al. 2012; Schreier et al. 2016). Although Delta Smelt are rare in the stomachs of Striped Bass (Nobriga and Feyrer 2007; Nobriga et al. 2013), new modeling efforts suggest that Striped Bass can limit annual Delta Smelt production (Nobriga in press).

Silversides may also compete with Delta Smelt for prey and may be at an advantage over Delta Smelt because they spawn repeatedly throughout late spring, summer, and fall (Bennett 2005). The closely related smelt species Wakasagi (*Hypomesus nipponensis*) occurs in the Delta and has prompted concern because of its broader environmental tolerance than Delta Smelt (Swanson et al. 2000), which could lead it to outcompete Delta Smelt and hybridize.

2.1.4.6 Climate Change

The anticipated effects of climate change on the SFE and watershed, such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflows from the Delta, and the potential for frequent extreme drought (Knowles and Cayan 2002; Dettinger 2005), indicate challenges to maintaining a sustainable Delta Smelt population (Brown et al. 2013, 2016). A rebound in relative abundance during the very wet and cool conditions during 2011 indicated that Delta Smelt retained some population resilience (IEP 2015). However, since 2012, declines to record low population estimates have been broadly associated with the 2012–2015 drought, and wetter conditions in 2017 and 2018 have not produced a rebound similar to that seen in 2011.

Central California's warm summers are already a source of energetic stress for Delta Smelt and warm springs already compress the duration of their spawning season (Rose et al. 2013; Moyle et al. 2016). Central California's climate is anticipated to get warmer (Cayan et al. 2009). Warmer estuary temperatures present a significant conservation challenge for Delta Smelt (Brown et al. 2013, 2016). Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern et al. 2011). Warmer water temperatures could further reduce Delta Smelt spawning opportunities, decrease juvenile growth during the warmest months, and increase mortality via several food web pathways, including increased vulnerability to predators, increased vulnerability to toxins, and decreased capacity for Delta Smelt to successfully compete in an estuary that is energetically more optimal for warm water-tolerant fishes (Swanson et al. 2000).

2.2 LONGFIN SMELT

2.2.1 Legal Status

In December 2007, CDFG completed a preliminary review of the Longfin Smelt petition (California Department of Fish and Game 2007) and concluded that there was sufficient information to warrant further consideration by the California Fish and Game Commission. On February 7, 2008, the California Fish and Game Commission designated the Longfin Smelt as a candidate for potential listing under the CESA. On June 26, 2009, the California Fish and Game Commission ruled to list the status of Longfin Smelt as threatened under the CESA.

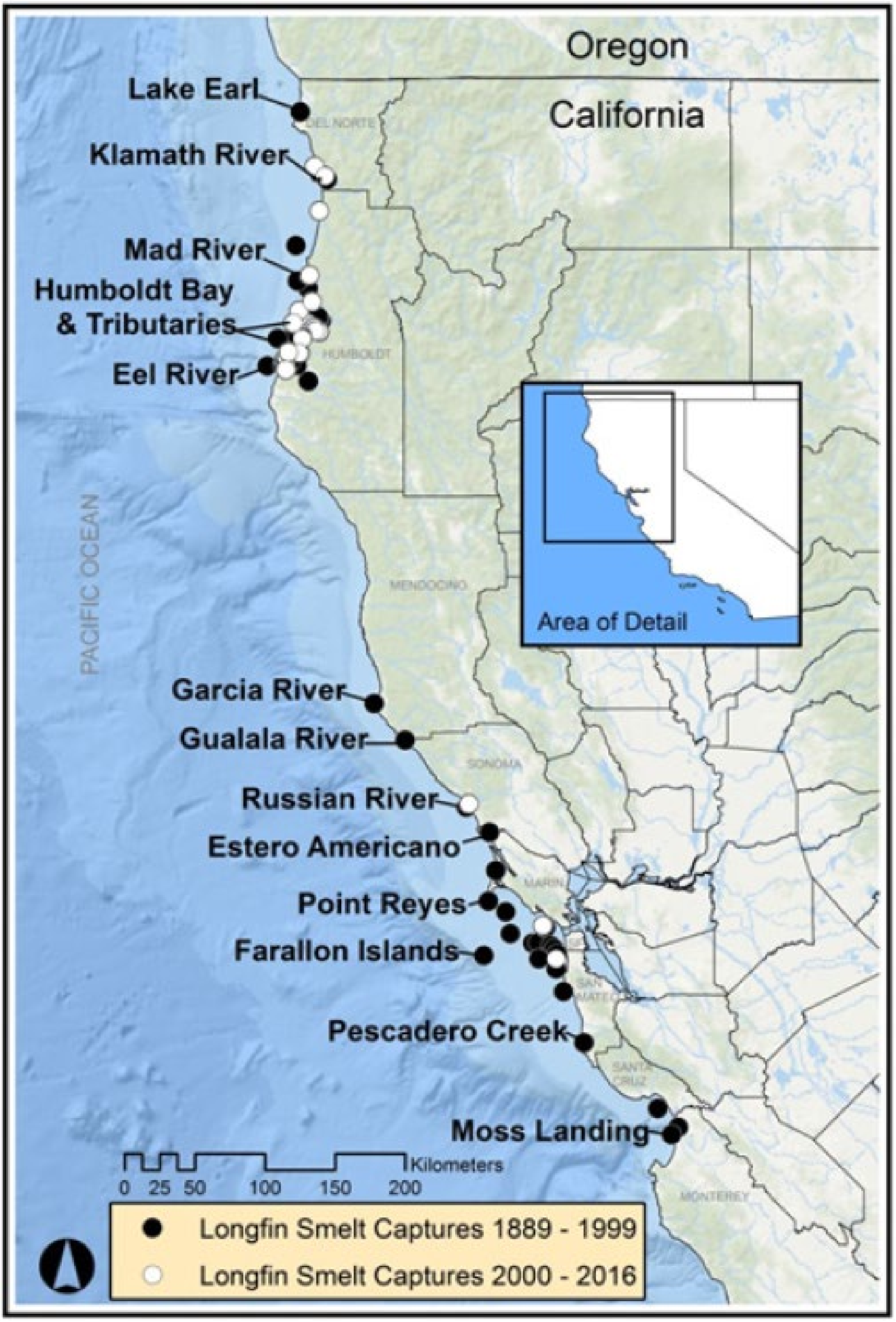
2.2.2 Life History and Ecology

Longfin Smelt is a small, euryhaline, anadromous, and semelparous fish with a life cycle of approximately 2-3 years (Rosenfield 2010). Longfin Smelt reach 90 to 110 millimeters (mm) standard length (SL), with a maximum size of 120 to 150 mm SL standard length (Moyle 2002; Rosenfield and Baxter 2007). Longfin Smelt belongs to the true smelt family Osmeridae and is one of three species in the *Spirinchus* genus; the Night Smelt (*Spirinchus starksi*) also occurs in California, and the Shishamo (*Spirinchus lanceolatus*) occurs in northern Japan (McAllister 1963:10 and 15). Delta Smelt and Longfin Smelt hybrids have been observed in the Bay-Delta estuary, although these offspring are not thought to be viable because Delta Smelt and Longfin Smelt are not closely related taxonomically or genetically (Fisch et al. 2013). Longfin Smelt occur from tidal freshwater, through the estuary's LSZ (where brackish and fresh waters meet), seaward and into the coastal ocean. Longfin Smelt can be distinguished from other California smelt by their long pectoral fins which reach or nearly reach the bases of the pelvic fins), their incomplete lateral line, weak or absent striations on the opercular bones, low number of scales in the lateral series, and long maxillary bones (which in adults extend just short of the posterior margin of the eye (Moyle 2002). Populations of Longfin Smelt occur along the Pacific Coast of North America, from Hinchinbrook Island, Prince William Sound, Alaska to the SFE (Lee et al. 1980).

Longfin Smelt are periodically caught in the nearshore ocean, suggesting that some individuals migrate out into the Gulf of Farallones to feed and then back into the estuary (Rosenfield and Baxter 2007). Although individual Longfin Smelt have been caught in Monterey Bay (Moyle 2002), there is no evidence of a spawning population south of the Golden Gate Bridge. Longfin Smelt have been documented in Humboldt Bay, the Eel River estuary, the Klamath River estuary, the Russian River, and in smaller river estuaries from the central and northern coast of California, including Pescadero Creek, the Garcia River, the Gualala River, and the Mad River (Figure 2-2) (Moyle 2002; Pinnix et al. 2004; Garwood 2017). It is not known what portion of ocean-bound fish return to San Francisco Bay each year or if they return to other coastal streams north and south of San Francisco Bay (Rosenfield and Baxter 2007; Nobrgia and Rosenfield 2016).

The Bay-Delta population of Longfin Smelt occurs throughout the San Francisco Bay and the Delta, and in coastal waters west of the Golden Gate Bridge. Within the SFE, they have been observed north as far as the town of Colusa on the Sacramento River, east as far as Lathrop on the San Joaquin River, and south as far as Alviso and Coyote sloughs in the South San Francisco Bay (Merz et al. 2013; Hobbs et al. 2015a).

In Lake Washington, Longfin Smelt spawn over sandy substrate, but spawning substrates are unknown in the SFE. Longfin Smelt eggs are adhesive and demersal (Moyle 2002). Evidence from Grimaldo et al. (2017) suggests spawning habitats include open shallow water and tidal marshes. Longfin Smelt produce between 1,900 and 18,000 eggs, with greater fecundity in fish with greater lengths (CDFG 2009). Incubation times for egg development range between 25 to 42 days (Rosenfield 2010). Evidence for individuals spawning multiple times in a season has not been investigated, but given that Longfin Smelt have such a broad spawning window (5-6 months), some females may undergo repeated spawning events. Newly hatched larvae have been observed in salinities up to 12 practical salinity units (psu) with peak observations occurring between 2-4 psu (Grimaldo et al. 2017). Early juvenile Longfin Smelt (20-40 mm SL) are found in salinities up to 30 psu, but most are found in salinities between 2 to 18 psu (Mac Williams et al. 2016). By late summer, late juveniles can tolerate full seawater.



Source: Garwood 2017

Figure 2-2. Locations of Longfin Smelt Captures, 1889–2016, Excluding the San Francisco Bay-Delta

Longfin Smelt are anadromous and semelparous, moving from saline to brackish or freshwater for spawning from November to May (Grimaldo et al 2017; Lewis et al 2019). Longfin Smelt usually live for 2 years, spawn, and then die, although some individuals may spawn as 1-year-old or 3-year-old fish before dying (Rosenfield 2010). Age 2 adults generally migrate upstream to spawning areas during the late fall and early winter (Rosenfield and Baxter 2007). Spawning occurs at temperatures that range from 5.0°C to 15.0°C (Grimaldo et al. 2017). Peak spawning takes place in January and February of most years, when water temperatures are between 5°C and 11°C. Special studies and CDFW Smelt Larval Survey (SLS) data show that spawning appears to be centered in brackish water (2 to 4 psu and 0-12 psu range; Grimaldo et al. 2017). Hobbs et al. (2010) provides evidence that larvae that recruit to later life stages are those that reared in salinities around 2 ppt.

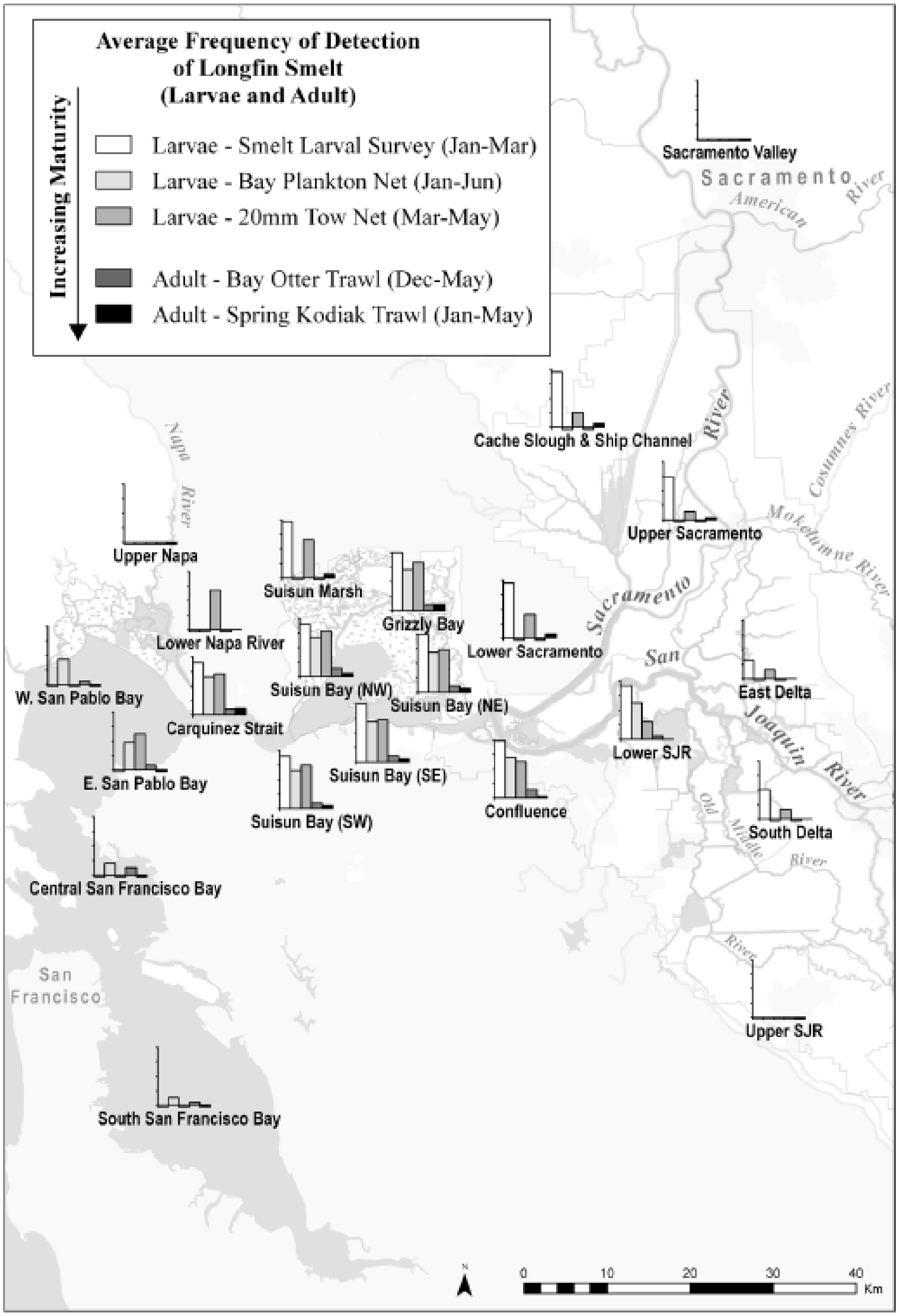
Newly hatched Longfin Smelt larvae appear to be surface-oriented and probably have little ability to control their position in the water column before they develop their air bladder (Bennett et al. 2002). Once their air bladder is developed (~12 mm SL), they can control their position in the water column by undergoing reverse diel vertical migrations or tidal vertical migration, depending on flow conditions (Bennett et al. 2002). Bennett et al. (2002) believed that the ability of Longfin Smelt to undergo tidal vertical migrations allows them to maintain their position on the axis of the estuary. During the first few months of their lives (approximately January through May), Longfin Smelt primarily prey on calanoid copepods such as *Pseudodiatomus forbesi* and *Eurytemora affinis*, before switching to mysids as soon as they are large enough to feed on them (Slater 2008; Baxter et al. 2010).

2.2.3 Distribution and Abundance

During late summer and early fall, juvenile and adult Longfin Smelt are more common throughout San Francisco Bay than in other areas (Rosenfield and Baxter 2007; Mac Williams et al. 2016). During the spawning period in late fall and early winter, adults are more commonly found in San Francisco Bay tributaries and marshes (Lewis et al. 2019; Grimaldo et al. submitted manuscript), Suisun Bay, and the Delta (Rosenfield and Baxter 2007). Larval Longfin Smelt are broadly distributed throughout San Francisco Bay and its associated tributaries during wet years Mac Williams et al. 2016; Lewis et al. 2019; Parker et al. 2017; Grimaldo et al. submitted in manuscript). Merz et al. (2013) found that larvae were more frequently detected in the Delta in drier years than in wet years (Figure 2-3), but overall, more than 50 % of the measured larval abundance in any given year occurred in Suisun Bay and Suisun Marsh (Grimaldo et al. 2017). Some juveniles (and adults Longfin Smelt) are believed to move to the coastal ocean during the summer and fall (Rosenfield and Baxter 2007; MacWilliams et al. 2016).

The Longfin Smelt population has experienced an approximate thirty-fold reduction in abundance since the early 1980’s (Figure 2-4; Rosenfield and Baxter 2007; Sommer et al. 2007; Kimmerer et al. 2009). The rate of decline has been particularly steep, especially since the onset of the POD (Sommer et al. 2007; Thomson et al. 2010). Although the population has declined, the slope of the relationship between winter-spring flow and fall Longfin Smelt abundance remains unchanged. The intercept of this relationship has dropped nearly two-fold, suggesting that flow or hydrological conditions are strong drivers of their population abundance (Kimmerer et al. 2009; Maunder et al. 2015; Nobriga and Rosenfield 2016).

Threats that may be directly or indirectly affected by the Proposed Project are described in the subsections below.



Note: To calculate the annual frequency of Longfin Smelt detection in a region, the percentage of sampling events where Longfin Smelt were observed is divided by the total number of sampling events for the region. In this graphic, where no column/bar is shown in the bar graph for a region, the average annual frequency of detection for the given Longfin Smelt life stage(s) was zero.
Source: Merz et al. 2013

Figure 2-3. Average Annual Frequency of Longfin Smelt Detection (%) for Larvae and Adult Life Stages by Region and Interagency Ecological Program Survey Type

Source: CDFW 2019

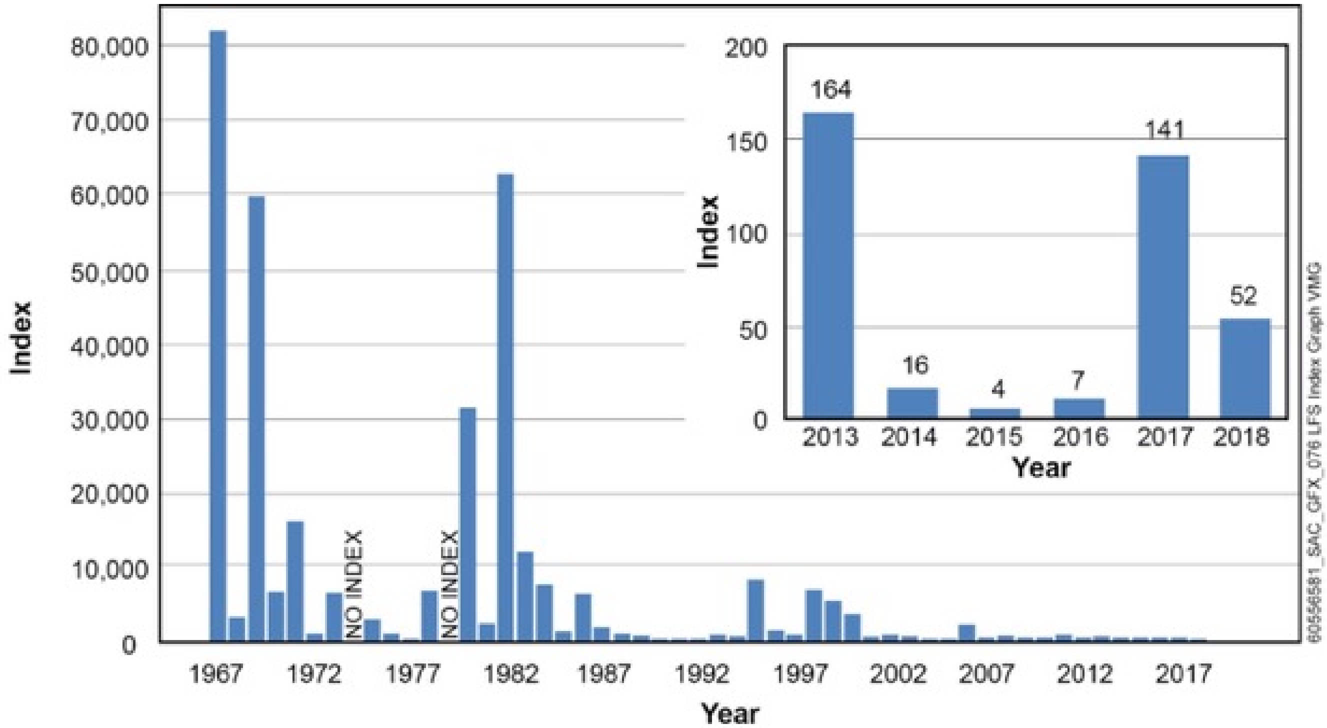
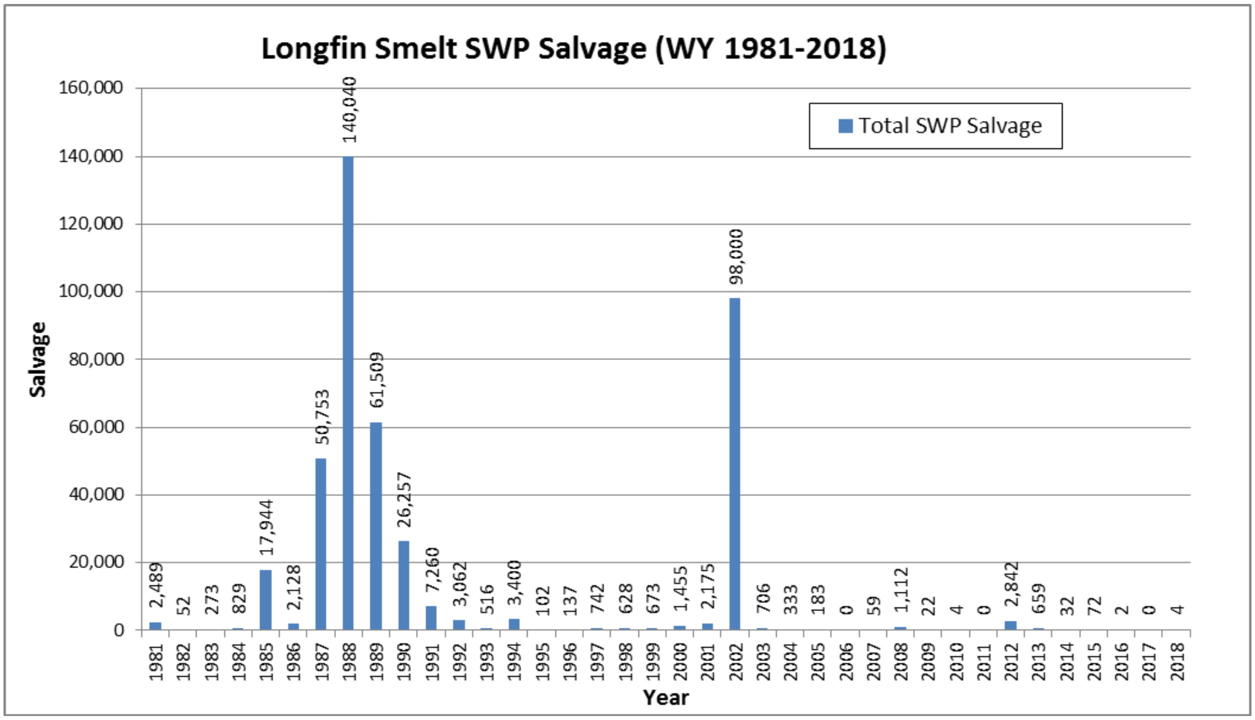


Figure 2-4. Longfin Smelt Fall Midwater Trawl Abundance Indices (All Ages), 1967–2018

2.2.3.1 ENTRAINMENT

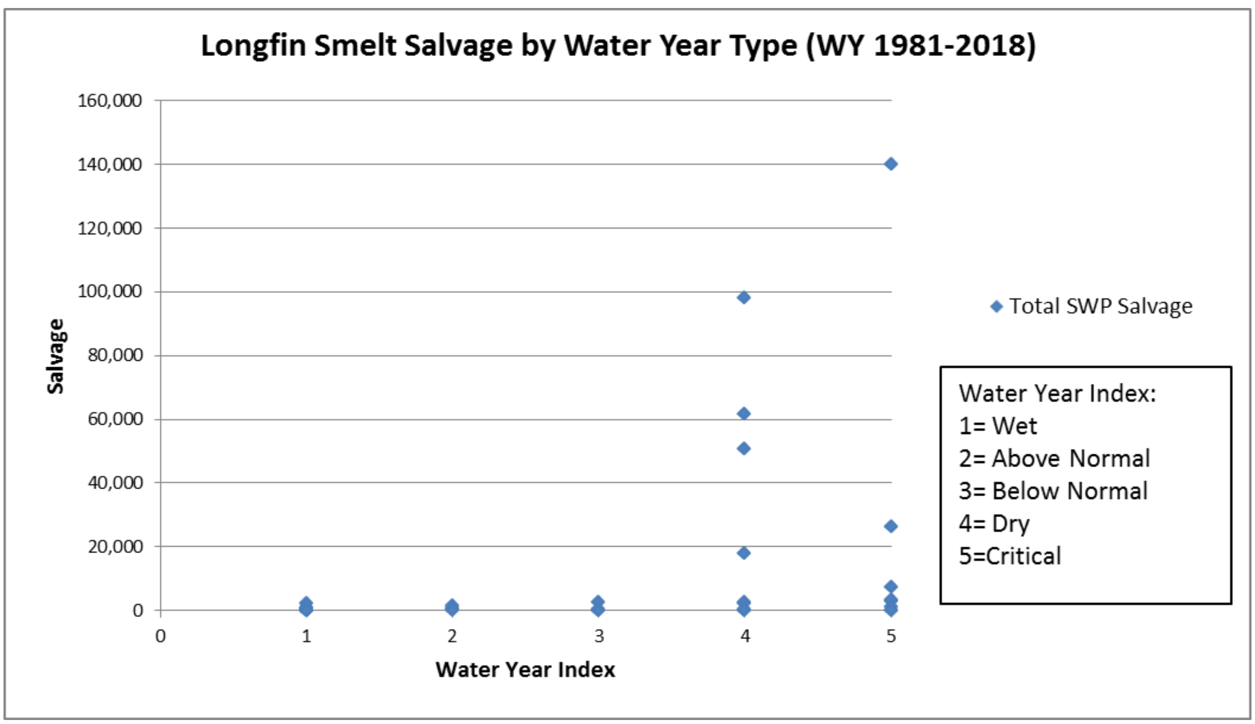
All life stages of Longfin Smelt are vulnerable to entrainment. However, overall Longfin Smelt salvage has been generally low since the 1980s, except for the year 2002 (Figure 2-5), especially since the 2009 USFWS and NMFS Biological Opinions have been in effect (Figure 2-6). In general, Longfin Smelt entrainment risk increases with reverse OMR flow (Grimaldo et al. 2009), and salvage can be higher in drier years compared to wetter years (Figure 2-6), probably as a result of the landward shift in their distribution in drier years.

Larval Longfin Smelt could be entrained in relatively high numbers; however, because the SWP salvage facilities do not sample fish smaller than 20 mm SL, it is difficult to ascertain how many larvae are entrained (CDFG 2009). Larval entrainment at the SWP is likely higher during drier periods compared to wetter periods, but overall larval entrainment risk is likely low because most Longfin Smelt hatch downstream of the Delta (Grimaldo et al. 2017). Overall, the effect of entrainment on the Longfin Smelt population has not been found to be important (Maunder et al. 2015), perhaps because such a small fraction of the population is entrained on an annual basis (see Section 4, "Analysis of Take and Effects"). Figure 2-7 shows the distribution of larval and juvenile Longfin Smelt salinity tolerance in dry, moderate, and wet water years.



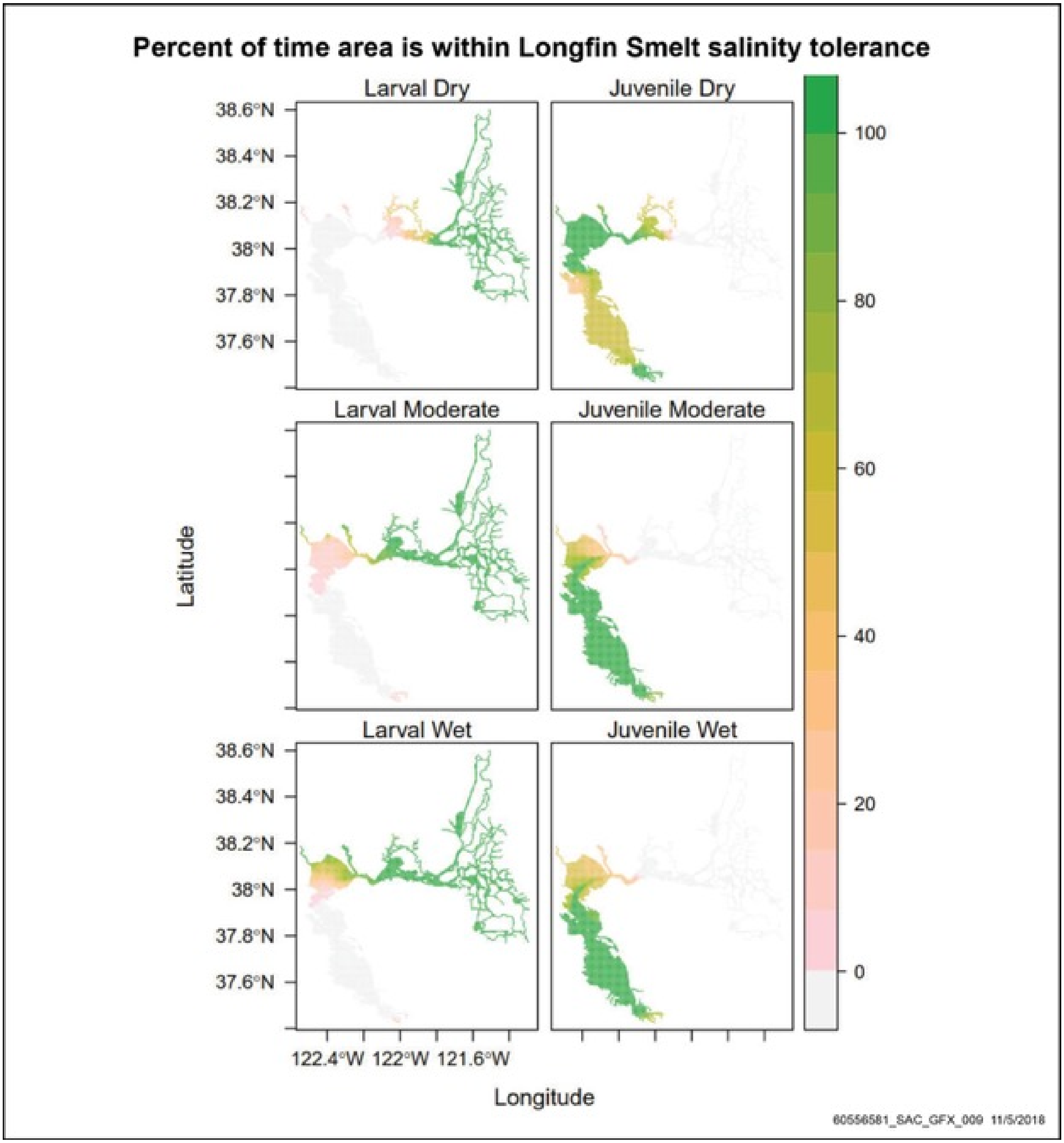
Source: Data compiled by AECOM in 2018

Figure 2-5. Salvage at the State Water Project John E. Skinner Delta Fish Protective Facility, 1981–2018



Source: Data compiled by AECOM in 2018

Figure 2-6. Salvage at the State Water Project John E. Skinner Delta Fish Protective Facility by Water Year Type, 1981–2018



Note: The larval maps span January 1–March 31 and the juvenile maps span April 1–August 31. Salinities are within the tolerable range for Longfin Smelt based on 10th- and 90th-percentile salinities for catches in the Smelt Larval Survey (Larval) and the Bay Study (Juvenile). The three water years are 2014 (Dry), 2011 (Moderate), and 2006 (Wet). The color scale is the percentage of days in the evaluated range that met the salinity tolerance criteria (green = 100%; white = 0% days in salinity tolerance range). Data used to develop this figure is provided in Appendix A.

Source: Metropolitan Water District 2018

Figure 2-7. Distribution of Larval and Juvenile Longfin Smelt Salinity Tolerance in Dry, Moderate, and Wet Water Years

2.2.3.2 Flow

As previously described, Longfin Smelt abundance increases with Delta outflow and low spring X2 (Jassby et al. 1995; Kimmerer 2002b; Kimmerer et al. 2009; Baxter et al. 2010; Mac Nally et al. 2010; Thomson et al. 2010; Mount et al. 2013; Nobriga and Rosenfield 2016) or by general indicators of hydrological conditions (e.g., watershed runoff; Maunder et al. 2015). Numerous mechanisms have been proposed for this relationship, including lower entrainment losses, advection to suitable habitat, reduced predation due to elevated turbidity, increased retention in favorable habitats, and access to marsh habitats that are unsuitable during drier periods.

The effect of entrainment appears to be unimportant (Maunder et al. 2011) or at least has diminished in recent decades, since Longfin Smelt proportional losses are very low (see Section 4, “Analysis of Take and Effects”). Vertical retention via estuarine circulation is still hypothesized as an important mechanism that retains age 0 Longfin Smelt in high-quality habitats during higher flows (Kimmerer et al. 2009), but horizontal retention in large, shallow bays is now hypothesized to be an important feature that enhances Longfin Smelt survival and abundance during higher flows based on new data that targeted larval and juvenile Longfin Smelt in shallow and marsh habitats (Grimaldo et al. submitted manuscript).

Kimmerer et al. (2009) concluded that habitat volume, as defined by salinity and water clarity, may be partly responsible for the Longfin Smelt abundance relationship with Delta outflow (X2), but that other mechanisms such as outflow-driven retention, are more important. With respect to habitat availability, although freshwater flow affects dynamic habitat availability, recent investigations by Grimaldo et al. (2017) of stationary habitat found that larval Longfin Smelt were relatively abundant in tidal marsh and shallow open waters of the LSZ. This work suggests that stationary shallow habitat also provides key rearing habitat for larval Longfin Smelt, a situation that increased when San Pablo Bay and the South San Francisco Bay became fresh to low salinity habitat during wet years.

2.2.3.3 Habitat

Adult Longfin Smelt use tidal marshes for spawning (Lewis et al. 2019). Larval Longfin Smelt use marsh and shoal habitats as rearing habitat (Grimaldo et al. 2017; Grimaldo et al. submitted manuscript). Juvenile Longfin Smelt are mostly found in deeper channels, often exhibiting diel movements, presumably to reduce predation risk.

It is important to note that the salinity distribution in the SFE is not solely dependent on Delta outflow. For example, MacWilliams et al. (2016) showed that salinity in San Francisco Bay was influenced by tributaries as well (e.g., in south San Francisco Bay). Figure 2-7 shows the availability of habitat for larval and juvenile Longfin Smelt based on Longfin Smelt salinity tolerance in dry, moderate, and wet water years. Habitat suitability is represented by the percentage of time when a specific location is within the salinity range where 80% of larval and juvenile Longfin Smelt were observed in the Smelt SLS and Bay Study surveys, respectively.

Turbidity levels have declined in the Delta (Cloern et al. 2011). Although Delta Smelt has often been the focus for potential effects of turbidity reduction, some of the same mechanisms could be important for Longfin Smelt. For example, young juvenile Longfin Smelt distribution in spring is negatively associated with water clarity (Kimmerer et al. 2009) and trends in abundance are also negatively associated with water clarity in fall (Thomson et al. 2010), which to some extent could reflect changes in catchability during surveys (fish are better able to avoid trawls when water is clearer; Latour 2016).

2.2.3.4 PREY AVAILABILITY

Longfin Smelt have experienced a significant decline in food resources in recent decades (Sommer 2007). A decrease in foraging efficiency and/or the availability of suitable prey for various life stages of Longfin Smelt may result in reduced growth, survival, and reproductive success. This may contribute to an observed lower population abundance and a downward shift in the flow-abundance relationship, particularly after the introduction of the invasive clam *P. amurensis* (Feyrer et al. 2003; Nobriga and Rosenfield 2016). Other factors affecting food resources are ammonium, which was found to be negatively associated with Longfin Smelt abundance in the population dynamics model of Maunder et al. (2015).

2.2.3.5 PREDATION AND COMPETITION

The effect of non-native predators, such as Mississippi Silversides and Striped Bass, has been identified as a potential threat to Longfin Smelt populations (Sommer 2007; Rosenfield 2010), with potentially large predation losses even if the predation rate is low (CDFG 2009). A composite index of predatory fish density in Central Bay and San Pablo Bay was found to be negatively associated with trends in Longfin Smelt abundance in population dynamics modeling by Maunder et al. (2015). Competition also occurs with species such as age 0 Striped Bass or American Shad (*Alosa sapidissima*; Feyrer et al. 2003), although the effect of competition on the Longfin Smelt population is unknown.

2.2.4 CLIMATE CHANGE

Water temperature tends to limit the upstream distribution of Longfin Smelt in the warmer months (Baxter et al. 2010) and spring (April–June) water temperature is negatively associated with survival (Maunder et al. 2015). Climate change could result in detrimental effects on Longfin Smelt ecology related to factors such as maturation and spawning season length and timing, as well as reduction in habitat extent.

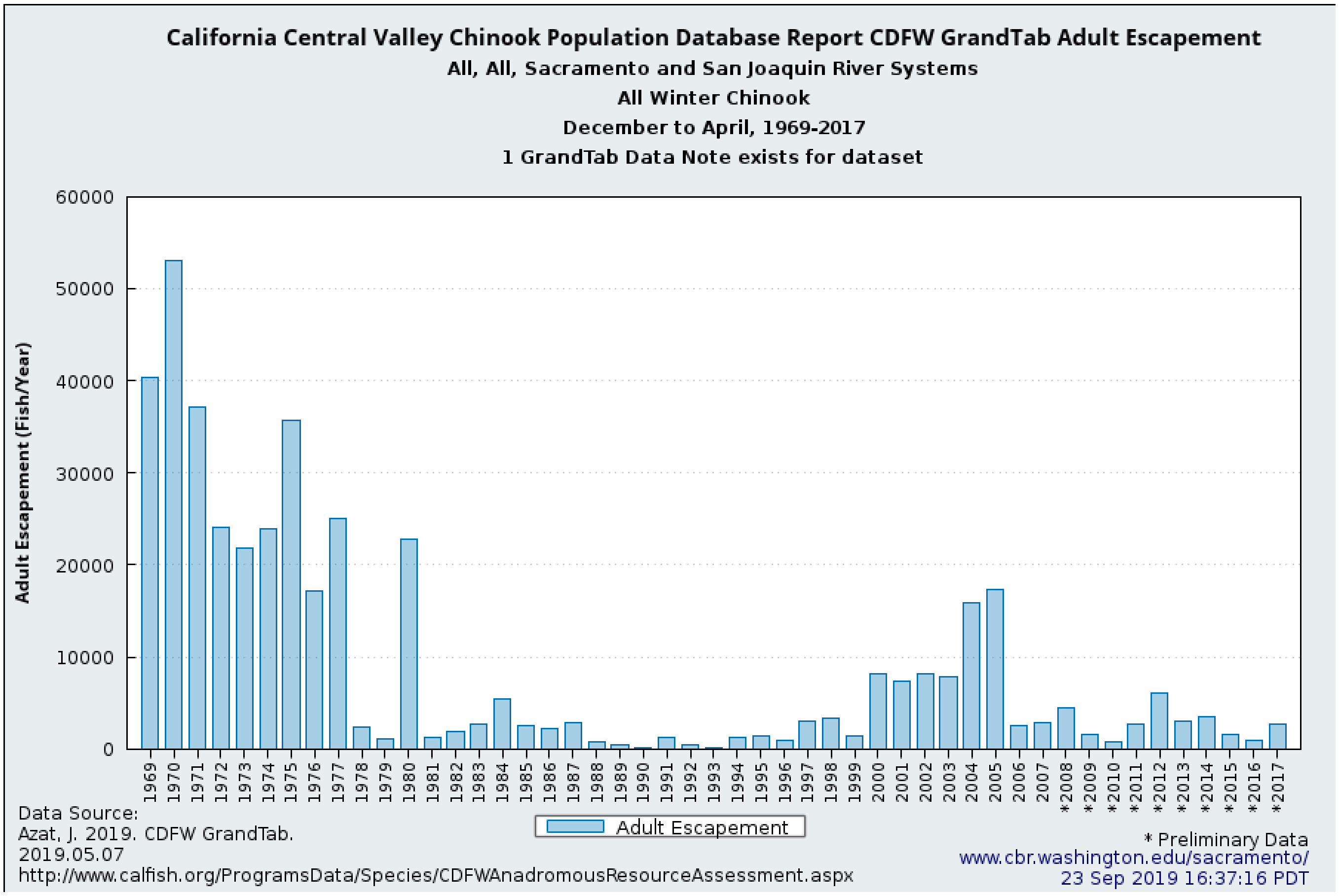
2.3 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

2.3.1 LEGAL STATUS

On May 16, 1989, the California Fish and Game Commission listed the Sacramento River Winter-run Chinook Salmon Evolutionarily Significant Unit (ESU) as endangered under the CESA due to persistent long-term declines (Figure 2-8).

2.3.2 DISTRIBUTION AND ABUNDANCE

Relative distribution, abundance, and migration timing in the Delta is inferred from salvage monitoring data, the USFWS Delta Juvenile Fish Monitoring Program, the Enhanced Delta Smelt Monitoring program, Sherwood and Mossdale trawls, and the Chipps Island Trawl. Juvenile mortality in the Delta from predation by piscivorous non-native fishes and conditions that increase risk of mortality have been at the forefront of special studies (Demetras et al. 2016; Zeug et al. submitted manuscript). Special studies are also underway to describe rearing in Delta bays and marshes and identify variation in quality of rearing habitat (Harvey, personal communication).

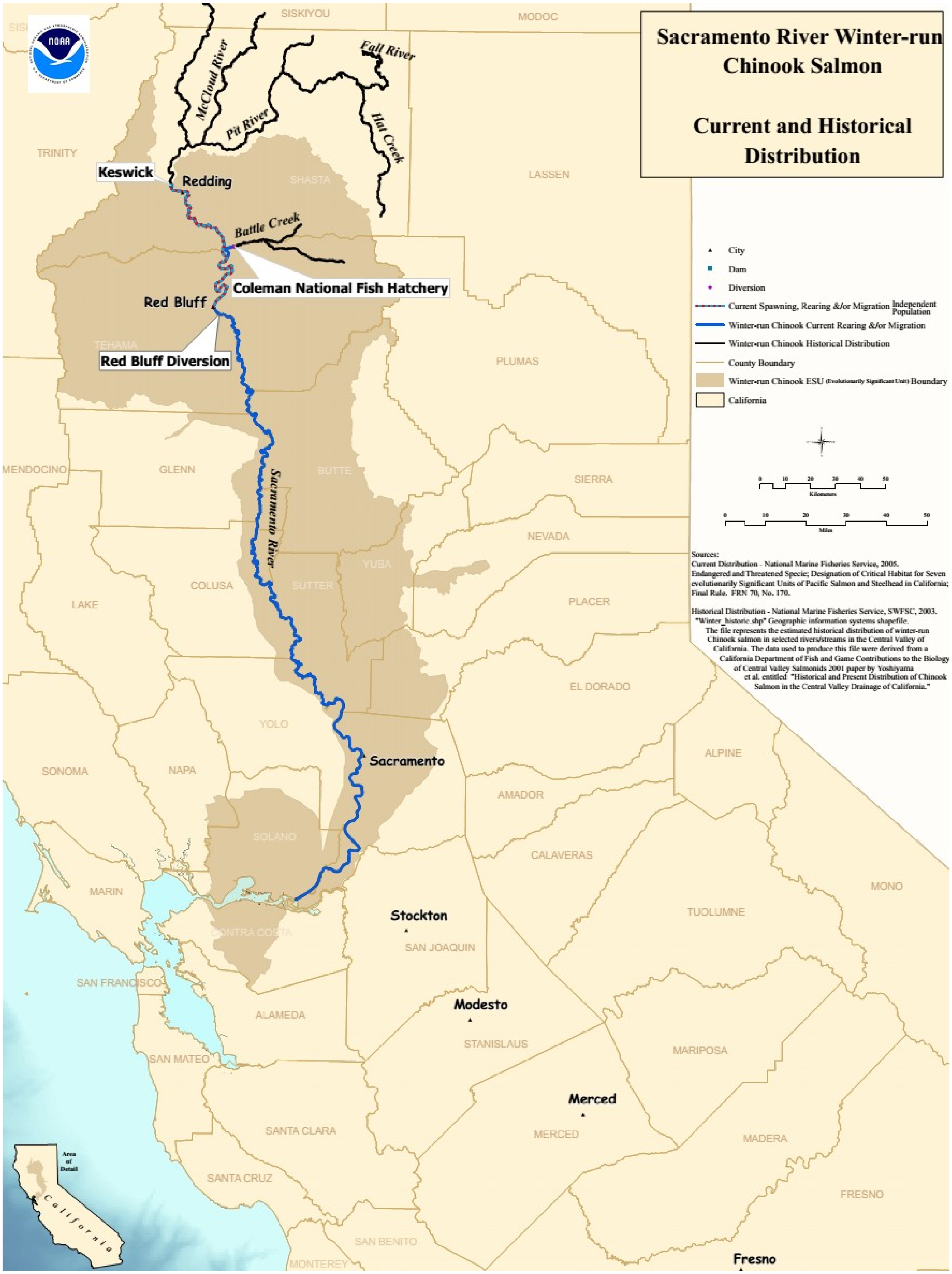


Source: CDFW GrandTab
Asterisks denote preliminary data

Figure 2-8. Winter-run Escapement (1969–2017)

Adult Sacramento River Winter-run Chinook Salmon enter the San Francisco Bay in November to begin their spawning migration and continue upstream from December through early August to the extent of anadromy at the base of Keswick Dam (Figure 2-10). Winter-run Chinook Salmon spawn in the upper mainstem Sacramento River from mid-April through August, peaking in June and July. All known Winter-run Chinook Salmon production currently occurs either in the mainstem Sacramento River or Livingston National Fish Hatchery (LSNFH; 2004).

In addition to the Sacramento River, juveniles have also been found to rear in areas such as the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). Phillis et al. (2018) found with isotope data that 44% to 65% of surviving adults reared in non-natal habitats as juveniles. The lower reaches of the Sacramento River, the Delta, and San Francisco Bay serve as migration corridors for both smolts and adults and are thought to serve as juvenile rearing habitat.



Source: NOAA 2014

Figure 2-10. Winter-run Chinook Salmon Current and Historic Distribution

Until recent years, salmon passage was not possible above the Coleman Hatchery barrier weir located on Battle Creek. No Winter-run Chinook Salmon spawning has been observed in Battle Creek, but the fish were detected above the weir in 2006 (a high flow year).

2.3.3 Life History and Ecology

Adults return from the ocean prior to reaching full sexual maturity and hold in the Sacramento River for several months before spawning. Current spawning is confined to the mainstem of the Sacramento River above Red Bluff Diversion Dam (RBDD; RM 243) and below Keswick Dam (RM 302) (NMFS 2014).

Juvenile Winter-run Chinook Salmon begin to enter the Delta in October and smolt outmigration continues until April. Timing of smolt movement is thought to be strongly correlated with winter rain events that result in pulse flows in the Sacramento River (del Rosario et al. 2013). Although the Delta was historically used for rearing, it appears that Winter-run Chinook Salmon now use the Delta primarily as a migration corridor to Suisun Bay and Marsh (Hassrick, pers. comm).

The project area represents a portion of the habitat Winter-run Chinook Salmon need to migrate through to adult spawning grounds or to sea as outmigrating smolts. Fry and smolts are known to use the SFE as rearing habitat before entering the ocean (Sturrock et al. 2015). In addition to monitoring salvage of Winter-run Chinook Salmon at the Tracey and Skinner fish collection facilities in the South Delta, temporal occurrence of each life stage in the project area is monitored using screw trapping data in the rivers, trawls and beach seines in the estuary and, more recently, acoustic tagging using a network of receivers located throughout the extent of their range, from Keswick Dam to the Golden Gate Bridge (Perry et al. 2019).

2.3.4 Species Threats

2.3.4.1 Habitat

Construction of Keswick and Shasta dam for agricultural, municipal, and industrial water supply eliminated access to approximately 200 river miles of historical holding and spawning grounds above Keswick Dam, (Yoshiyama et al. 1996). Rearing habitat quantity and quality has been reduced in the upper mainstem Sacramento River as a result of channel modification and levee construction (Lindley et al. 2009). Without access to historic coldwater spawning tributaries above Shasta Dam, persistence of the Winter-run Chinook Salmon ESU is dependent on maintaining adequate coldwater pool in Shasta Reservoir in order to maintain suitable temperatures for Winter-run Chinook Salmon egg incubation, fry emergence, and juvenile rearing in critically dry years and extended droughts. Warm water releases during 2014 and 2015 contributed to 5.9% and 4.2% egg-to-fry survival rates to RBDD, respectively. As part of a coordinated drought response, measures taken to preserve Shasta Reservoir's coldwater pool included relaxing Wilkins Slough navigational flow requirements, relaxing D-1641 Delta water quality requirements, and delaying Settlement Contractor depletions into the fall.

Much of the historical floodplain habitat has been developed or converted, which has decreased shallow water habitat with high residence time needed for food production (Jeffries et al. 2008; Katz et al. 2017; Ahearn et al. 2006). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid to high water years, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Restoration Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (DWR and Reclamation 2012). Shoreline armoring and development have reduced access to floodplain rearing habitat for rearing juveniles in the Sacramento River and Delta (Boughton and Pike 2013).

2.3.4.2 ENTRAINMENT

Juvenile migration corridors are impacted by reverse OMR flows that are exacerbated by south Delta export facility operations at the CVP and SWP pumping plants. Bi-directional flow at Georgiana Slough causes juveniles into the interior Delta, which results in greater travel times and lower survival (Perry et al. 2013, 2018). Other potential impacts resulting from entrainment include loss at the South Delta export facilities, diseases that are exacerbated by high water temperatures in the interior Delta, and predation from non-native species.

2.3.4.3 FLOW

Results of studies show that route selection is generally proportional to the flow split at channel junctions (Perry et al. 2018). Fish that route the South Delta experience low through-Delta survival (Perry et al. 2010; Buchanan et al 2018). Reduced Sacramento River outflow shifts the zone of tidal influence upstream to the vicinity of the Georgiana Slough junction, causing an increase in the proportion of flow down Georgiana Slough and into the South Delta. By this mechanism, water project operations that reduce Sacramento River outflow result in reduced survival rates for migrating juveniles (Perry et. al 2018). Similarly, water project operations that increase flow splits off migration routes in the South Delta toward export facilities which has the potential to reduce survival rates for migrating juvenile salmon (Salmonid Scoping Team 2017; Perry et al. 2018).

Factors currently limiting abundance include altered flow regime, which has led to changed water temperatures, reduced gravel mobilization, reduced riparian recruitment, deteriorated habitat quality, entrainment in water diversions, predation pressure on juveniles, and loss of riparian and floodplain habitat. New temperature modeling shows higher sensitivity to increases in water temperature because it leads to exponential increases in oxygen demand with a rise in temperature during the final weeks of egg-embryo maturation before the alevin stage (Martin et al. 2016; Anderson 2018).

2.3.4.4 HATCHERY INFLUENCE

Hatchery fish production generally has deleterious genetic impacts on natural in-river populations due to hatchery fish spawning with naturally produced fish (Sturrock et al. 2019). These impacts include smaller size at spawning, poor predator avoidance by offspring, and generally reduced overall fitness (Matala et al. 2012). LSNFH, which is a dedicated conservation fish hatchery for Sacramento River Winter-run Chinook Salmon, uses wild broodstock trapped at the base of Keswick Dam and genetic techniques to maximize genetic diversity. However, during recent years, when hatchery production was scaled up and natural production faltered, hatchery fish made up the vast majority of Winter-run Chinook Salmon that spawned both in the river and at LSNFH. The Winter-run Chinook Salmon conservation program at LSNFH is controlled by the USFWS to reduce competition for resources by holding releases after the in-river production of juveniles has migrated downstream. The average annual hatchery production at LSNFH is approximately 176,348 Winter-run Chinook Salmon per year compared to the estimated natural production that passes the Red Bluff Diversion Dam, which is approximately 878,000 per year based on the 2012 to 2018 average (Voss and Poytress 2018), or 4.7 million per year based on the 2002 to 2010 average (Poytress and Carrillo 2011). Therefore, hatchery production can be up to approximately 20% of the total in-river juvenile production in any given year. However, during the prolonged drought in 2015 and 2016, hatchery production was enhanced to triple the normal release size out of concern that loss of coldwater pool would eliminate the contribution from in-river spawners. This effort to prevent losing an entire year class may have resulted in elevated competition for resources between any natural production that survived and the enhanced hatchery production.

2.3.4.5 Climate Change

Climate experts predict physical changes to ocean, river and stream environments along the West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated changes in water temperature, hydrology, and ocean conditions are generally expected to have substantial effects on Chinook Salmon populations in the future (NMFS 2014; Lindley et al. 2009). Because the only remaining population of Winter-run Chinook Salmon relies on a cold-water pool in Shasta Reservoir to maintain spawning conditions in the mainstem Sacramento River, this run is particularly at risk from global warming. Drought years are predicted to occur with greater frequency in the Sacramento Valley with climate change (Purkey et al. 2008). Increased water temperature associated with lower flows favors non-native competitors and predators that are adapted to warm water because predation rates increase in response to elevated metabolic rates of predators (Petersen et al. 2001). Increasing the frequency of dry years also reduces turbidity because sediment loads are not mobilized and transported downstream. Juvenile salmon are thought to use turbid water to avoid detection by predators (Gregory et al. 1998). Increased prevalence of submerged aquatic vegetation in the Delta reduces water flow and therefore also reduces turbidity, which has the effect of creating cover for predators and making passing salmon easier for predators to detect (Hestir et al. 2016). Finally, climate change is projected to increase the variability of ocean conditions, such as the North Pacific Gyre Oscillation, the Pacific Decadal Oscillation, and El Nino Southern Oscillations (Di Lorenzo et al. 2010). Anomalies, such as the warm water blob in the North Pacific, disrupt upwelling processes, which drive plankton production in the California Current (Leising et al. 2015). Juvenile salmon distribution is associated with oceanic plankton distribution, and mismatches in space and time that reduce access marine prey aggregations are thought to influence early marine survival of Central Valley salmon populations (Hassrick et al. 2016).

2.4 CENTRAL VALLEY SPRING-RUN CHINOOK SALMON ESU

2.4.1 Legal Status

Spring-run Chinook Salmon, which were historically the most abundant run in the Central Valley, are now remnant in Butte, Mill, Deer, Antelope and Beegum creeks, which are all tributaries of the Sacramento River. Spring-run Chinook Salmon were extirpated from most rivers by mining or dam construction (Williams 2006). Due to the small number of these populations remaining and the significant hybridization with Fall-run Chinook Salmon that has occurred in the mainstem of the Sacramento (Moffett 1949) and Feather rivers (Lindley et al. 2004), Spring-run Chinook Salmon were listed as threatened under CESA in 1999. Native Spring-run Chinook Salmon have been extirpated from the San Joaquin River watershed, which represented a large portion of their historic range.

2.4.2 Life History and Ecology

Life history and habitat requirements are the same as those described for Winter-run Chinook Salmon, with differences primarily in the duration and time of year that the Spring-run Chinook Salmon ESU occupies habitat. Adult Spring-run Chinook Salmon enter freshwater as sexually immature fish between mid-February and July and remain in deep cold pools in proximity to spawning areas until late summer and early fall when they are sexually mature and ready to spawn, depending on water temperatures (CDFG 1998; NMFS 2009).

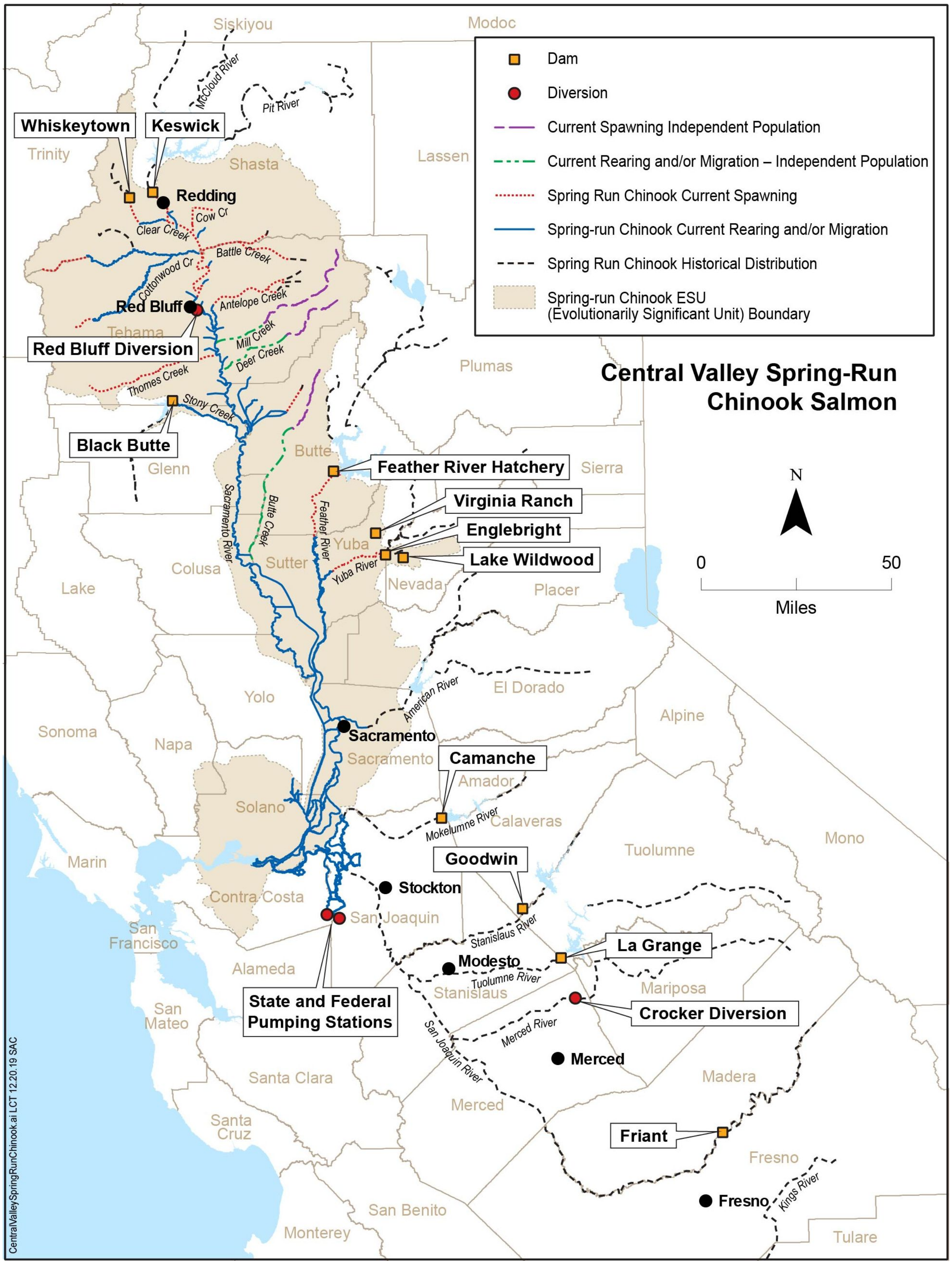
Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water which promotes higher oxygen levels and reduced deposition of fines. Adult spawning conditions, incubation, and emergence from gravel is dependent on cold water temperatures (Myrick and Cech 2004). Fry emerge from gravels are from November to March (Williams 2006). Post-emergent fry inhabit calm, shallow waters with fine substrates and depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

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

Juveniles prefer stream margin habitats with enough depth and velocities to provide suitable cover and foraging opportunities during rearing and downstream movement. Off-channel areas and floodplains can provide important rearing habitat. A greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem Sacramento River, which can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001).

2.4.3 Distribution and Abundance

Spring-run Chinook Salmon were historically the dominant run of salmon in the Central Valley. The Central Valley drainage is estimated to have supported annual runs of Spring-run Chinook Salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Following construction of major dams, annual runs were estimated to be no more than 26,000 fish in the 1950s and 1960s (CDFW GrandTab data; Yoshiyama et al. 1998). Dams on the Sacramento River blocked upstream passage of Spring-run Chinook Salmon to historically available spawning habitat and confined them to a much smaller area of the watershed (Figure 2-11). Today, only the mainstem Sacramento River and Butte, Mill, and Deer creeks maintain wild Spring-run Chinook Salmon populations. In most years, some adults return to Antelope, Big Chico, Little Chico, Beegum, Battle, and Clear creeks, but these populations are not considered self-sustaining. Recent surveys have documented very few Spring-run Chinook Salmon in the Stanislaus, Tuolumne, and Merced rivers. Nearly 50,000 adults were counted in the San Joaquin River (Fry 1961) before the construction of Friant Dam (completed in 1942). The San Joaquin River watershed populations were essentially extirpated by the 1940s, with only small remnants of the run persisting through the 1950s in the Merced River (Hallock and Van Woert 1959; Yoshiyama et al. 1998).



Source: NOAA 2014

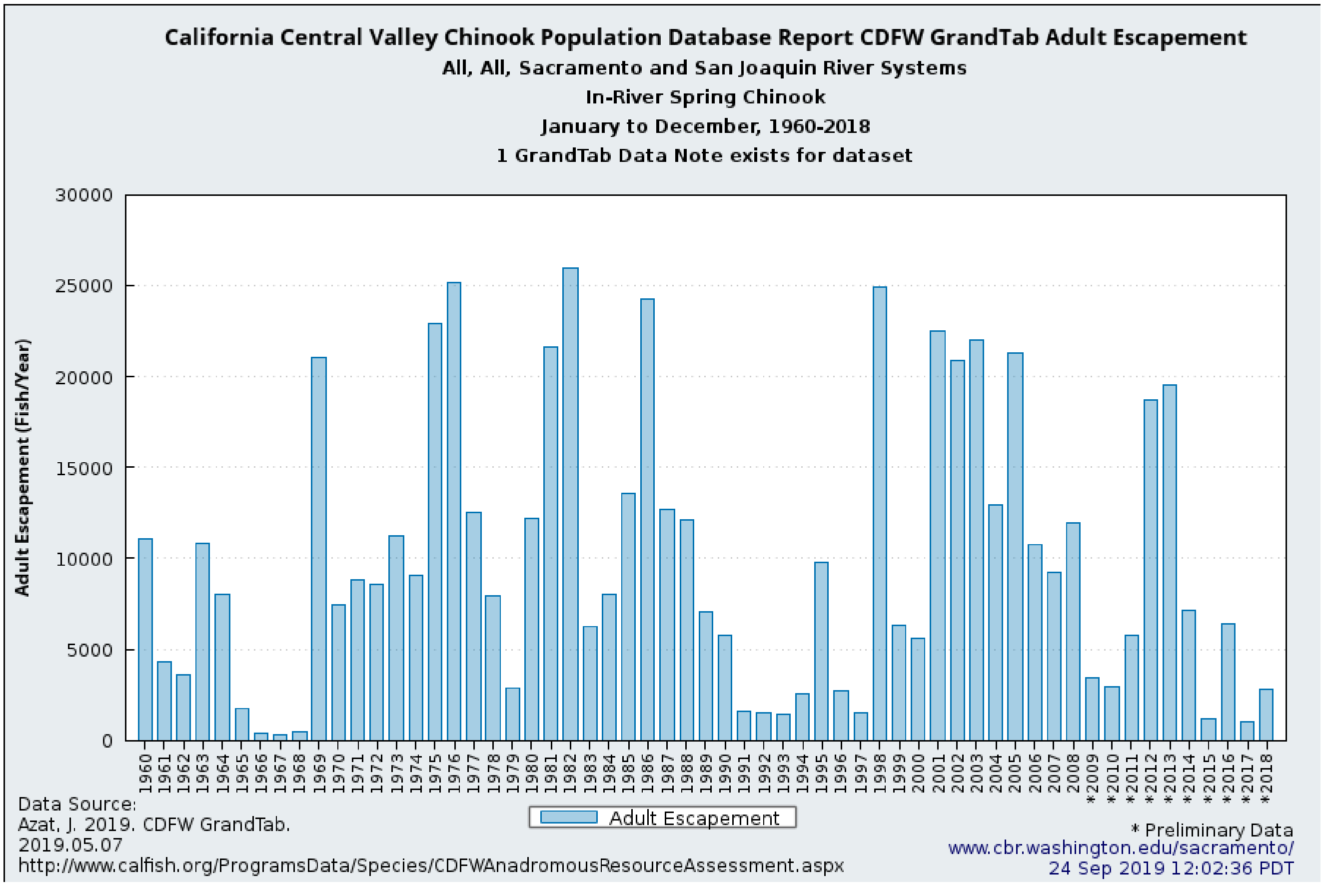
Figure 2-11. Central Valley Spring-run Chinook Salmon ESU Current and Historical Distribution

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

The Central Valley Spring-run Chinook Salmon ESU has displayed broad fluctuations in adult abundance. Estimates of Spring-run Chinook Salmon in the Sacramento River and its tributaries have ranged from 1,105 in 2017 to 25,890 in 1982. This estimate does not include in-river or hatchery spawners in the lower Yuba and Feather rivers because CDFW's GrandTab does not distinguish between Fall-run Chinook Salmon and Spring-run Chinook Salmon in these rivers.

Since 1995, Spring-run Chinook Salmon annual run size estimates typically have been dominated by Butte Creek returns. Of the three tributaries producing naturally spawned Spring-run Chinook Salmon (Mill, Deer, and Butte creeks), Butte Creek has produced an average of two-thirds of the total production over the past 10 years (DWR and Reclamation 2017; CDFW 2018b). During recent years, Spring-run Chinook Salmon escapement estimates (excluding in-river spawners in the Yuba and Feather rivers) have ranged from 23,696 in 2013 to 1,796 in 2017 throughout the tributaries to the Sacramento River surveyed (CDFW 2018).

Spring-run Chinook Salmon population estimates remain low. Escapement was estimated to be 6,453 in 2016 and 1,105 in 2017 (Figure 2-12; Azat 2019). In addition, fish monitoring is conducted throughout the year at the Tracy Fish Collection Facility (TFCF) and the John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) (collectively referred to as the Delta fish facilities). During water year 2017, 26,551 wild juvenile Spring-run and 963 hatchery Spring-run Chinook Salmon were observed at the Delta fish facilities, and 9,487 wild juvenile Spring-run and 1,010 hatchery Spring-run were observed during water year 2018. Fish monitoring is also conducted at the Rock Slough Intake by the Contra Costa Water District (CCWD). No Spring-run Chinook Salmon have been collected in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2008.



Source: CDFW GrandTab

Figure 2-12. California Central Valley Spring-run Chinook Salmon ESU annual escapement estimates dating back to 1960.

2.4.4 Species Threats

2.4.4.1 Habitat

As discussed in the Winter-run Chinook Salmon section, accessible habitat for Spring-run Chinook Salmon has been negatively impacted by inadequate flows and increased water temperatures from dam and water diversion operations on streams throughout the Sacramento River Basin. In Deer, Mill, and Antelope creeks, losses of suitable spawning gravel, the development of deep channels and levees, pollutants and siltation from urban development, mining, and water diversions are also stressors on this ESU (NMFS 2009; NMFS 2014).

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

Spring-run Chinook Salmon migration survival and routing is linked to flow management, particularly at junctions where fish can route into the interior Delta and become entrained by the export facilities in the South Delta. Within the Delta, warming and stable hydrology has favored the expansion of introduced predators, which function as a source of indirect mortality by entrainment towards the export facilities.

2.4.4.2 ENTRAINMENT

Increased exports can influence the direction and velocity of flow in the South Delta, with high exports causing stronger reversal in flows. When fish route into the interior Delta via Georgiana Slough or the Delta Cross Channel, entrainment from reverse flows in Old and Middle River result in longer travel time and indirect mortality (i.e., predation) and direct mortality through loss at the export facilities.

Flow in the South Delta tends to be more complex than in the North Delta because of the influence of radial gate operations at the head of Clifton Court Forebay and the influence of exports on OMR dynamics, as described above. This is further complicated by the presence of temporary barriers at the head of Old River, lower inflow from the San Joaquin River, and greater tidal excursion. Highly channelized levee characteristics maintained for water conveyance affect the potential for the Delta to function as rearing habitat for juvenile salmonids.

Recent work by the Collaborative Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST) suggests that high correlations between inflows and exports make it difficult to evaluate their effects on salmon survival independently using statistical methods (Buchanan et al. 2018). There are very few observations of salmon survival at high export rates, which makes it difficult to determine if there is a relationship, but most acoustic tagging studies show support for a positive relationship between flow and survival (Perry et al. 2010, 2018, Michel et al. 2012).

Temporary barriers are installed by DWR in the South Delta for the purpose of stabilizing and increasing water surface elevations to facilitate agriculture irrigation. A temporary barrier at the head of Old River (HOR) is designed to reduce movement of migrating salmonids into Old River. Conceptual models identified by the CAMT's SST salmon scoping team predict that survival to Chipps Island will be higher with the barriers in place by forcing salmon to avoid the interior Delta. Changes in flows resulting from the barrier installation are also expected to benefit salmonid route selection and migration rates, although localized predation around the barriers themselves is expected to increase.

2.4.4.3 FLOW

Results of survival and migration studies in the Sacramento and San Joaquin rivers and Delta suggest that relationships between river flow and migration rates are more complicated than has been observed in the Pacific Northwest, where flow is more unidirectional (Zabel et al. 1998, Smith et al. 2002). More precise estimates of migration rates have shown a positive relationship with water velocities, particularly in the upper river (Michel et al. 2012) and during wet years (Henderson et al. 2018), although Henderson et al. (2018) showed a diminishing effect, or asymptote of the effect of flow on Late Fall-run Chinook Salmon survival in wet years. Routing down Georgiana Slough has also been shown to increase when unidirectional flow gives way to tidal influences and flow becomes more bi-directional between 20,000 and 30,000 cfs at Freeport (Perry et al. 2018). These studies are based on surrogate Late Fall-run Chinook Salmon, which, due to their large size, were more feasible to carry early generation tags with reduced tag burden. Because of this, it is important to consider operational differences, such as closure of the Delta Cross Channel gates and temporal differences in the relative influence of bi-directional flows at Georgiana Slough, that influence the degree to which a run is exposed to re-routing. Studies are underway to verify the applicability of these results.

2.4.4.4 Hatchery Influence

Historically, wherever Spring-run Chinook Salmon and Fall-run Chinook Salmon populations overlapped, they were temporally segregated and genetic integrity was maintained. However, because of difficulties associated with holding adults over the summer in a hatchery, fish were left in the river until spawning, which presumably led to mixing with Fall-run Chinook Salmon in the hatchery (Williams 2006). Loss of life history diversity limits a species ability to deal with environmental change, such as timing of ocean productivity and leads to increased vulnerability through a weakened portfolio effect (Carlson and Satterthwaite 2011).

2.4.4.5 Climate Change

Climate change possess similar threats to Spring-run Chinook Salmon that were described for Winter-run Chinook Salmon with increasingly high water temperatures and changes to ocean conditions being limiting factors. Like Winter-run Chinook Salmon, Spring-run Chinook Salmon are particularly vulnerable to these limiting factors because their life history is adapted to streams with snowmelt runoff, with relatively dependable sustained high flows that allow fish to ascend to high enough elevations where water temperatures remain tolerably cool through the summer. Snowmelt runoff is relatively more important in the San Joaquin River and its major tributaries, where historically spring-run were more abundant.

Recoveries of coded wire tags and genetic samples suggest that Spring-run Chinook Salmon have a more northerly ocean distribution and mature later than Winter-run Chinook Salmon (Satterthwaite et al. 2018). Therefore, climate-induced changes in ocean prey distributions that limit access to coastal prey may disproportionately affect Spring-run Chinook Salmon that rely on marine resources to a greater degree in order to mature.

3 PROJECT DESCRIPTION

3.1 INTRODUCTION

The SWP includes water, power, and conveyance systems, conveying an annual average of 2.9 million acre-feet (AF) of water. The principal facilities of the SWP are Oroville Reservoir and related facilities, and San Luis Dam and related facilities, facilities in the Sacramento-San Joaquin Delta (Delta), the Suisun Marsh Salinity Control Gates, the California Aqueduct including its terminal reservoirs, and the North and South Bay Aqueducts. DWR holds contracts with 29 public agencies in northern, central, and southern California for water supplies from the SWP. Water stored in the Oroville facilities, along with water available in the Delta (consistent with applicable regulations) is captured in the Delta and conveyed through several facilities to SWP contractors. The SWP is operated to provide flood control and water for agricultural, municipal, industrial, recreational, and environmental purposes.

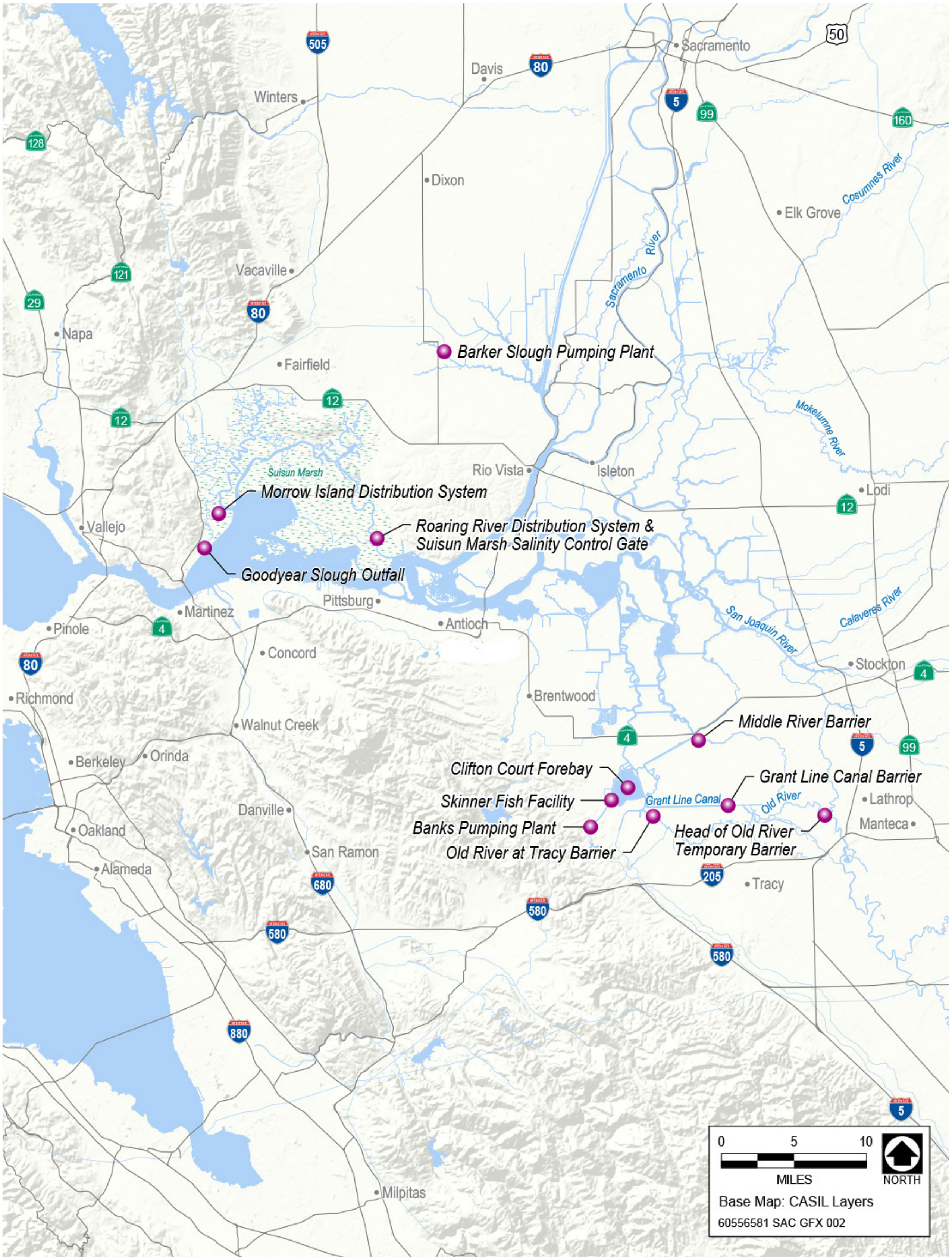
3.1.1 PROJECT OBJECTIVES

The objective of the Proposed Project is to continue the long-term operation of the SWP consistent with applicable laws, contractual obligations, and agreements. DWR proposes to store, divert, and convey water in accordance with DWR's existing water rights to deliver water pursuant to water contracts and agreements up to full contract quantities. DWR seeks to optimize water supply and improve operational flexibility while protecting fish and wildlife based on the best available scientific information.

3.1.2 PROJECT LOCATION

The project area includes the SWP Service Areas and existing SWP storage and export facilities located within the Delta and vicinity. Figure 1-1 shows the entire project area, including the SWP Service areas, while Figure 3-1 shows those SWP facilities located in the Delta and vicinity.

The DWR operates the SWP in coordination with the Central Valley Project (CVP), under the COA between the federal government and the State of California (authorized by Pub. L. 99 546). The CVP and SWP operate pursuant to water rights permits and licenses issued by the State Water Resources Control Board. The CVP and SWP water rights allow appropriation of water by directly using the water, diverting water to storage for later withdrawal, and rediverting water to storage further downstream for later consumptive use. Requirements of the SWP and CVP to either bypass or withdraw water from storage and to help satisfy specific water quality, quantity, and operations criteria in source rivers and within the Delta are among the conditions of their water rights.



Source: Data compiled by AECOM in 2017

Figure 3-1. Locations of State Water Project Facilities in the Delta, Suisun Marsh, and Suisun Bay

3.1.3 Description of Existing SWP Facilities

The SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta, and to regions south of the Delta. The main SWP Delta features are Suisun Marsh and Bay facilities, the Harvey O. Banks Pumping Plant (Banks Pumping Plant), the Clifton Court Forebay (CCF), the Skinner Fish Facility, and the Barker Slough Pumping Plant (BSPP).

3.1.3.1 Harvey O. Banks Pumping Plant

The Banks Pumping Plant, located about 8 miles northwest of Tracy, marks the upstream end of the California Aqueduct. The plant discharges into five pipelines that convey water into a roughly 1-mile-long canal, which in turn conveys water to Bethany Reservoir (DWR and Reclamation 2015). The Banks Pumping Plant consists of 11 pumps—two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity—that provide the initial lift of water 244 feet from the CCF into the California Aqueduct. The rated capacity of the Banks Pumping Plant is 10,300 cfs. The plant maximum daily pumping rate is controlled by a combination of the State Water Resources Control Board's (SWRCB's) D-1641 and permits issued by the U.S. Army Corps of Engineers (USACE) that regulate the rate of diversion of water into the CCF. The diversion rate is normally restricted to 6,680 cfs as a 3-day average inflow and 6,993 cfs as a 1-day average inflow to the CCF in accordance with the existing USACE Section 10 permit issued in pursuant to the Rivers and Harbors Act (SWRCB 2017). The diversions may be greater in the winter and spring, depending on San Joaquin River flows at Vernalis (DWR and Reclamation 2015). As part of the adaptive management process, the SWP is permitted to pump an additional 500 cfs between July 1 and September 30 to offset water costs associated with fisheries actions, making the summer limit effectively 7,180 cfs (Reclamation 2008).

3.1.3.2 John E. Skinner Delta Fish Protective Facility

The Skinner Fish Facility is west of the CCF, about 2 miles upstream from the Banks Pumping Plant. The Skinner Fish Facility guides fish away from entering the pumps that convey water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers. These smaller fish pass through a secondary system of screens, louvers, 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.

3.1.3.3 Clifton Court Forebay

The CCF is located near the city of Byron in the South Delta. The Banks Pumping Plant pumps water diverted from the CCF via the intake channel past Skinner Fish Protective Facility (SFPF). A set of five radial gates are located at the CCF inlet near the confluence of the Grant Line and West Canal. They are operated so that they can be closed during critical periods of the ebb/flood tidal cycle to protect water levels experienced by local agricultural water users in the South Delta. The gates are operated on the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize fluctuations in water elevation in the South Delta by taking water in through the gates at times other than low tide.

Banks Pumping Plant pumping rates are constrained operationally by limits on CCF diversions from the Delta. The maximum daily diversion limit from the Delta into the CCF is 13,870 AF per day (6,990 cfs/day) and the maximum averaged diversion limit over any 3 days is 13,250 AF per day (6,680 cfs/day). In addition to these requirements, DWR may increase diversions from the Delta into the CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in USACE Public Notice 5820A Amended (Oct. 13, 1981).

From July through September, the maximum daily diversion limit from the Delta into the CCF is increased from 13,870 AF per day (6,990 cfs/day) to 14,860 AF per day (7,490 cfs/day), and the maximum averaged diversion limit over any 3 days is increased from 13,250 AF per day (6,680 cfs/day) to 14,240 AF per day (7,180 cfs/day). These increases are for the purpose of recovering water supply losses incurred earlier in the same year to protect ESA-listed fish species. Those increases are a separate action permitted for short-term time periods.

3.1.3.4 Barker Slough Pumping Plant

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery to Napa and Solano counties. The NBA intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. In accordance with salmon screening criteria, each of the aqueduct’s 10 pump bays are 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 and prevent the entrainment of fish measuring approximately 1 inch or larger. The bays tied to the two smaller units have an approach velocity of about 0.2 foot per second (ft/sec). The larger units were designed for a 0.5 ft/sec approach velocity, but actual approach velocity is about 0.44 ft/sec. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increases in localized approach velocities.

3.1.3.5 Suisun Marsh Operations

The Suisun Marsh Preservation Agreement (SMPA) among DWR, Reclamation, CDFW, and Suisun Resource Conservation District (SRCD) contains provisions for DWR and Reclamation to mitigate the impacts on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough, and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since the 1980s and have proven to be a highly reliable method for meeting standards.

Physical facilities in the Suisun Marsh and Bay include the Suisun Marsh Salinity Control Gates (SMSCG), the Roaring River Distribution System (RRDS), the Morrow Island Distribution System (MIDS) and the Goodyear Slough Outfall (GYSO). The location and operation of these facilities is described below.

The SMSCG are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west through Suisun Marsh.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by salinity at D-1641 compliance stations, hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The boat lock portion of the gate is now held partially open during SMSCG operation to allow an opportunity for continuous salmon passage. At a future date when an engineering solution is implemented to prevent boaters from entering the boat lock without approval from the operator, the boat lock gate will be held open at all times. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations will remain at current levels or as needed to implement the summer action to benefit Delta Smelt.

The 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 the RRDS above the adjacent managed wetlands. The intakes to the RRDS are 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 average approach velocity of 0.2 ft/sec at the intake fish screens except during the period from September 14 through October 20, when RRDS diversion rates are controlled to maintain a maximum average approach velocity of 0.7 ft/sec for fall flood up operations.

The MIDS allows Reclamation and DWR to provide fresher water to the landowners for managed wetland activates approved in local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough. The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor.

The GYSO connects the south end of Goodyear Slough to Suisun Bay. Prior to construction of the outfall, Goodyear Slough was a dead-end slough. The GYSO was designed to increase circulation and reduce salinity in Goodyear Slough 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. Any fish that entered the system would be able to leave via the intake or the outfall, as GYSO is an open system.

3.1.3.6 South Delta Temporary Barrier Project

DWR's South Delta Temporary Barrier Project (TBP) was initiated in 1991. The objectives of the TBP are to increase water levels, circulation patterns, and water quality in the southern Delta area for local agricultural diversions. The existing SWP consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 mile south of the confluence of Middle River, Trapper Slough, and the North Canal
- Old River near Tracy, approximately 0.5 mile east of the Delta-Mendota Canal intake
- Grant Line Canal, approximately 400 feet east of the Tracy Boulevard Bridge

These rock barriers are designed to act as flow control structures, trapping tidal waters behind them after a high tide. These barriers improve water levels and circulation for local South Delta farmers and are collectively referred to as agricultural barriers.

Rock barriers at Old River near Tracy, Middle River, and the Grant Line Canal are in place from April 15 to September 30 each year. The Old River barrier near Tracy has been installed since 1991 and the Middle River barrier has been installed since 1987. A rock barrier was first installed in the Grant Line Canal in spring 1996, and since then the barrier has been installed in every year except 1998.

This document is focused on the operation of the barriers within the South Delta and does not analyze or address the construction or removal of the barriers, which is covered by a separate Biological Opinion (BiOp) and associated permits.

3.1.3.7 Head of Old River Barrier

The Head of Old River Barrier (HORB) is a temporary structure at the divergence from the San Joaquin River. The fall HORB is intended to keep water in the San Joaquin River, which may improve downstream dissolved-oxygen conditions. The spring barrier is intended to prevent downstream-migrating salmonid smolts in the San Joaquin River from entering Old River.

The HORB has been installed seasonally, between September 15 and November 30, in most years since 1963. Since 1992, the rock barrier has also been installed frequently in the spring, between April 15 and May 30. For various reasons installation of the HORB did not occur in 1993, 1995, 1998, 1999, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2017, 2018, and 2019. The spring installation of the HORB is currently required as part of the 2009 NMFS Biological Opinion, but is not included in the 2019 NMFS Biological Opinion.

3.1.3.8 San Luis Reservoir

San Luis Reservoir is an off-stream storage facility located along the California Aqueduct downstream of the Jones and Banks pumping plants. The CVP and SWP share San Luis Reservoir storage roughly 50/50 (CVP has 966 thousand acre-feet [TAF] of storage, and SWP has 1062 TAF of storage). San Luis Reservoir is used by both the SWP and CVP to meet deliveries to their contractors during periods when Delta pumping is insufficient to meet demands. San Luis Reservoir is also operated to supply water to the CVP San Felipe Division in San Benito and Santa Clara counties.

San Luis Reservoir operates as a regulator on the CVP/SWP system, accepting any water pumped from the Banks and Jones pumping plants that exceeds contractor demands, then releasing that water back to the aqueduct system when the pumping at the Jones and Banks pumping plants is insufficient to meet demands. The reservoir allows the CVP/SWP to meet peak-season demands that are seldom balanced by Jones and Banks pumping.

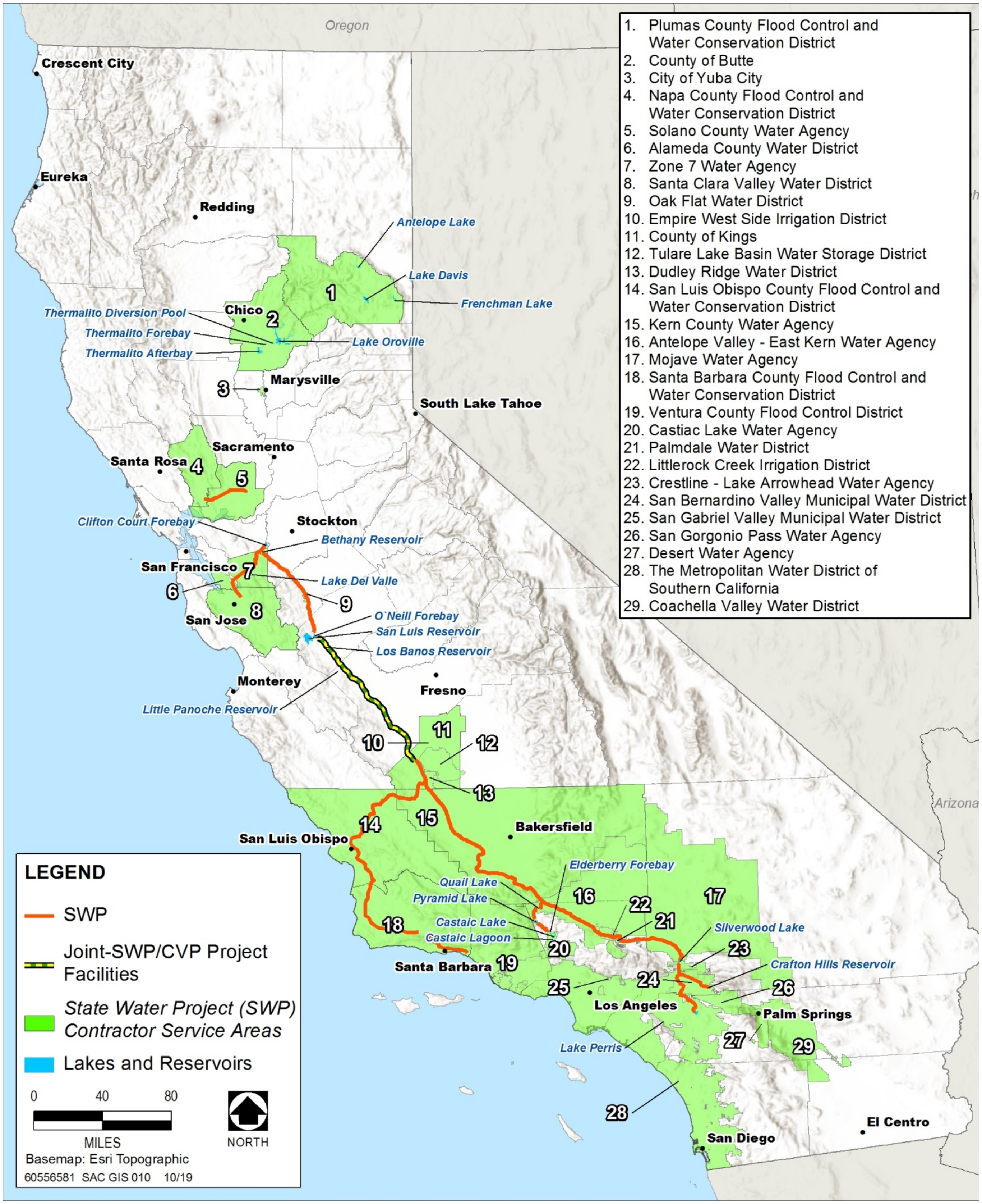
As San Luis Reservoir is drawn down to meet contractor demands, it usually reaches its low point in late August or early September. From September through early October, demand for deliveries declines until it is less than the rate of diversions from the Delta at the Jones and Banks pumping plants. At this point, the additional diverted water is added to San Luis Reservoir, reversing its spring and summer decline and eventually filling the San Luis Reservoir—typically before April of the following year.

Operations of the San Luis Reservoir are not discussed further in this document, as there will be no changes to the operations of this reservoir and it is an off-stream facility.

3.1.4 Description of Existing SWP Water Service Contracts

DWR has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system (Figure 3-2). These contracts are with both municipal and industrial (M&I) water users and agricultural water users. The contracts specify the charges that will be made by the water agency for both (1) water conservation and (2) conveyance of water. The foundation allocation of water to each contractor is based on their respective “Table A” entitlement, which is the maximum amount of water delivered to them by the SWP on an annual basis.

Under statewide contracts, DWR allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with more than 3 million acre-feet (MAF) for San Joaquin Valley and Southern California water users.



Source: California Spatial Information Library, DWR 2019

Figure 3-2. The 29 Water Purveyors Under Contract to Receive SWP Water Deliveries

Article 21 of the long-term SWP water supply contracts provides an interruptible water supply made available only when certain conditions exist: (1) The SWP share of San Luis Reservoir is physically full or is projected to be physically full; (2) other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess conditions; (4) current Table A demand is being fully met; and (5) Banks Pumping Plant has export capacity beyond that which is needed to meet current Table A and other SWP operational demands.

Table 3-1 shows the maximum contracted annual water supply per water purveyor per DWR's most recent water supply reliability report.

Table 3-1. State Water Contractors

State Water Contractors	Table A Contracted Water Supply (acre-feet)	Purpose of Use
Butte County	27,500	M&I
Plumas County	2,700	M&I
Yuba City	9,600	M&I
Napa County Flood Control and Water Conservation District	29,025	M&I
Solano County Water Agency	47,756	M&I
Alameda County—Zone 7	80,619	M&I
Alameda County Water District	42,000	M&I
Santa Clara Valley Water District	100,000	M&I
Oak Flat Water District	5,700	Agriculture
Kings County	9,305	Agriculture
Dudley Ridge Water District	45,350	Agriculture
Empire West Side Irrigation District	3,000	Agriculture
Kern County Water Agency	982,730	Agriculture/M&I[1]
Tulare Lake Water Storage District	87,471	Agriculture
San Luis Obispo County	25,000	M&I
Santa Barbara County	45,486	M&I
Antelope Valley-East Kern Water Agency	144,844	Agriculture/M&I[2]
Santa Clarita Valley Water Agency	95,200	M&I
Coachella Valley Water District	138,350	M&I
Crestline-Lake Arrowhead Water Agency	5,800	M&I
Desert Water Agency	55,750	M&I
Littlerock Creek Irrigation District	2,300	M&I
Metropolitan Water District of Southern California	1,911,500	M&I
Mojave Water Agency	85,800	M&I
Palmdale Water District	21,300	M&I
San Bernardino Valley Municipal Water District	102,600	M&I
San Gabriel Valley Municipal Water District	28,800	M&I
San Gorgonio Pass Water Agency	17,300	M&I
Ventura County Watershed Protection District	20,000	M&I

Notes:

[1] Approximately 15% of the Kern County Water Agency Table A Amount is classified as municipal and industrial (M&I) supply.

[2] Approximately 25% of the Antelope Valley-East Kern Water Agency Table A amount is used for agricultural purposes. Source: DWR 2016

M&I = municipal and industrial

3.1.5 SWP Settlement Agreements

DWR has water rights settlement agreements to provide water supplies with entities north upstream of Oroville, along the Feather River and Bear River and in the Delta. These agreements provide users diverters with SWP water supplies. The agreements are premised upon the idea that these diverters that they were entitled to water prior to the construction of the SWP's Oroville Complex. Collectively, these agreements are between DWR and with more than 60 riparian diverters along the Feather and Bear rivers provide water for diversion. Table 3 2 summarizes the volume under the water rights settlement agreements. In addition to Table 3-2, Additional water may be diverted by the Feather River Settlement Contractors agreement allows for diversion of SWP water in the fall and winter months consistent with their settlement contracts. DWR proposes to operate the SWP in accordance with these agreements contracts with senior water rights holders in the Feather River Service Area (approximately 983 TAF) and in the Delta.

Table 3-2. SWP Settlement Agreements

Location	Entity	Amount (Acre-Feet)
North of Oroville	Andrew Valberde	135
North of Oroville	Jane Ramelli	800
North of Oroville	Last Chance Creek WD	12,000
Feather River	Garden Highway Mutual Water	18,000
Feather River	Joint Water Districts Board	620,000
Feather River	South Feather Water & Power	17,555
Feather River	Oswald WD	3,000
Feather River	Plumas Mutual Water	14,000
Feather River	Thermalito Irrigation District	8,200
Feather River	Tudor Mutual Water	5,000
Feather River	Western Canal/PG&E	295,000
Bear River	South Sutter/Camp Far West	4,400
Delta	Byron-Bethany ID	50,000
Delta	East Contra Costa ID	50,000
Delta	Solano Co./Fairfield, Vacaville and Benicia	31,620

Notes:
ID = Irrigation District
PG&E = Pacific Gas & Electric Company
WD = water district

3.1.6 SWP Allocation and Forecasting

At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist in the future several months, and hence the water supplies that will be allocated by the SWP to its water contractors. In recognition of this, DWR uses a forecasting water supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies that can be delivered to SWP contractors as the water year progresses.

There are many factors considered in the forecast-supply process. Some of these factors are the following:

- Water storage in Lake Oroville (both updated and end-of-water-year (September 30)
- Water storage in San Luis Reservoir (both updated and end-of-calendar-year)
- Flood operations constraints at Lake Oroville
- Snowpack surveys (updated monthly from February through May)
- Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)
- Feather River settlement agreement obligations
- Feather River fishery flows and temperature obligations
- Anticipated depletions in the Sacramento and Delta basins
- Anticipated Delta standards and conditions
- Anticipated CVP operations for joint responsibilities
- Contractor supply requests and delivery patterns

Staff from both the Operations Control Office (OCO) and the State Water Project Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. OCO primarily focuses on runoff/operations models to determine allocations. SWPAO requests updated information from the contractors on supply requests and delivery patterns to determine allocations. Both OCO and SWPAO staff meet at least once a month with the Director of DWR to make final decisions on staff's proposed allocations.

The Initial Allocation for SWP Deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid overallocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured and known information and conservative forecasts of future hydrology. Monthly briefings are held with the Director of DWR to determine formal approvals of delivery commitments announced by DWR.

Another water supply consideration is the contractual ability of SWP contractors to "carry over" allocated (but undelivered) Table A supplies from the previous year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor's current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by SWP contractors can result in higher storage levels in San Luis Reservoir. As SWP pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, then becomes water available for reallocation to all contractors in a given year.

Article 21 (surplus to Table A) water, which is delivered early in the calendar year, may be reclassified as Table A water later in the year depending on final allocations, hydrology, and contractor requests.

Reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules.

3.1.7 Daily Operations

After the allocations and forecasting process, Reclamation and DWR coordinate their operations on a daily basis. Some factors Reclamation and DWR consider when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, schedules for the joint use facilities, pumping and wheeling arrangements, and any facility limitations. Both the SWP and CVP must meet the flood obligations of individual reservoirs. CVP operations must also consider flows at Wilkins Slough and associated pump intake elevations.

During balanced water conditions, Reclamation and DWR maintain a daily water accounting of CVP and SWP obligations. This accounting allows for flexible operations and avoids the need to change reservoir releases made several days in advance (due to travel time from the Delta). Therefore, adjustments can be made "after the fact," using actual observed data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses. This iterative process of observation and adjustment results in a continuous trueing up of the running COA account. If either the SWP or CVP is "owed" water (i.e., the project that provided more or exported less than its COA-defined share), each may request the other to adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The COA provides the mechanism for determining SWP and CVP responsibility for meeting in-basin use, but real-time conditions dictate real-time actions. Conditions in the Delta can change rapidly. For example, weather conditions combined with tidal action can quickly affect Delta salinity conditions and therefore the Delta outflow required to maintain joint salinity standards under D-1641.

Increasing or decreasing SWP or CVP exports can achieve changes to Delta outflow immediately. Imbalances in meeting each other's initial shared obligations are captured by the COA accounting and balanced out later.

When more reaction time is available, reservoir release changes are used to adjust to changing in-basin conditions. If Reclamation decides the reasonable course of action is to increase upstream reservoir releases, the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. DWR's Lake Oroville water releases require about 3 days to reach the Delta, while water released from Reclamation's Shasta Reservoir requires 5 days to travel from Keswick Reservoir to the Delta. As water from another reservoir arrives in the Delta, Reclamation can adjust Folsom Reservoir releases downward. Alternatively, if sufficient time exists for water to reach the Delta, Reclamation may choose to make initial releases from Shasta Reservoir. Each occurrence is evaluated on an individual basis, and appropriate action is taken based on multiple factors. Again, the COA accounting captures imbalances in meeting each other's initial shared obligation.

The duration of balanced water conditions varies from year to year. Balanced conditions never occur in some very wet years, while very dry years may have long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one balanced water condition through the excess water condition and into the next balanced water condition. When either the SWP or CVP enters into flood control operations, the accounting is zeroed out for that project.

Reclamation and DWR staff meet daily to discuss and coordinate CVP and SWP system operations. Several items are discussed at this daily meeting, including:

- Current reservoir conditions
- Pumping status and current outages (for both the CVP and the SWP and how they are affecting combined operations)
- Upcoming planned outages (CVP and SWP) and what that means for future operations
- Current reservoir releases and what changes may be planned
- Current regulatory requirements and compliance status
- Delta conditions to determine if CVP and SWP pumping make use of all available water

Reclamation and DWR also coordinate with Hydrosystem Controllers and Area Offices to ensure that, if necessary, personnel are available to make the desired changes. Once Reclamation and DWR each decide on a plan for that day and complete all coordination, the respective agencies issue change orders to implement the decisions, if necessary.

Reclamation and DWR are co-located in the Joint Operations Center. In addition, the California Data Exchange Center, California-Nevada River Forecast Center, and the DWR Flood Management Group are also co-located in the Joint Operations Center. This enables efficient and timely communication, particularly during flood events.

3.2 EXISTING REGULATIONS

3.2.1 U.S. ARMY CORPS OF ENGINEERS PERMITS

In Public Notice 5820A (October 1981), USACE limited the volume of daily SWP diversions from the Delta into Clifton Court Forebay, stating that such diversions may not exceed 13,870 AF and 3-day average diversions into the CCF may not exceed 13,250 AF. In addition, the SWP can increase diversions into the CCF by one-third of the San Joaquin River flow at Vernalis from mid-December to mid-March when the river's flow at Vernalis exceeds 1,000 cfs (USACE 1981).

In August 2013, USACE issued Permit SPK-1999-0715 and raised the daily diversion from 13,870 AF to 14,860 AF and the 3-day average diversion from 13,250 AF to 14,240 for calendar years 2013 through 2016 (USACE 2013). These increased diversions also required compliance with applicable terms and conditions in the existing BiOps and installation of the South Delta temporary barriers.

In 2017, USACE issued a revised Permit SPK-1999-0715 and raised the daily diversion from 13,870 AF to 14,860 AF and the 3-day average diversion from 13,250 AF to 14,240 AF. The conditions in this permit apply to SWP operations from 2017 through 2020 (USACE 2016). The permit also required compliance with applicable terms and conditions in the existing BiOps and installation of the South Delta temporary barriers.

3.2.2 State Water Resources Control Board Water Rights and D-1641

Reclamation and DWR operate the CVP and the SWP in accordance with the joint obligations under D-1641, which provides protection for fish and wildlife, M&I water quality, agricultural water quality, and Suisun Marsh salinity. D-1641 granted Reclamation and DWR the ability to use or exchange either SWP or CVP diversion capacity capabilities to maximize the beneficial uses of the CVP and SWP. The SWRCB conditioned the use of Joint Point of Diversion capabilities based on staged implementation and conditional requirements for each stage of implementation.

3.2.3 Federal Endangered Species Act

The SWP and CVP are currently operated in accordance with the 2008 USFWS Biological Opinion and the 2009 NMFS Biological Opinion, issued pursuant to Section 7 of the ESA. Both BiOps included Reasonable and Prudent Alternatives (RPAs) designed to allow the SWP and CVP to continue operating without causing jeopardy to listed species or adverse modification to designated critical habitat provided the RPAs were implemented.

On August 2, 2016, Reclamation and DWR jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation of the CVP and SWP. The USFWS accepted the reinitiation request on August 3, 2016, and NMFS accepted the reinitiation request on August 17, 2016. Reclamation completed a biological assessment to support consultation under the federal Endangered Species Act (ESA) Section 7, which documents the potential impacts of the proposed action on federally listed endangered and threatened species that have the potential to occur in the study area and on critical habitat for these species. The biological assessment also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH).

The new USFWS and NMFS Biological Opinions were issued on October 22, 2019, and they include incidental take statements (ITS) for Delta Smelt, Winter-run Chinook Salmon, Spring-run Chinook Salmon, Green Sturgeon, and steelhead. Although these Biological Opinions have not yet been adopted, DWR will comply with the ITS in accordance with federal law when they are adopted, in addition to state requirements. As a result of the difference in species listed under the state and federal ESAs and the coordinated operation of the SWP and CVP, DWR’s Proposed Project includes operations for the protection of federally listed steelhead and Green Sturgeon in addition to operations for the protection of state-listed species. These operations and the ITS for federally listed species result in reductions in SWP pumping in addition to the reductions that would be necessary to comply with state law.

3.2.4 California Endangered Species Act

In 2009, CDFW issued an Incidental Take Permit (ITP) for the ongoing and long-term operation of the SWP’s existing facilities in the Delta for the protection of Longfin Smelt. CDFW also issued consistency determinations to DWR for the 2009 NMFS and 2008 USFWS Biological Opinions for continued operation of the SWP and other actions related to water diversion, storage, and transport that are described in the BiOps.

DWR is seeking a new ITP from CDFW pursuant to Section 2081 of the Fish and Game Code. The new ITP will cover aquatic species listed under CESA that are subject to incidental take from long-term operation of the SWP (Delta Smelt, Longfin Smelt, Winter-run Chinook Salmon, and Spring-run Chinook Salmon).The 2009 Incidental Take Permit from CDFW for Longfin Smelt expires on December 31, 2019 but, on December 2, 2019, DWR submitted an Application for a Minor Amendment to extend the expiration date until March 31, 2020 or until a new ITP covering the fourth CESA-listed species is issued, whichever comes first.

3.3 DESCRIPTION OF THE PROPOSED PROJECT

The Proposed Project consists of multiple elements that characterize future operations of SWP facilities including Banks Pumping Plant, Skinner Fish Protection Facility, Clifton Court Forebay, Barker Slough Pumping Plant, and Suisun Marsh facilities, modify ongoing programs being implemented as part of SWP operations, improve specific activities that would enhance protection of special-status fish species, or support ongoing studies and research on these special-status species to improve the basis of knowledge and management of these species. Implementation of these elements is intended to continue operation of the SWP and deliver up to the full contracted water amounts while minimizing and fully mitigating the take of listed species consistent with CESA requirements.

These elements are divided into four categories and consist of (1) proposed SWP operations that can be described in detail and assessed on a project-level basis; (2) proposed SWP operations that can only be described generally and assessed on a program-level basis; (3) proposed environmental protective measures that would offset, reduce, or otherwise mitigate potential environmental impacts on special-status species, and (4) adaptive management actions that include establishing a governance framework, a compliance and reporting program, specific drought- and dry-year actions, and independent review panels, as well as conducting Four-Year Reviews of management measures.

Table 3-3 identifies the actions and facilities associated with the long-term operation of the SWP that are included in the Proposed Project.

Table 3-3. Proposed Project Elements – Table 3-3 a – Table 3-3 d

Table 3-3 a. Proposed Project Elements – Proposed Project-Level SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Existing Regulatory Requirements	Comply with D-1641 and USACE Permit 2100.	Continue to comply with existing limits and permit requirements to protect water quality for the beneficial uses of fish and wildlife, agriculture and urban uses.
Minimum Export Rate	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.	Establish minimum export rate to protect human health and safety.
Old and Middle River Requirements	Manage OMR reverse flows based on species distribution, modeling, and risk analysis, with provisions for capturing storm flows.	Implement real-time OMR management to minimize entrainment and aquatic species loss during water operations at Bank Pumping Plant.

Facility or Action	Proposed Project Actions	Action Goal or Objective
Barker Slough Pumping Plant (BSPP)	Continue operating BSPP to minimize effects on Delta Smelt and Longfin Smelt, and continue implementing sediment removal and aquatic weed management actions as part of normal operations at Barker Slough Pumping Plant.	Implement actions as components of facility maintenance for continued water supply deliveries.
South Delta Temporary Barriers	Continue operation of three South Delta Temporary Agricultural Barriers according to existing terms and conditions.	Maintain ongoing annual installation of three South Delta Temporary Agricultural Barriers with goal of maintaining surface water levels and circulation) in the South Delta.
Suisun Marsh Operations	Operate the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall in compliance with D-1641.	Operate the Suisun Marsh Salinity Control Gates to improve habitat conditions for the benefit of Delta Smelt.
Delta Smelt Summer-Fall Habitat Action	Operate the Suisun Marsh Salinity Control Gate for up to 60 days (not necessarily consecutive) in June through October of below normal, above normal, and wet years. Project operations would maintain a monthly average 2 ppt isohaline at 80 kilometers (km) from the Golden Gate Bridge in above-normal and wet water years in September and October. Food enhancement actions would be similar to the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation).	Operate the Suisun Marsh Salinity Control Gate, provide outflow, and conduct food enhancement actions to improve Delta Smelt food supply and habitat.
North Delta Food Subsidies and Colusa Basin Drain Project	Facilitate downstream transport of phytoplankton and zooplankton to areas inhabited by Delta Smelt.	Implement actions to transport productivity downstream to where it can be utilized by Delta Smelt.

Table 3-3 b. Proposed Project Elements – Proposed Program-Level Changes to SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Water Transfers	Water transfers would occur during an expanded water transfer window, between July through November, with volumes up to 600 TAF.	Increase SWP operational flexibility.

Table 3-3 c. Proposed Project Elements – Proposed Environmental Protective Measures

Facility or Action	Proposed Project Actions	Action Goal or Objective
Clifton Court Forebay	Continue implementing actions to reduce mortality of listed fish species at the Clifton Court Forebay; these measures would include: (a) continued evaluation of predator relocation methods; and (b) controlling aquatic weeds.	Increase species survival and control weeds to reduce impacts on the SWP's physical facilities (clogging screens) and predation reduction.
Skinner Fish Facility	Continue implementing studies to better understand and continuously improve the performance of the Skinner Fish Facility, including: (a) changes to release site scheduling and rotation of release site locations to reduce post-salvage predation, and (b) continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival.	Continue ongoing salvage fish at the Skinner Fish Facility and implement actions to reduce post-salvage predation and improve the accuracy and reliability of data and fish survival.

Facility or Action	Proposed Project Actions	Action Goal or Objective
Longfin Smelt Science Program	DWR proposes to continue implementing studies to better understand Longfin Smelt population distribution and abundance in San Francisco Bay and Delta, and identification of environmental factors that limit its abundance.	Study of environmental factors affecting Longfin Smelt distribution and reproduction, and identification of management actions to improve the status of the population.
Studies to support Establishment of a Delta Fish Hatchery	Conduct further studies to locate, design, construct, and operate a hatchery facility that would be capable of producing a substantial number of Delta Smelt and other Delta fish species for reintroduction to the Delta and recovery of the species populations. A related use for this fish is to provide an Adaptive Management tool to assess the effects of different management actions (e.g., cage studies).	Protect the species and provide resiliency.
Conduct Further Studies to Prepare for Delta Smelt Reintroduction from Stock Raised at the U.C. Davis Fish Conservation and Cultural Laboratory (FCCL)	Continue to support facilities and research to establish a Delta Smelt conservation population that is as genetically close as possible to the wild population and to provide a safeguard against extinction.	Protect the species and provide resiliency.
Additional elements related to real-time operation of the SWP	DWR proposes a governance structure for real-time operation of the SWP that includes compliance and performance reporting, monitoring, convening of independent panels, drought and dry year actions, and Four-Year Reviews.	Advancements in science and minimization of effects of project operations.

Table 3-3 d. Proposed Project Elements – Adaptive Management Actions

Facility or Action	Proposed Project Actions	Action Goal or Objective
Adaptive Management Plan	The Adaptive Management Plan (AMP) will be carried out to evaluate the efficacy of the operations and activities stated in Section 3,3,18. An Adaptive Management Team (AMT) will be established to carry out this AMP. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP will be developed before issuance of, and could be incorporated into, the Incidental Take Permit that DWR is seeking for CESA coverage for the Proposed Project.	The objectives to the AMP are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements; and (ii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species

Notes:
AMP = Adaptive Management Plan
AMT = Adaptive Management Team
CESA = California Endangered Species Act
cfs = cubic feet per second
D-1641 = State Water Resources Control Board's Water Rights Decision 1641
DWR = California Department of Water Resources
FCCL = Fish Conservation and Culture Laboratory
km = kilometers
OMR = Old and Middle River
ppt = parts per thousand
SWP = State Water Project

TAF = thousand acre-feet
USACE = U.S. Army Corps of Engineers

DWR is requesting an ITP for the exercise of discretion in operational decision-making, including how to comply with the terms of its existing water supply and settlement contracts (which include maximum deliveries under the terms of these contracts), and other legal obligations. DWR is not requesting an ITP from CDFW for the following actions:

- Flood control
- Oroville Dam and Feather River operations
- Prior execution of existing SWP contracts
- Coordinated Operation Agreement
- Any previously identified or potential future habitat restoration actions [2]
- Suisun Marsh Habitat Management Preservation and Restoration
- Suisun Marsh Preservation Agreement
- CVP facilities, operations, and agreements

These facilities and operations activities are already covered under existing permits or addressed by other legal authorities. The actions included as elements of the Proposed Project are described in the following discussion.

3.3.1 OMR Management

DWR, in coordination with Reclamation, proposes to operate the SWP in a manner that maximizes exports while minimizing direct and indirect impacts on state and federally listed fish species. Old and Middle River (OMR) flow is a surrogate indicator of the influence of export pumping at Banks Pumping Plant on hydrodynamics in the South Delta. The management of OMR flow, in combination with other environmental variables, can minimize or avoid entrainment of fish in the South Delta and at the SWP salvage facilities. DWR proposes to manage OMR flow by incorporating all available information into decision support for the management of OMR flow. The available information includes real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models. The objective of the OMR management will be to provide focused protection for fish when necessary and to provide flexibility where possible. DWR, in coordination with existing multi-agency Delta-focused technical teams, will use estimates of species distribution and other environmental variables based on ongoing monitoring.

From the onset of OMR management to the end, DWR, in coordination with Reclamation, will operate to an OMR index that is no more negative than a 14-day moving average of -5,000 cfs unless Delta excess conditions occur (described below). Grimaldo et al. (2017) indicated that -5,000 cfs OMR flow is an inflection point for fish entrainment. OMR flow could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR flow control

[2] CESA coverage for habitat restoration actions will be covered under separate CESA permitting processes.

exports. The OMR flow index would be computed using an equation presented in Hutton (2008). An OMR flow index allows for shorter-term operational planning and real-time adjustments. DWR, in coordination with Reclamation, will make a change to exports within 3 days of the trigger when monitoring, modeling, and operational criteria indicate protection for fish is necessary. The 3-day period is consistent with the 2008 and 2009 Biological Opinions and allows for efficient power scheduling.

3.3.1.1 Collaborative Real-time Risk Assessment

During the OMR Management period for species listed under CESA, DWR and CDFW technical staff, as part of the Smelt Monitoring Group and Salmon Monitoring Group, will meet weekly to consider survey data, salvage data and other pertinent biological and abiotic factors as described in Section 3.3.4. Portions of the Proposed Project include decision points that would trigger, or off-ramp, an OMR flow requirement or an export constraint. These decision points may require a risk assessment to determine whether or not a requirement is triggered or can be off-ramped. Under those circumstances, DWR and CDFW technical staff will jointly develop a risk assessment and supporting documentation based on the monitoring data and operations forecast. DWR, in coordination with Reclamation, will recommend the OMR operations for species listed under CESA species based on the jointly developed risk assessment with WOMT. The WOMT will then confer and attempt to reach a resolution. If a resolution is reached, DWR will operate to the decision from WOMT. If the WOMT does not reach a resolution, then CDFW Director may require DWR to implement CDFW's operational decision and DWR will implement the decision required by CDFW. CDFW will provide its decision in writing. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. Figure 3-3 shows the collaborative real-time risk assessment decision-making process.

3.3.1.2 Onset of OMR Management

DWR, in coordination with Reclamation, would start OMR management when one or more of the following conditions have occurred, as shown in Figure 3-4.

- Integrated Early Winter Pulse Protection (First Flush Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, DWR and Reclamation would reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period would 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, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polansky et al. 2018). The "First Flush" action may be triggered between December 1 and January 31. The triggers include a running 3-day average of the daily flows at Freeport that is greater than 25,000 cfs and a running 3-day average of the daily turbidity at Freeport that is 50 Nephelometric Turbidity Units (NTU) or greater; or, real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.
    - This "First Flush" action may only be initiated once during the December through January period.

- Salmonids Presence: After January 1, if more than 5% of any one or more salmonid species (wild young-of-the-year (YOY) Winter-run, wild YOY Spring-run, or wild California 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 (e.g., SAC PAS).
- Longfin Smelt protection: After December 1, trigger adult Longfin Smelt entrainment protection, if:
  - The cumulative salvage index (defined as the total estimated Longfin Smelt salvage at the CVP and SWP in the December through February period divided by the immediately previous Fall Midwater Trawl (FMWT) Longfin Smelt annual abundance[3] exceeds five,[4] or
  - Real-time monitoring indicates a risk of movement into areas that may be subject to high entrainment.

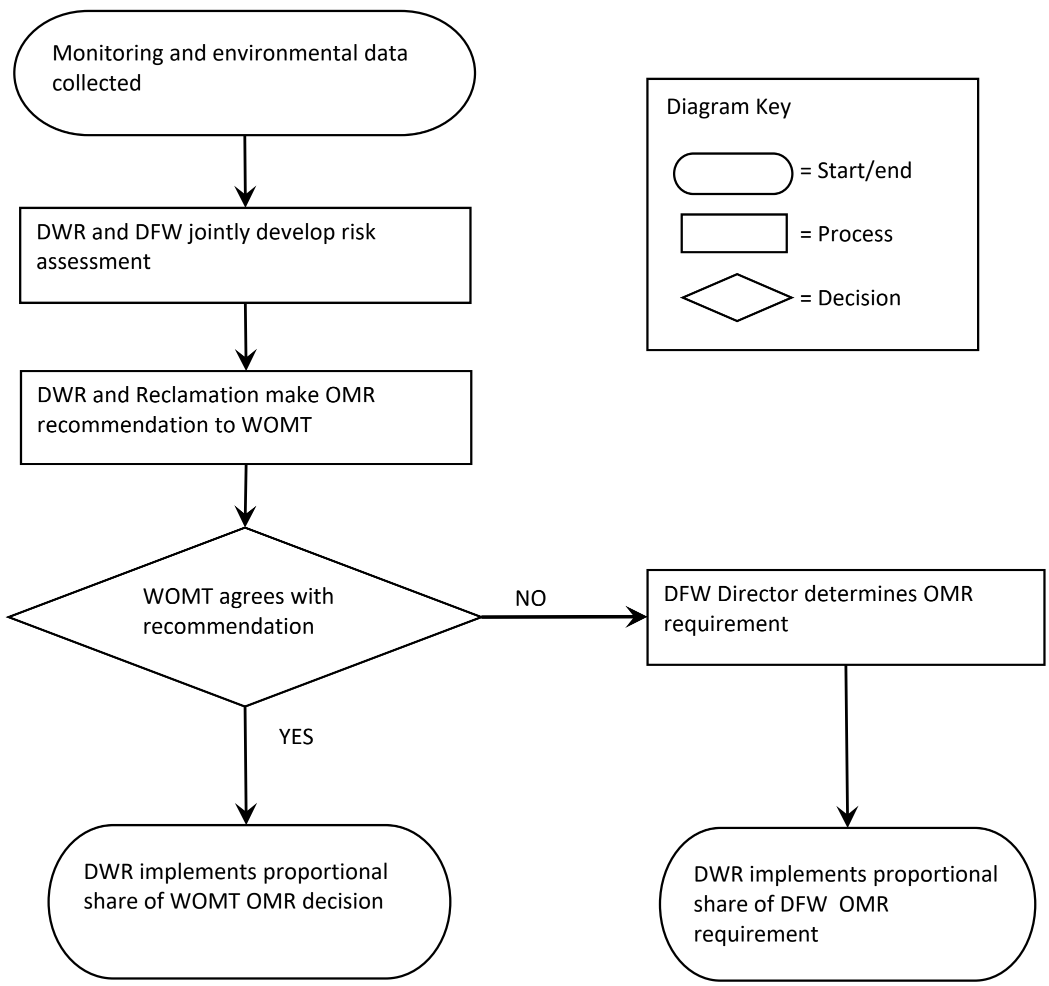


Figure 3-3. Collaborative real-time risk assessment decision-making process for OMR management

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[3] The Fall Midwater Trawl (FMWT) Survey annual abundance index for Longfin Smelt is calculated as the sum of September through December monthly abundance indices and is typically reported at about the same date as adult salvage begins in December. Early December salvage can be compared to September through November abundance as an approximation of the salvage index.

[4] Cumulative salvage index criteria may be modified as part of the adaptive management program in coordination with CDFW.

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Action	**OMR Management (OMR ≥ -5000 after Onset of OMR Mgt)**											
Delta smelt (adult) First Flush & **Onset of OMR Mgt**	**Trigger:** FPT > 25000 cfs & 50 NTU * **Action:** OMR ≥ -2000 cfs for 14 days **Offramp:** After 14 days or if action previously triggered											
Delta smelt (adult) Turbidity Bridge Avoidance			**Trigger:** After First Flush or Feb 1 and OBI > 12 NTU **Action:** OMR ≥ -2000 cfs for 5 days **Offramp:** Spent female or Apr 1									
Delta smelt Larval/Juvenile entrainment protection				**Trigger:** ≥ Mar 15 & QWEST < 0 & larvae/juvenile in corridor **Action:** OMR ≥ protective level based on modeling tools **Offramp:** CCF ≥ 25 degrees °C for 3 consecutive days								
Longfin smelt adult entrainment protection & **Onset of OMR Mgt**	**Trigger:** Cumulative salvage index > 5 * **Action:** OMR ≥ -5000 **Suspension:** Rio Vista > 55000 or SJR > 8000 **Offramp:** LFS spawning											
Longfin smelt Larval/Juvenile entrainment protection		**1st Trigger:** LFS larvae/juvenile detected in specific stations **1st Action:** OMR ≥ -5000 **2nd Trigger:** QWEST < 0 & LFS larval smelt present in corridor **2nd Action:** OMR ≥ protective level based on modeling tools **Offramp:** CCF ≥ 25 degrees °C for 3 consecutive days										
Salmonid **Onset of OMR Mgt**		**Trigger:** 5% of any salmonid species present in the Delta **Action:** OMR ≥ -5000 **Offramp:** 95% of WRC and SRC past Chipps or MOS ≥ 22.2 °C for 7 days										
Salmonid single year loss		**1st Trigger:** 50% of annual loss threshold reached **1st Action:** OMR ≥ -3500 or as adjusted based on risk **2nd Trigger:** 75% of annual loss threshold reached **2nd Action:** OMR ≥ -2500 or as adjusted based on risk **Offramp:** 95% of WRC and SRC past Chipps or MOS ≥ 22.2 °C for 7 days										
OMR Flex	**Trigger:** After onset of OMR Mgt & Excess conditions & no additional real-time OMR restrictions are active **Action:** OMR ≥ -6250 **Offramp:** Additional real-time OMR restriction triggered, SRCS surrogate >0.5%, risk analysis indicates need for more protective OMR, balanced conditions, or end of OMR Mgt											

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Action							**Summer-Fall Smelt Habitat**					
Maintain low salinity in Suisun Marsh (W and AN years)										**Trigger:** W or AN water year **Action:** Maintain X2 at 80 km		
SMSCG Operation for Delta Smelt Habitat (W, AN, and BN years)							**Trigger:** W, AN, or BN water year **Action:** Operate SMSCG for up to 60 days					

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Action	**D-1641 Fishery related export contraints**											
Vernalis 1 to 1					**Action:** exports ≤ 1500 or SJR (1:1) **Offramp:** 31 days after beginning of action							
Export to Inflow (EI) Ratio	EI ≤ 65%		EI ≤ 35% to 45%	EI ≤ 35%				EI ≤ 65%				

Color Key:
- **Export Constraints for Fishery Protection Provided in D-1641**
- **Protection Provided in SWP LTO above D-1641**
- **Actions Limiting Exports for Fishery Protection**
- **Actions Resulting in Increased Outflow**
- **Limited OMR Flex when Conditions Allow**

* Action can be initiated if a risk analysis indicates the need to trigger

Figure 3-4. Fish Protection Matrix

3.3.1.3 Real-time OMR Limits and Performance Objectives

DWR, in coordination with Reclamation, would operate to an OMR flow requirement that is more positive than a -5,000 cfs OMR flow based on conditions that would protect the following fish species and groups of species from entrainment:

- Longfin Smelt
- Delta Smelt
- Salmonids

The conditions for each of these species and species groups (salmonids) are described below.

Longfin Smelt Entrainment Protections

Additional Real-time Consideration for Adult Longfin Smelt

From onset of OMR protections for Adult Longfin Smelt through February 28, using the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment, DWR and CDFW will decide whether a more restrictive OMR flow requirement than -5,000 cfs is needed for adult Longfin Smelt protection.

After onset of OMR protections for Adult Longfin Smelt through February 28, DWR, in coordination with Reclamation, will ensure that the OMR flow 14-day running average is no more negative than -5,000 cfs unless:

1. During any time OMR flow restrictions for Delta Smelt are being implemented, this measure will not result in additional OMR flow requirements for protection of adult Longfin Smelt, or
2. When Longfin Smelt spawning has been detected in the system, adult Longfin Smelt migration and spawning action will terminate and Larval Longfin Smelt Entrainment Protection will be implemented, or
3. Adult Longfin Smelt migration and spawning action, including the OMR flow requirement, is not required or would cease if previously required when river flows are (a) greater than 55,000 cfs in the Sacramento River at Rio Vista or (b) greater than 8,000 cfs in the San Joaquin River at Vernalis, or
4. If subsequent to the high flows identified in number 3 above, flows go below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, the OMR flow in the adult Longfin Smelt migration and spawning action may resume if triggered previously and not precluded by another adult Longfin Smelt migration and spawning action off-ramp. In the implementation of this resumption, in addition to river flows, the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine relaxation or cessation of this OMR flow requirement.

Larval and Juvenile Longfin Smelt

From January 1 through June 30, when a single Smelt Larva Survey (SLS) or 20 mm Survey (20 mm) sampling period results in one of the following triggers, DWR in coordination with Reclamation will ensure the OMR flow 14-day running average is no more negative than -5,000 cfs:

- Longfin Smelt larvae or juveniles found in eight or more of the 12 SLS or 20 mm stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919), or
- Longfin Smelt catch per tow exceeds 15 Longfin Smelt larvae or juveniles in four or more of the 12 stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919).

If QWEST is negative and larval or monitoring detects juvenile Longfin Smelt within the corridors of the Old and Middle rivers, DWR will assess potential entrainment impacts of fish in the corridors of the Old and Middle rivers relative to their estuarine-wide distribution from monitoring data (e.g., SLS and Enhanced Delta Smelt Monitoring Program [EDSM] for larvae; 20 mm Survey and EDSM for juveniles) using Particle Tracking Model (PTM) runs weighted by the distribution in the surveys. In addition to PTM outputs, DWR will use real-time hydrological conditions, salvage data, forecast models (e.g., statistics-based models of historical data), other potential hydrodynamic models, and water quality to assess entrainment risk and to determine appropriate OMR flow targets to minimize entrainment or entrainment risk, or both. In coordination with CDFW, DWR will determine the best available models, the model inputs, and the assessment methods for determining larval and juvenile Longfin Smelt entrainment risk.

The process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine if an OMR flow protection target is warranted and determine the timing (e.g., days or weeks) and magnitude of the action. Implemented OMR flow management actions will continue until it is determined that the risk is abated based on changes in real-time conditions or until the off-ramp has been met as described in the “End of OMR Management” section below.

Off-Ramps for Larval and Juvenile Longfin Smelt Entrainment Protection

DWR will continue to manage OMR flows for the protection of Longfin Smelt until the off-ramp criteria have been met, as described in the “End of OMR Management” section below or until one of the following off-ramp criteria are met:

1. During periods when OMR flow restrictions for larval and juvenile Delta Smelt are being implemented, this measure shall not result in additional OMR flow requirements for protection of larval and juvenile Longfin Smelt, or
2. When river flows meet one of the following requirements, larval and juvenile Longfin Smelt protections would not trigger, or would be relaxed if triggered previously:
    - Greater than 55,000 cfs in the Sacramento River at Rio Vista
    - Greater than 8,000 cfs in the San Joaquin River at Vernalis

3. If subsequent to the high flows identified in (2), flows drop below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, larval and juvenile Longfin Smelt protection will resume if triggered previously. In implementing this resumption, in addition to river flows, the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine relaxation or cessation of this OMR flow requirement.

As Longfin Smelt are not a federally listed species and because DWR has limited control over OMR flows, DWR can take actions to make OMR flows more positive, but there are circumstances when the actual OMR flow may not respond to DWR's actions, particularly if the CVP is operating differently. DWR will make efforts to coordinate with Reclamation, but Reclamation is not legally required to comply with the Longfin Smelt operations. DWR will ensure that its proportional share of the OMR flow requirements described for Longfin Smelt are satisfied.

Delta Smelt Entrainment Protections

Turbidity Bridge Avoidance (South Delta Turbidity)

After the Integrated Early Winter Pulse Protection (above) or February 1 (whichever comes first), until when a spent female is detected or April 1 (whichever is first), DWR, in coordination with Reclamation, would 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 corridors of the Old and Middle rivers, where they are subject to high entrainment risk. 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 prespawning adult Delta Smelt. If the daily average turbidity at Bacon Island could not be maintained at less than 12 NTU, DWR, in coordination with Reclamation, would manage exports to achieve an OMR flow that is 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 flow that is less negative than -2,000 cfs does not reduce daily average turbidity at Bacon Island below 12 NTU in a given month, DWR, in coordination with Reclamation, may determine that OMR restrictions to manage turbidity are infeasible and will instead implement an OMR flow target that is deemed protective based on turbidity and adult Delta Smelt distribution and salvage, but will not a more negative OMR flow than -5,000 cfs.

DWR and Reclamation recognize that readings at individual sensors can generate spurious results in real time. Such changes could be incorrectly interpreted as a full turbidity bridge, when in fact the cause a result of local conditions or sensor error. To avoid excessive OMR restrictions during a sensor error or a localized turbidity spike, DWR, in coordination with Reclamation, will consider and review data from other locations and sources. Additional information that will be reviewed include regional visualizations of turbidity, alternative sensors, and boat-based turbidity mapping, particularly if there was evidence of a local sensor error.

The process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine if the OMR requirement could be off-ramped after 5-days of implementation of the Turbidity Bridge Avoidance action or to determine that this action is not warranted.

Larval and Juvenile Delta Smelt Protection

DWR, in coordination with Reclamation, will use results produced by life cycle models approved by CDFW and USFWS to manage the annual entrainment levels of larval and juvenile Delta Smelt. The USFWS models will be publicly vetted and peer reviewed prior to March 15, 2020. CDFW and 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 flow 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 period.

DWR, in coordination with Reclamation, CDFW, and USFWS 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 detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, Reclamation and DWR, or both, 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, DWR and Reclamation will manage exports to limit entrainment to be protective, based on the modeled recruitment levels. DWR, in coordination with Reclamation, 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 off-ramp criteria have been met, as described in the “End of OMR Management” section below. In the event the life cycle models cannot be operationalized in a manner that can be used to inform real-time operations, Reclamation, DWR, CDFW, and USFWS will coordinate to develop an alternative plan to provide operational actions protective of this life stage.

If CDFW does not agree with the operational actions determined above, the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine the appropriate action.

Salmonid Entrainment Loss Protections

Cumulative Loss Thresholds

DWR, in coordination with Reclamation, would target exceedance of cumulative loss thresholds over the duration of the 2019 BiOps for natural Winter-run Chinook Salmon, hatchery Winter-run Chinook Salmon, natural Central Valley Steelhead from December through March, and natural Central Valley Steelhead from April 1 through June 15.

DWR, in coordination with Reclamation, proposes to avoid exceeding cumulative loss thresholds by 2030 as follows:

- Natural Winter-run Chinook Salmon (cumulative loss = 8,738)
- Hatchery Winter-run Chinook Salmon (cumulative loss = 5,356)
- Natural Central Valley Steelhead from December through March (cumulative loss = 6,038)

- Natural Central Valley Steelhead from April 1 through June 15 (cumulative loss = 5,826).

Natural Central Valley Steelhead would be 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 do not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook Salmon is based on length-at-date criteria.

The cumulative loss thresholds would be based on the cumulative historical loss from 2010 through 2018. DWR and Reclamation's performance objectives are intended to avoid loss such that the cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.

If at any time prior to 2024, DWR, in coordination with Reclamation, were to exceed 50% of the cumulative loss threshold, DWR, in coordination with Reclamation, would convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.

In the year 2024, DWR, in coordination with Reclamation, would convene an independent panel to review the first 5 years of actions and determine whether continuing these actions is likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.

If during real-time operations, DWR, in coordination with Reclamation, were to exceed the cumulative loss threshold, DWR, in coordination with Reclamation, would immediately seek technical assistance from CDFW and NMFS, as appropriate, on the coordinated operation of the SWP and CVP, respectively for the remainder of the OMR management period. In addition, prior to the next OMR management season, DWR in coordination with Reclamation would convene an independent review panel to review the actions contributing to this loss trajectory and make recommendations for modifications or additional actions to stay within the permitted take.

Single-Year Loss Thresholds

In each year, DWR, in coordination with Reclamation, would avoid exceeding an annual loss threshold equal to 90% of the greatest salvage loss that occurred in the historical record from 2010 through 2018 for each of the following:

- Natural Winter-run Chinook Salmon (loss = 1.17% of juvenile production estimate [JPE])
- Hatchery Winter-run Chinook Salmon (loss = 0.12% of JPE)
- Natural Central Valley Steelhead from December through March (loss =1,414)
- Natural Central Valley Steelhead from April through June 15 (loss = 1,552)

Natural Central Valley Steelhead would be 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 is based on length-at-date criteria.

During the year, if SWP and CVP operations were to exceed the average annual loss threshold, DWR in coordination with Reclamation would review recent fish distribution information and operations with the fisheries agencies at the Water Operations Management Team (WOMT) and seek technical assistance on future planned operations. DWR, Reclamation, USFWS, NMFS, and CDFW could elevate an issue from WOMT to a Directors' discussion, as appropriate.

During the year, if SWP and CVP operations exceed 50% of the annual loss threshold, DWR, in coordination with Reclamation, would restrict OMR to a 14-day moving average OMR index that is no more negative than −3,500 cfs, unless the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment determines 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 -3,500 OMR flow operational criteria adjusted and informed by this risk assessment would remain in effect for the rest of the season. DWR and Reclamation would seek CDFW and 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 flow index that is no more negative than -2,500 cfs unless the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment determines 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 -2,500 OMR flow operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. DWR and Reclamation will seek CDFW and NMFS technical assistance on the risk assessment and real-time operations.

Regarding the risk assessments (identified above), the process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to 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 and entering the South Delta, fish detected in salvage, and relevant environmental conditions. Risks will be measured against the potential to exceed the next single-year loss threshold.

If during real-time operations, Reclamation and DWR were to exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from CDFW, USFWS, 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 would, prior to the next OMR management season, convene an independent panel to review the OMR Management Action. The purpose of the independent review would be to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the annual loss threshold, if any.

DWR, in coordination with Reclamation, would continue monitoring and reporting salvage at the Jones and Tracy fish facilities. DWR and Reclamation would continue the release and monitoring of yearling Coleman National Fish Hatchery (NFH) Late Fall-run and yearling Spring-run Chinook Salmon surrogates. DWR, in coordination with Reclamation, would use the reported real-time salvage counts along with qualitative and quantitative tools such as the “Salmonid Entrainment Model” to inform operations.

OMR Flexibility During Delta Excess Flow Conditions

DWR, in coordination with Reclamation, may operate to a more negative OMR flow but no more negative than -6,250 cfs on a 5-day average to capture excess flows in the Delta. Excess flows occur typically from storm-related events and are defined as flows in excess of that required to meet water quality control plan flow and salinity requirements and other applicable regulations. DWR, in coordination with Reclamation, would continue to monitor fish in real time and would operate in accordance with the “Additional Real-time OMR Restrictions,” previously described.

Figure 3-5 shows the physical checks that would preclude implementation of an OMR flexibility action. As shown, if any other OMR flow limit is active, an OMR flexibility action would be precluded.

Unless the following species protections occur, DWR has the discretion to capture excess flows if:

1. Integrated Early Winter Pulse Protection or additional real-time OMR restrictions are triggered and the required OMR flow is more positive or less negative than -5,000 cfs. Under such conditions, DWR and Reclamation have already determined that a more restrictive OMR flow is required.
2. An evaluation of environmental and biological conditions by DWR, in coordination with Reclamation, indicates more negative OMR would likely trigger an additional real-time OMR restriction.
3. Salvage of yearling Coleman NFH Late Fall-run (as yearling Spring-run Chinook Salmon surrogates) exceeds 0.5% within any of the release groups.
4. DWR, in coordination with Reclamation, identifies changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those anticipated to occur under OMR management.

DWR, in coordination with Reclamation, would continue to monitor conditions and could resume management of OMR flows to levels no more negative than −5,000 cfs if conditions indicate the defined off-ramps are necessary to avoid additional adverse impacts.

End of OMR Management

OMR flow criteria may control operations until June 30 or when the following species-specific off-ramps have occurred, whichever is earlier.

- Longfin Smelt and Delta Smelt: When the daily mean water temperature at the CCF reaches 77 degrees Fahrenheit (°F) (25 degrees Celsius [°C]) for 3 consecutive days.
- Salmonids: When more than 95% of Winter-run Chinook Salmon and Spring-run Chinook Salmon have migrated past Chipps Island, as determined by DWR and Reclamation’s monitoring working group, or after daily average water temperatures at Mossdale exceed 72°F (22.2 °C) for 7 days during June (the 7 days do not have to be consecutive).

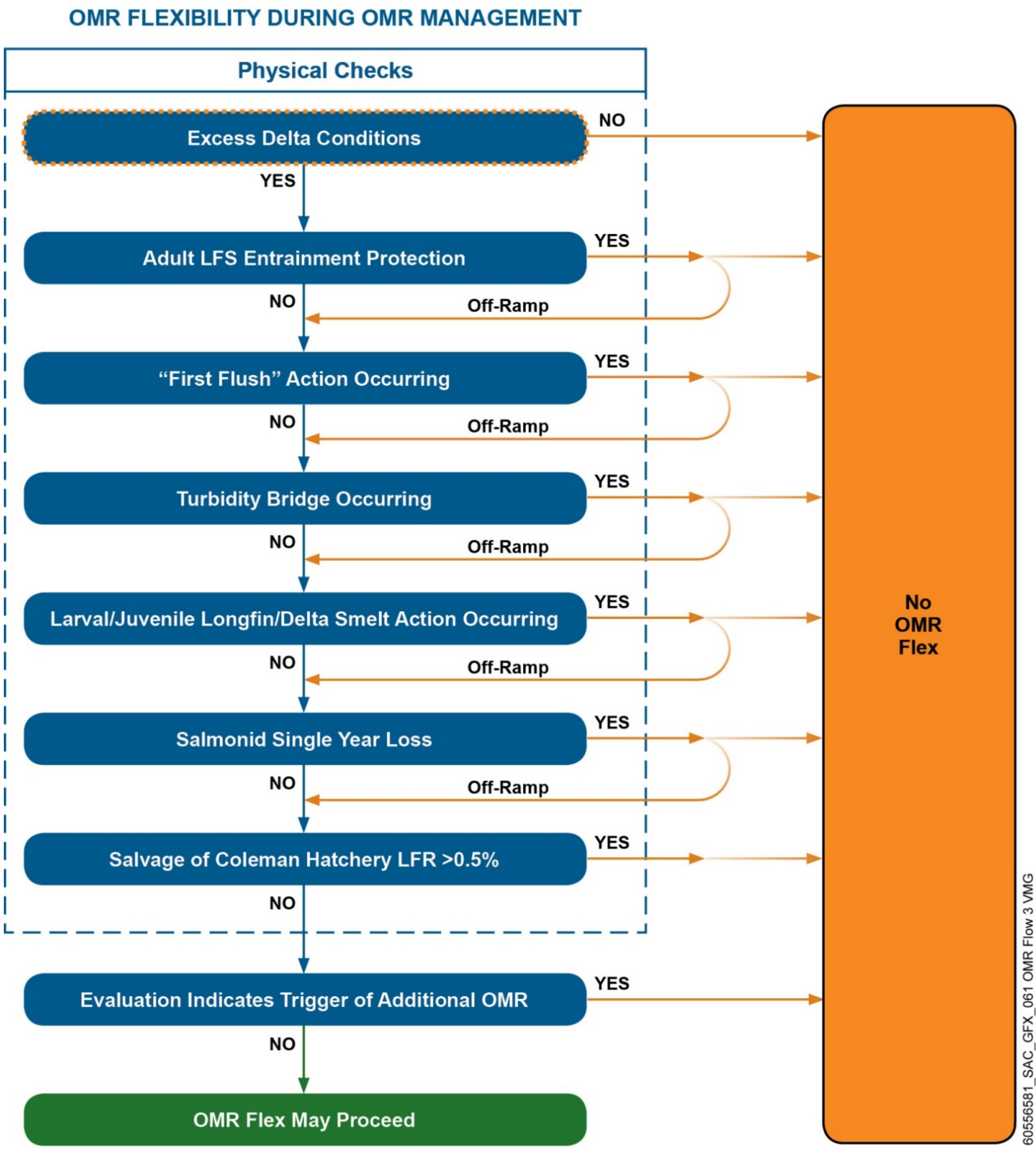

Figure 3-5. OMR Flexibility During OMR Management

Real-Time Decision-Making and Loss 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, USFWS, and CDFW if they desire to operate to a more negative OMR flow than what is specified in "Additional Real-Time OMR Limits and Performance Objectives." Upon mutual agreement, the Directors of NMFS and USFWS may authorize DWR and Reclamation to operate to a more negative OMR flow than the "Additional Real-Time OMR Restrictions," but no more negative than -5,000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR flow than the "Additional Real-Time OMR Restrictions," but no more negative than -5,000 cfs. This process would be separate from the risk analysis process described above.

The process described in Section 3.3.1.1, Collaborative Real-time Risk Assessment will be used to determine the DWR's operational action.

3.3.2 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.

3.3.3 Delta Smelt Summer-Fall Habitat Action

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model states that Delta Smelt habitat should include low-salinity conditions of 0 to 6 parts per thousand (ppt), turbidity of approximately 12 NTU, temperatures below 25°C, food availability, and littoral or open water physical habitats (FLaSH Synthesis:15–25). The Delta Smelt Summer-Fall Habitat Action is being undertaken recognizing that the highest-quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Summer-Fall Habitat Action is to provide the aforementioned habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

DWR and Reclamation 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.
- Establish contiguous low-salinity habitat from Cache Slough Complex to Suisun Marsh.

The action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline at 80 km (X2) from the Golden Gate in above-normal and wet water years in September and

October. DWR and Reclamation will also implement additional measures that are expected to achieve additional benefits. These measures include, but are not limited to:

- Suisun Marsh Salinity Control Gates (SMSCG) operations for up to 60 days (not necessarily consecutive) in June through October of below-normal and above-normal years. This action may also be implemented in wet years, if preliminary analysis shows expected benefits.
- Food enhancement action (for example, those included in the Delta Smelt Resiliency Plan to enhance food supply). These projects include the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation). DWR and Reclamation will monitor dissolved oxygen at Roaring River distribution system drain location(s) during Delta Smelt food distribution actions.

These considerations (listed above) and 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 Delta Smelt 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. In every action year, Reclamation and DWR will propose, based on discussions with the USFWS and CDFW, a suite of actions that would meet the action's environmental and biological goals. This action would be coordinated with Reclamation and categorized as an in-basin use for COA purposes. In the event that Reclamation does not meet its share of the Delta outflow to meet 80 km X2, DWR will implement its share of this action.

3.3.3.1 FOOD ENHANCEMENT SUMMER-FALL ACTIONS

North Delta Food Subsidies and Colusa Basin Drain Project: DWR proposes to implement actions to improve flow conditions in the North Delta in summer and fall, thereby facilitating downstream transport of phytoplankton and zooplankton. While the Cache Slough Complex and the lower Yolo Bypass are known to have relatively high levels of food resources, local water diversions create net negative flows during summer and fall that may inhibit downstream food transport. By enhancing summer and fall flows through the Yolo Bypass, downstream transport of food could be improved.

DWR and partners would test two different ways to improve flow conditions in the North Delta. For the first approach, water would be provided by Sacramento River water districts, such as Reclamation District 108 and Glenn Colusa Irrigation District. The water districts would use their facilities to move freshwater into Colusa Drain. By adjusting the operations of Knights Landing Outfall Gates and Wallace Weir, much of this water would be routed into the Yolo Bypass.

The second approach would use agricultural drain water in fall, which is available in fall when valley rice fields discharge irrigation water at the end of the growing season. Agricultural drain water would be routed into the Yolo Bypass via Knights Landing Ridge Cut.

DWR proposes flow pulses would include summer actions using fresh Sacramento River water and fall actions using agricultural drain water from Colusa Drain. Initial results suggest that a target pulse of 27 TAF over a 4-week period would improve downstream transport of phytoplankton. This flow volume is not sufficient to inundate the floodplain in the Yolo Bypass, nor would it constitute a consumptive use of water because the water used for this action would be allowed to move through the North Delta and contribute to Delta outflow.

This food subsidy action is an adaptive management action that relies on monitoring and evaluation in order to optimize its efficacy. Similarly, the action depends on partnerships with local water users including Reclamation District 108, Glenn Colusa Irrigation District, Conaway Ranch, and Swanston Ranch. All actions should be developed in consultation with the needs of local water users and landowners. Food enhancement action design and implementation would be determined through the Summer-Fall Adaptive Management process.

Roaring River Distribution System Reoperations: 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.

3.3.3.2 Delta Smelt Summer-Fall Habitat Action Adaptive Management Planning

Conceptual Model

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to improved Delta Smelt habitat conditions. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0 to 6 ppt, turbidity of approximately 12 NTU, temperatures below 25°C (77 °F), food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Habitat Action is being undertaken recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Habitat Action is to provide these habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

Planning Process

The adaptive management process would be investigating the way in which SWP-CVP operations interact with the full range of components of Delta Smelt habitat. The process would be investigating the extent that providing flow and/or low salinity conditions of various volumes and locations improves the quality and quantity of Delta Smelt habitat in the summer and fall, and whether Delta Smelt survival, viability, and/or abundance improves in relation to the Delta Smelt Habitat Actions. The planning process will also consider other tradeoffs, including effects on other species.

An adaptive management plan will be developed following issuance of the Notice of Determination (NOD). The framework for the adaptive management plan is as follows:

- DWR and Reclamation shall form a Delta Coordination Group (Reclamation, DWR, USFWS, NMFS, CDFW, and representatives from federal and state water contractors).
- The Delta Coordination Group would use one of the existing structured decision-making models or adopt a new model to analyze proposed summer-fall habitat actions, making predictions regarding the potential outcomes for various implementation scenarios. This structured decision-making process would inform each year's Habitat Action Plan.
- Within 6 months of signing the NOD, the Delta Coordination Group would meet to select a structured decision-making model and complete initial model runs (and annual model runs thereafter) testing various approaches to satisfying the environmental and biological goals, using the available tool box of approaches.
- Each year, the Delta Coordination Group would develop a Habitat Action Plan accounting for forecasted hydrology and temperatures over the summer and fall. The Habitat Action Plan would describe how the proposed action would meet the environmental and biological goals of the action. The Habitat Action Plan would include the hypotheses to be tested, the suite of actions and operations to test the hypotheses, and the expected outcomes. The Habitat Action Plan would be informed by the annual results of the structured decision-making process. In recognition of the time required for annual planning, the Habitat Action Plan process would occur every year so the Plan would be prepared in time for review by the USFWS and CDFW in the event the action is triggered.
- CDFW and USFWS would review the Habitat Action Plan in each year in which an action is triggered and confirm that the impacts of the action are within what was analyzed in the BiOp and the California Fish and Game Code Section 2081 permit, and that the action is consistent with the project description.
- After the completion of each summer-fall habitat action, DWR and Reclamation will share preliminary monitoring results through the Delta Coordination Group. At the beginning of the next water year, DWR and Reclamation would provide a synthesis of the monitoring results to the Delta Coordination Group. The Delta Coordination Group would review the synthesis of results and use the results of the monitoring to inform a subsequent structured decision-making modeling exercise using the tool box of available approaches.
- The Delta Smelt Summer-Fall Habitat Action would be included in the Four-Year Reviews under the Governance section of this Proposed Action. The structured decision-making model and the multi-year science and monitoring plan would be part of this Peer Review.

3.3.4 Real-time Water Operations Process

DWR, in coordination with Reclamation, would implement activities, monitor performance, and report on compliance with the commitments in the Proposed Project. Implementing the proposed action would require coordination between CDFW, DWR, USFWS, NMFS, Reclamation, and the SWP-CVP water contractors. The federal government is proposing a Real-Time Operations Charter to facilitate federal coordination with the State.

Investments in science, monitoring, and decision support tools since the 2008 and 2009 federal Biological Opinions, state Consistency Determinations, and the Fish and Game Code Section 2081 permit for Longfin Smelt provide the ability to reduce reliance on professional opinion and increase the use of qualitative and quantitative models to assess risk in real time based on the real-time monitoring of species and relevant other physical and biological factors. While DWR and Reclamation hold the responsibility for operating the SWP and CVP in a coordinated manner, many agencies and organizations assist in monitoring field conditions to provide information that assists in real-time decisions. Communication on real-time conditions and the implementation of water operations provides assurance that DWR, in coordination with Reclamation, is meeting the commitments within the Proposed Project.

Portions of the Proposed Project rely on real-time monitoring to inform DWR and Reclamation on how to minimize and/or avoid stressors on listed species. The Proposed Project seeks to take advantage of the expertise within the state and federal fish agencies in the real-time monitoring of species distribution and life stage. DWR, in coordination with Reclamation, would then use qualitative and quantitative tools to perform risk analyses that inform operations. Actions to address stressors in real-time include Old and Middle River Flow Management.

Some elements of the Proposed Project include seasonal input by the state and federal regulatory agencies on scheduling actions to benefit the fishery. Actions requiring seasonal input from CDFW include the Delta Smelt Summer-Fall Habitat Action.

DWR, in coordination with Reclamation, would demonstrate compliance with the commitments of the Proposed Project and provide sufficient information for evaluation of federal initiation triggers through regular monitoring and reporting. New information and changing conditions may exceed a federal reinitiation trigger and could require subsequent federal ESA Section 7 consultation. As the SWP and CVP must coordinate operations, a federal reinitiation of Section 7 consultation would require discussions with CDFW and possible need for a permit amendment.

- Real-Time Operation participants
- Action Agencies: DWR and Reclamation
- Regulatory Agencies: USFWS, NMFS, CDFW, SWRCB, USACE
- Stakeholders: state and federal water contractors
- Decision-Making for Real-Time Operations

Nothing in this project description modifies the rights and responsibilities of the agencies. Decisions shall be made consistent with the authorizing legislation and the regulations and policies under the federal and state Endangered Species Acts, as appropriate.

DWR and Reclamation shall retain sole discretion for:

- Water Operations of the SWP and CVP, including allocations, under Reclamation Law and the State Water Project, as appropriate
- Agency appropriations (budget requests, fund alignment, contracting, etc.)

- Section 7 Action Agency and Applicant (consultation)
- Coordination and cooperation with Public Water Agencies (PWAs) as required by contracts and agreements

CDFW, USFWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate and the associated Incidental Take Statements/Permits
- Agency Appropriations

State Water Resources Control Board shall retain the sole discretion for:

- Enforcement as allowable under federal and state law (e.g., Clean Water Act and Porter-Cologne Water Quality Control Act)

State and federal water contractors shall retain all existing authority and discretion, and are participating in a technical and policy advisory capacity.

DWR would continue to coordinate with USACE, as appropriate, under existing permits as wells as in venues such as the Interagency Ecological Program. Other agencies (e.g., the U.S. Geological Survey [USGS]) may also be involved in monitoring physical conditions in the Delta.

3.3.4.1 Annual Process

Reclamation and DWR will continue to provide standard reporting on real-time operations, environmental conditions, and biological parameters, such as species distribution, life stage, and dynamics. These data are available daily through Reclamation and DWR websites and additional tools such as CDEC, NWIS, RWIS, SacPAS, Bay-Delta Live, and SHOWR.

Monitoring for the proposed real-time management include:

- Delta flow, temperature, and salinity stations
- Chinook Salmon biological information:
  - Juvenile abundance and timing: Implementation of OMR management (Sacramento Trawl and Chipps Island Trawl)
  - Delta distribution: Informs OMR actions and is currently supported through beach seines, acoustic tagging, and EDSM
  - Salvage count: Informs the direct impacts on listed fish
  - Genetic identification: Informs the salvage of listed Chinook Salmon species versus non-listed Chinook Salmon species.
- Delta Smelt biological information:
  - Turbidity stations: Inform the potential for a "turbidity bridge" that would inform OMR actions.
  - Temperature stations: Informs the transition between life stages and the need for protective measures.

  - Water quality stations: Track the movement of the low salinity zone and parameters associated with the food web (e.g., chlorophyll)
  - Delta distribution: Informs the entrainment risk due to OMR actions and would be supported by EDSM.
  - Fish condition: Informs when adults have spawned and the need for larval protections.
- Longfin Smelt biological information:
  - Water quality stations: Track the movement of the low salinity zone and parameters associated with the food web (e.g., chlorophyll)
  - Delta distribution: Informs the entrainment risk due to OMR actions.
  - Fish condition: Informs when adults have spawned and the need for larval protections

Status and Trend Monitoring

Status and trend monitoring characterizes the population of species and their environments over time including the impacts of stressors from sources other than the CVP and SWP. Recovery plans characterize the status and trends differently depending upon the species in the general categories of abundance, production, life history diversity, and geographic diversity. In addition to the Core Monitoring, a number of additional programs are anticipated to continue and will continue to be funded by DWR. The majority of monitoring programs are supported by Reclamation and DWR for CVP, SWP, and Delta watersheds:

- Hatchery Proportion (Constant Fractional Marking)
- Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries
- Fall Midwater Trawl
- 20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin Smelt
- Spring Kodiak Trawl
- Estuarine and Marine Fish Abundance and Distribution Survey
- Smelt Larva Survey (SLS)
- Summer Townet Survey
- Environmental Monitoring Program (EMP)

The coordinated operation of the SWP requires the following deliverables throughout the year. In addition to those identified herein, Reclamation would have additional deliverables that would be provided to USFWS and NMFS related to the operation of the CVP.

DWR and Reclamation will provide products on the schedule identified below:

1. Monitoring Program for Core Water Operations, Ongoing
2. December through June, Weekly and Biweekly, Real-Time Species Distribution and Life Stage

3. Monthly (and as needed), Water Operation Status
4. Monthly (and/or as needed), Specific operations for:
   - Old and Middle River Reverse Flow Storm Events (December through June)
   - Delta Smelt Fall Habitat and Suisun Marsh Salinity Control Gates (May)
5. Seasonal and Annual Compliance Reporting
   - September, Annual Summary of Water Supply and Fish Operations

3.3.5 Monitoring Workgroups

DWR and Reclamation would continue to convene Monitoring Workgroups as needed. Reclamation would be solely responsible for convening Watershed Workgroups for each of the Upper Sacramento, American, and Stanislaus watersheds. Each of Reclamation's Watershed Workgroups would be responsible for real-time synthesis of fisheries monitoring information and providing recommendations on scheduling specific volumes of water for restorations actions described in the federal proposed action. DWR, in coordination with Reclamation, would convene the Delta Monitoring Workgroup which would be responsible for integrating species information across watersheds, including Delta Smelt, Winter-run Chinook Salmon and other salmonids and sturgeon. In addition to the Delta Monitoring Workgroup, the program may include a Smelt Monitoring and Salmonid monitoring teams. The Delta Monitoring Workgroup will include technical representatives from federal and state agencies and stakeholders and will provide information to DWR and Reclamation on species abundance, species distribution, life stage transitions, and relevant physical parameters.

A Water Operations Team (WOMT) comprised of agency managers will coordinate on overall water operations to oversee the implementation of various real-time provisions. The WOMT shall be responsible for overseeing the Watershed Monitoring Workgroups and elevating disagreements to the Directors of CDFW, DWR, Reclamation, USFWS and NMFS, where necessary. The coordinated state and federal monitoring group structure is as follows:

- Directors
- WOMT
- Delta Monitoring Workgroup
  - Smelt Monitoring Team
  - Salmon Monitoring Team
  - Program Teams

The WOMT shall coordinate the preparation of seasonal and annual reporting in coordination with the Watershed Monitoring Teams.

DWR would continue to coordinate with the Interagency Ecological Program for permitting and coordination for physical and biological monitoring. It would also continue to coordinate with the Collaborative Science and Adaptive Management Program for synthesis of monitoring and studies. In the event that either of these groups is unwilling or unable to provide for the commitments in the

Proposed Project, DWR (in coordination with Reclamation) would confer with CDFW, USFWS, and NMFS on alternative implementation plans.

3.3.6 Four-Year Reviews

In January of 2024 and January of 2028, DWR, in coordination with Reclamation, would convene an independent panel to review OMR management and measures to improve survival through the South Delta and the Delta Smelt Summer-Fall Habitat Action.

Establishment of independent review panels composed of subject matter experts is a key component of DWR proposed adaptive management approach to operation of the SWP CDFW, NMFS, and USFWS may provide technical assistance and input regarding the panel and its panel charge. The panel would evaluate the efficacy of these and other project actions and make recommendations.

The independent panels would review actions for consistency with applicable guidance and will provide information and recommendations to DWR. DWR, in consultation with Reclamation, will provide the results of the independent review to CDFW, NMFS, and USFWS. DWR will coordinate with Reclamation to document a response to the independent review.

3.3.7 Drought and Dry Year Actions

DWR shall coordinate with Reclamation to develop a voluntary toolkit of drought actions that could be implemented at the discretion of DWR and/or Reclamation. On October 1st, if the prior water year was dry or critical, DWR, in coordination with Reclamation, shall meet and confer with USFWS, NMFS, CDFW, and Public Water Agencies on voluntary measures to be considered if drought conditions continue into the following year. If dry conditions continue, DWR, in coordination with Reclamation, will regularly meet with this group (and potentially other agencies and organizations) to evaluate hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit) for the water year.

By February of each year following a critical hydrologic year type, DWR, in coordination with Reclamation, shall report on the measures employed and assess their effectiveness. The toolkit shall be revisited at a frequency of not more than 5-year intervals.

3.3.8 Continued Installation of South Delta Temporary Barriers

DWR proposes to continue operating three temporary agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year, when necessary to maintain operations of agricultural water users. These three rock barriers are designed to act as flow control structures, trapping tidal waters behind them after a high tide. These barriers improve water levels and circulation for local South Delta farmers and collectively are referred to as agricultural barriers.

The objectives of operating the three temporary barriers are to increase water levels, circulation patterns, and water quality in the South Delta area for local agricultural diversions. DWR installs and removes the temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 mile south of the confluence of the Middle River, Trapper Slough, and the North Canal
- Old River near Tracy, approximately 0.5 mile east of the Delta-Mendota Canal intake
- Grant Line Canal, approximately 400 feet east of the Tracy Boulevard Bridge

The agricultural barriers will continue to be installed under existing permits starting in May provided San Joaquin River flow at Vernalis is low enough to enable installation, typically less than 5,000 cfs. All three agricultural barriers operate until the fall and must be completed removed by November 30 of each year. Full closure of the Grant Line Canal Barrier requires NMFS, USFWS, and CDFW approval and a demonstrated need for the full closure based on actual conditions and modeling. Barriers would include at least one open culvert, to allow fish passage when water temperatures are less than 22°C (77 °F).

DWR is not proposing to install Head of Old River Barrier as part of this consultation.

3.3.9 Barker Slough Pumping Plant Operations

BSPP diverts water from Barker Slough into the NBA for delivery in Napa County and to the Solano County Water Agency (SCWA). The NBA intake is approximately 10 miles from the Sacramento River at the northwest end of Barker Slough. The maximum pumping capacity of this facility is 175 cfs. The annual maximum diversion is 125 TAF.

DWR will work with the USFWS to develop Delta Smelt minimization measures. 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.

BSPP will be operated to protect larval Longfin Smelt from January 15 through March 31 of dry and critically dry years. The Water Year type is as defined in D-1641 for the Sacramento River Basin. If the Water Year type changes after January 1 to below normal, above normal, or wet, this action will be suspended. If the Water Year type changes after January to dry or critical, this action will occur.

DWR personnel in coordination with CDFW staff will review weekly the abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk and detection of larval Longfin Smelt at Station 716. When conditions warrant it, BSPP's maximum 7-day average will not exceed 60 cfs from January 15 through March 31 within 5 days. During the 5-day period, the rate of diversion at BSPP will not increase. This restriction will be removed when larval Longfin Smelt are no longer detected at Station 716.

Operation of BSPP also includes ongoing maintenance of the facility. Maintenance activities included in the Proposed Project include fish screen cleaning, sediment removal, and aquatic weed removal. Each of these activities is described below.

3.3.9.1 Fish Screen Cleaning

The 10 pump bays are 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. The screens are routinely cleaned to prevent excessive head loss and minimize increases in localized approach velocities (CDFG 2009).

3.3.9.2 Sediment Removal

Sediment accumulated on the concrete apron in front of the fish screen and in the pump wells behind the fish screen would be removed by suction dredge. Removal of sediment from within the pump wells would occur as needed, year-round.

Removal of sediment from the front apron would occur during summer and early fall months and during the annual NBA shutdown in March. The NBA is annually taken off-line for one to two-weeks for routine maintenance and repairs, and the BSPP is non-operational during this period.

Sediment would be tested and disposed at a suitable location or existing landfill.

3.3.9.3 Aquatic Weed Removal

Aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the BSPP pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to two aggregate base spoil sites located near the pumping plant.

Removal of aquatic weeds from the BSPP fish screens would typically occur during summer and fall months when aquatic weed production is highest. Floating aquatic vegetation, i.e., water hyacinth, may need to be removed during spring months if water hyacinth becomes entrained into Barker Slough and accumulates in front of BSPP fish screens.

3.3.10 Clifton Court Forebay Operations

Clifton Court Forebay operations included in the Proposed Project include predator management and aquatic weed removal and disposal. Each of these operations is described below.

3.3.10.1 Predator Management

Fish entering the CCF must travel approximately 2.1 miles across the CCF to reach the Skinner Fish Facility. The loss of fish between the CCF Radial Gates and the Skinner Fish Facility is termed pre-screen loss (PSL). PSL includes, but is not limited to, predation by fish, birds, and other predatory species. Studies conducted by DWR and CDFW indicate that PSL of juvenile Chinook Salmon varies from 63% to 99% (Gingras 1997) and PSL of juvenile steelhead was 82 ± 3% (Clark et al. 2009). Predation by Striped Bass is thought to be the primary cause of high PSL in the CCF (Brown et al. 1996, Gingras 1997, Clark et al. 2009).

DWR proposes to continue the development of predator control methods within CCF including, but not limited to:

- Continued evaluation of the performance of various predator relocation methods
- Controlling aquatic weeds

Clifton Court Forebay Predator Studies

The Enhanced Predatory Fish Removal and Relocation Study is a combination of the most effective predator removal elements of previous predator reduction efforts; the Clifton Court Forebay Predation Study, the Predator Reduction Electrofishing Study, and the Predator Fish Relocation Study. The intent of this interim measure is to maximize the removal of predators from Clifton Court Forebay and relocate them to Bethany Reservoir, thereby reducing pre-screen losses.

3.3.10.2 Aquatic Weed Removal and Disposal

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in the CCF (Table 3-4). Herbicides may include Aquathol K or copper-based herbicides. Algaecides may include peroxygen-based algaecides (e.g., PAK 27). These products are used to control algal blooms that can degrade drinking water quality through production of taste and odor compounds or algal toxins. Dense growth of submerged aquatic weeds can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trash racks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trash racks and vertical louver array. The resulting blockage necessitates a reduction in the pumping rate of water to prevent potential equipment damage through cavitation at the pumps and excessive weight on the louver array causing collapse of the structure. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the SWP. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF (see Section *3.11.3, Skinner Fish Facility Improvements*).

Table 3-4. Methods to Control Aquatic Weeds and Algal Blooms in Clifton Court Forebay

Algae and Weed Treatments	Control Target	Period of Use	Limits to Application	Other Conditions of Use
Aquathol K, an endothall-based aquatic herbicide and Copper-based compounds, including copper sulfate pentahydrate and chelated copper herbicides	Pondweeds, Egeria densa, cyanobacteria, and green algae	As needed, from June 28 to August 31	The herbicide application would not begin until after the radial gates have been closed. Applications of Aquathol K for pondweed control will be applied at a concentration of 2 to 3 ppm. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1ppm with an expected dilution of 0.75 ppm dispersal in the water column. Application for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. The radial gates would remain closed for 12 to 24 hours after completion of the application.	The radial intake gates at the entrance to the CCF would be closed before application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta. The radial gates would remain closed for a minimum of 12 and up to 24 hours after treatment, to allow the recommended contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the CCF, and to reduce residual endothall concentrations for drinking water compliance. The radial gates would be re-opened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure). No more than 50% of the surface area of CCF will be treated at one time. Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per NPDES permit requirements, will be collected before, during and after application.
-	-	As needed, prior to June 28 or after August 31, when the average daily water temperature in the CCF is at or above 77°F (25°C)	When the average daily water temperature in the CCF is at or above 25°C, and when Delta Smelt and salmonid protective measures are not activated: prior to treatment outside the June 28 to August 31 time frame, DWR would notify and confer with CDFW, NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment. The herbicide application would not begin until after the radial gates have been closed. The radial gates would remain closed for 12 to 24 hours after completion of the application. Herbicides application concentrations will remain the same.	If the average daily water temperature in the CCF is at or above 25°C and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment as agreed by CDFW, NMFS and USFWS: close the radial intake gates at the entrance to the CCF before the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta

Algae and Weed Treatments	Control Target	Period of Use	Limits to Application	Other Conditions of Use
Aquathol K and Copper-based herbicides, continued	Pondweeds, Egeria densa, cyanobacteria, and green algae	As needed, prior to June 28 or after August 31, when the average daily water temperature in the CCF is below 77°F (25°C)	During periods of activated Delta Smelt and salmonid protective measures when the average daily water temperature in the CCF is below 25°C, if the following conditions are met: prior to treatment outside the June 28 to August 31 time frame, DWR would notify and confer with CDFW, NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment. The herbicide application would not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival in the CCF (e.g., after predicted mortality has occurred because of predation or other factors) has been exceeded. The radial gates would remain closed for 24 hours after completion of the application, unless it is agreed that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present in the CCF. Herbicides application concentrations will remain the same.	If the average daily water temperature in the CCF is below 25°C and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment as agreed by CDFW, NMFS and USFWS: close the radial intake gates at the entrance to the CCF before the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta
Peroxygen-based algaecides (e.g., PAK 27)	Cyanobacteria	As needed, year-round	The radial gates would be closed before the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may be re-opened immediately after the treatment, as the required contact time would be less than 1 minute and no residual by-product of concern would exist. Applied concentrations will be in the range of 0.3 to 10.2 ppm hydrogen peroxide.	No more than 50% of the surface area of CCF will be treated at one time. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.

Notes:
°C = degrees Celsius
CCF = Clifton Court Forebay
CDFW = California Department of Fish and Wildlife
DWR = California Department of Water Resources
ESA = federal Endangered Species Act
NMFS = National Marine Fisheries Service
NPDES = National Pollutant Discharge Elimination System
ppm = parts per million
USFWS = U.S. Fish and Wildlife Service

Mechanical Removal

Mechanical methods are used to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trash racks. During high weed load periods such as late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trash racks and louvers. The objective is to decrease the weed load on the trash racks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical weed harvester ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading sites, unsafe field conditions such as high winds, and equipment maintenance.

Aquatic Herbicide Application

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HABs), or the concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications. Treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. To effectively treat a dynamic aquatic weed assemblage and HABs, multiple aquatic pesticide compounds are required to control aquatic weeds and algal blooms in the CCF. The preferred products are the following:

- Aquathol K, an endothall-based aquatic herbicide that is effective on pondweeds
- Copper-based compounds that are effective on *E. densa*, cyanobacteria, and green algae; copper-based aquatic herbicides, including copper sulfate pentahydrate and chelated copper herbicides
- Peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria

Aquathol K

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12 to 48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis.

Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling E. densa.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in the CCF and in other lakes. Endothall has low acute and chronic toxicity effects on fish. The LC50 for salmonids is 20 to 40 times greater than the maximum concentration allowed to treat aquatic weeds. The U.S. Environmental Protection Agency (EPA) maximum concentration allowed for Aquathol K is 5 ppm. A recent study (Courter et al. 2012) of the effect of Cascade® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9 to 12 ppm, that is, two to three times greater than the 5 ppm maximum concentration allowed by the EPA and about four to six times greater than the 2 to 3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9 to 12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead, and other fish. No studies have assessed the exposure risk to Green Sturgeon.

When aquatic plant survey results indicate that pondweeds are the dominant species in the CCF, Aquathol K will be selected due to its effectiveness in controlling these species. Aquathol K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments is 2 to 3 ppm, which is well below the concentration of 9 to 12 ppm where sublethal effects have been observed (Courter et al. 2012). DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. There is no "real time" field test for endothall. No more than 50% of the surface area of the CCF will be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for National Pollutant Discharge Elimination System (NPDES) compliance purposes.

Copper Based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that E. densa is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. Application of Aquathol K does not affect *E. densa*. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of the CCF will be treated at one time.

Peroxygen-based Algaecides

The PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27, or an equivalent product, will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of the CCF will be treated at one time.

Herbicide Application Procedure

The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in the CCF:

- Apply Aquathol K and copper-based aquatic pesticides, as needed, from June 28 to August 31.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperature within the CCF is at or above 77°F (25°C) and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment, as confirmed by NMFS and USFWS.
    - Prior to treatment outside of the June 28 to August 31 time frame, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures and when the average daily water temperature in the CCF is below 77°F (25°C) if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 time frame, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.

- The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within the CCF (e.g., after predicted mortality has occurred due to predation or other factors) has been exceeded.
    - The radial gates remain closed for 24 hours after the completion of the application unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
- There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in the CCF during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in the CCF.
- For Aquathol K and copper compounds, the radial intake gates will be closed at the entrance to the CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol K and copper compounds, the radial gates will remain closed for a minimum of 12 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the forebay, and to reduce residual endothall concentration for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage.) Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment, as the required contact time is less than 1 minute and there is no residual by-product of concern.
- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.
    - Boat applications will be by subsurface injection system for liquid formulations and by a boat-mounted hopper dispensing system for granular formulations. Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
    - Aerial applications of granular and liquid formulations will be by helicopter or aircraft. No aerial spray applications will occur during wind speeds above 15 mph to prevent spray drift.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50% of the CCF will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per the NPDES permit requirements, will be collected before, during and after

application. Additional water quality samples may be collected during the following treatment for drinking water compliance purposes. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.

- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual by-product of concern. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and steelhead in the Central Valley's Delta region and of Delta Smelt. Green Sturgeon are present in the area year-round. Migrations of juvenile Winter-run Chinook Salmon and Spring-run Chinook Salmon primarily occur outside of the summer period in the Delta. Central Valley Steelhead have a low probability of being in the South Delta during late June, when temperatures exceed 77°F (25°C), through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta Smelt are not expected to be in the CCF during this time period. Delta Smelt are not likely to survive when water temperatures reach a daily average of 77°F (25°C), and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook Salmon, Central Valley Steelhead, and Delta Smelt during the proposed herbicide treatment time frame in the CCF is negligible.

Additional protective measures will be implemented to prevent or minimize adverse impacts from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within the CCF. The radial intake gates to the CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. In addition, following the gate closure and prior to the applications of Aquathol K and copper-based pesticides, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, lowers the water level in the CCF to decrease the total amount of herbicide needed to be applied per volume of water, and aids in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of the CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via the Banks Pumping Plant will reduce the exposure time of any ESA-listed fish species present in the CCF.

Avoidance and Minimization Practices

DWR implements the following best management practices during aquatic weed harvesting at the CCF to avoid and minimize potential impacts on sensitive resources:

- A pre-construction survey for nesting birds and burrowing owls is conducted by a qualified biologist within 2 weeks prior to the start of work. If burrowing owls are observed within 500 feet of the

Proposed Project, non-disturbance buffers are established and/or a qualified biological monitor is present during disposal activities.

- On the first day of work, and as needed once work has begun, a qualified biologist surveys for floating grebe nests within the CCF and identifies avoidance areas to prevent take of nests.
- All on-site personnel participate in environmental awareness training for special-status species with the potential to occur in the project area.
- If any wildlife is observed within the aquatic weed removal and disposal areas, work is halted immediately and the wildlife are allowed to move out of the area on their own.
- Work does not take place during rain events or within 24 hours of significant precipitation when special-status species could potentially be traveling to breeding ponds.
- Aquatic weed disposal and vehicle travel is contained within the established roadways and identified work area.

3.3.11 Skinner Fish Facility Improvements

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 then are returned to the Delta in oxygenated tank trucks. The sampling frequency at Skinner Fish Facility is generally 30 minutes of every 2 hours, but may be reduced based upon the presence of excessive numbers of fish or debris based upon procedures developed by CDFW. See Appendix G of the 2019 Biological Assessment for a summary of study results (Reclamation 2019).

DWR proposes to continue to salvage fish with the Skinner Fish Facility which is located about 2 miles upstream from the Banks Pumping Plant. In addition, DWR proposes the following:

- Operational changes to salvage release scheduling and location to reduce post-salvage predation
- Continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival

3.3.12 Longfin Smelt Science Program

CDFW, DWR and the State Water Contractors (SWC) entered into an agreement in 2014 to implement a multiyear Longfin Smelt Science Program. The Longfin Science Program was described in a Study Plan that identified the Napa River, Coyote Creek, and other areas that required further study of environmental factors affecting the species distribution and reproduction. In addition, the Study Plan focused studies on sampling efficiency, including time of day, water transparency, and tidal conditions. The Study Plan was intended to address eight research questions, six of which will be examined over the course of an initial 5-year period of field study and data analysis. The Longfin Smelt Science Program would be continued. An updated Study Plan would be developed jointly with DWR, CDFW and the SWC and would address issues that include external issues influencing population abundance, distribution, and catchability, including vertical migration behavior and water transparency and other factors that support growth and survival. A primary goal of this effort is to improve management of Longfin Smelt, and to identify potential management action that could improve its status.

A Longfin Smelt Life-Cycle Model will be developed as part of the proposed Longfin Smelt Science Program. DWR, CDFW and SWC will work collaboratively using the best available science to develop a mathematical life cycle model for Longfin Smelt, verified with field data collection, as a quantitative tool to characterize the effects of abiotic and biotic factors on Longfin Smelt populations

3.3.13 Conduct Further Studies to Prepare for Delta Smelt Reintroduction from Stock Raised at the UC Davis Fish Conservation and Cultural Laboratory

DWR is proposing to continue supporting the operation and research being conducted by the University of California, Davis (UC Davis), Fish Conservation and Culture Laboratory (FCCL).

The two main goals of the FCCL are to maintain a refuge Delta Smelt population in captivity that is as genetically close as possible to the wild population and provide a safeguard against extinction. The culture technique has been improved continuously over the years and the survival rate of cultured Delta Smelt at the FCCL is high (UC Davis 2019).

The FCCL is undertaking multiple research projects that will continue to add to the understanding of Delta Smelt and other species. The laboratory works collaboratively with other researchers from different agencies and institutions, assisting them with research projects and providing them with experimental fish populations of all life stages. The FCCL currently is expanding and renovating existing facilities, increasing the capacity for culture and research. Ongoing and future studies include the following:

- The FCCL currently is conducting studies to characterize and better understand Delta Smelt spawning behavior. Because spawning behavior has never been observed in the wild and has not been formally described yet, it is unclear how and where Delta Smelt naturally spawn. In ongoing experiments, the laboratory is conducting studies that characterize Delta Smelt spawning behavior under natural conditions and examining spawning substrate preferences. The findings from these studies will be critical to continued recovery and conservation efforts.
- The FCCL is investigating the optimum conditions for hatching Delta Smelt eggs in the wild. The current laboratory practice has been optimized to hatch good-quality eggs within 10 days of spawning, although it is important to consider the conditions in which the eggs are spawned in the wild. The laboratory is studying the effects of salinity and flow rate on the survival and condition of Delta Smelt eggs. This information will inform the proposed egg frame trials as well as the conservation of suitable breeding grounds.
- The FCCL is testing the possibilities of using an egg frame, created by the Lake Suwa Fishing Collective in Hokkaido, Japan for future restoration of Delta Smelt in the Delta. The frame was designed for hatching Wakasagi (*Hypomesus nipponensis*) into a body of water with constant flow. The water flow condition around the eggs in the frame will be studied using computational flow

dynamics, and the results will be used to suggest a suitable environment for applying the egg frame in the Delta.

- The FCCL is taking steps toward promoting survival of individual families by conducting trials using small culture containers that can rear single families at a time. This method could reduce competition between families and increase the survival of each individual family. The FCCL is carrying out trials to assess this factor by individually incubating an equal number of eggs from one, four, or eight family groups; parentage analysis will assess the survival of each family in these groups.
- The FCCL was able to increase survival rates to a level sufficient for the successful culturing of Delta Smelt from the egg through adult stage; the first complete life cycle in captivity was established in 2000–2001. Currently, the FCCL focuses on improving existing rearing techniques, with the goals of increasing the system's efficacy and rearing success. Some of the laboratory's current areas of emphasis are as follows:
    - Tank size and system parameters: As fish develop from newly hatched larvae to adults, they are transferred multiple times between fish-rearing systems to fulfill the needs of each life stage. Black interior tanks are used for all fish, as clear and acrylic tanks have been found to stress fish. Light is administered to the tanks, with varying intensities corresponding to what has been deemed optimal for each life stage. Each recirculating system provides ultraviolet (UV) sterilization, both particle and biological filtration, and heat pumps for temperature control. Currently, the FCCL is testing stocking densities and feeding rates for each tank and also is developing smaller culturing systems for research purposes.
    - Turbidity effect: Early-larval and late-larval stages require different turbidity environments to promote feeding. Although it is not completely understood why larval stages require turbidity, it is thought that the suspended particles provide a visual contrast that enables larval stages to better find their prey. Turbidity is introduced via the addition of concentrated algae. As fish mature into the adult stage, algal addition gradually is decreased to gently transition the fish into clearer water environments.
    - Weaning strategies: As the smelt develop, they are transitioned from a live prey diet to a dry feed diet. The FCCL currently is researching this topic to determine the best time for weaning.
    - Salinity: In their natural environment, Delta Smelt inhabit estuary areas of relatively low salinity. The precise environmental salinity values vary seasonally, in accordance with each year's freshwater availability. In collaboration with researchers at UC Davis, the FCCL is conducting experiments that analyze the physiological effects of salinity on Delta Smelt.

3.3.14 Continue Studies to Establish a Delta Fish Species Conservation Hatchery

The Delta Smelt (*Hypomesus transpacificus*) is currently in severe decline within its native range in the Sacramento-San Joaquin Delta. Delta Smelt have declined to such low numbers that it is difficult to detect them in traditional surveys, and it is possible that the species cannot sustain itself without additional recovery actions. In an effort to conserve the species, a refuge population has been maintained at the UC Davis FCCL in Byron, CA since 2006 (a smaller population exists as a backup to the

FCCL at Livingston Stone Hatchery in Shasta Lake, CA). The refuge population provides fish for research purposes, but more importantly, is a reservoir of Delta Smelt genetic diversity that has been specifically managed for potential wild population supplementation or reintroduction.

Currently, FCCL fish have not been released into the Delta, except as part of a predation study in a South Delta fish facility (Castillo et al. 2012). Yet under the present circumstances, there is a need to at least have an emergency plan to guide possible release of refuge fish into the wild. Logic suggests that the easiest and most effective course of action at present may be to supplement the wild population before it goes extinct. Unfortunately, little is known about the most effective way to release Delta Smelt into the Delta for the purpose of recovering the species.

In recognition of this issue, since 2017 DWR has facilitated studies with the overarching goal of determining the best methods to manage Delta Smelt releases from the refuge population to benefit the wild with maximum survival, retention of genetic diversity, and minimal risk to the wild population. A first step was the organization of a public workshop that identified some of the major scientific uncertainties and to guide future studies (Lessard et al. 2018). This workshop has led to DWR's collaborative work with UC Davis, USFWS, CDFW, and Reclamation to conduct initial investigations. The current work plan includes work on genetics, pathology, behavior, a Hatchery and Genetic Management Plan, and test use of hatchery fish in experimental enclosures placed in the wild. Ultimately, the goal of this work is to develop an adaptive population supplementation plan that will assemble current knowledge about Delta Smelt, describe successful supplementation/reintroduction approaches for other fish species, identify research priorities, recommend monitoring approaches for evaluating supplementation strategies, and detail facility upgrade requirements for the refuge population.

DWR is proposing to continue collaborative laboratory and field work to develop a strategy for successful reintroduction of Delta Smelt to their natural environment in the wild and prevention of extinction. Since previous field work on hatchery Smelt required the project team to secure CESA coverage for this project, we propose to include this work in our Project Description to allow continued laboratory and field research to support possible future supplementation. Some of this work on cultured fish could also be useful in the design and evaluation of different management approaches such as flow actions and tidal wetlands restoration projects. As in previous years, the work would be led by a hatchery advisory team, which could be the existing multi-agency group (CDFW, USFWS, Reclamation, DWR, UC Davis, USGS) or a potential new group organized by CDFW and USFWS.

For 2020 it is anticipated that the primary research activities will be deployment of custom smelt cages in multiple habitats (channel, tidal wetlands) and geographic areas (Suisun, Sacramento River, North Delta), genetic analysis of the wild and hatchery population, pathology, and behavioral studies. The specific details of the work will be subject to input and review by the agency hatchery advisory group. However, it is anticipated that caged smelt could be an important tool to help evaluate different management actions (see Adaptive Management Plan below).

No construction will occur as part of this proposal. Similarly, none of these studies are intended to directly augment the smelt population, nor are they intended to promote supplementation as an alternative to other conservation measures. Instead, cultured fish may be a future tool to help make other management actions more effective and easier to evaluate (e.g., flow, habitat restoration). Depending on study results, future decisions to proceed with supplementation would be subject to separate reviews under CESA, FESA, and CEQA.

3.3.15 Water Transfers

DWR and Reclamation propose to continue facilitating transfers of SWP water and other water supplies through CVP and SWP facilities, including north-to-south transfers and north-to-north transfers. The quantity and timing of Keswick releases would be similar to those that would occur absent the transfer. Water transfers would occur through various methods, including, but not limited to, groundwater substitution, release from storage, and cropland idling, and would include individual and multi-year transfers. The effects of developing supplies for water transfers in any individual year or a multi-year transfer is evaluated outside of this proposed action. North-to-South water transfers would occur from July through November in total annual volumes up to those described in Table 3-5.

Table 3-5. Proposed Annual North-to-South Water Transfer Volume

Water Year Type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following Critical)	Up to 600
Dry (following Dry)	Up to 600
All other years	Up to 360

Note:
TAF = thousand acre-feet

As part of this proposed action, DWR and Reclamation will provide a transfer window from July 1 through November 30. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g., when pumping capacity is needed for CVP or SWP water.

3.3.16 Adaptive Management Plan

The Adaptive Management Plan (AMP) will be carried out to evaluate the efficacy of the operations and activities stated below. An Adaptive Management Team (AMT), composed of one designated representative and one designated alternate each from DWR, DFW, and SWC will be established to carry out this AMP. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP will be developed before issuance of, and could be incorporated into, the ITP DWR is seeking for CESA coverage for the Proposed Project. Any proposed adaptive management changes should provide equivalent or superior conservation benefits to the listed species at equal or lesser societal costs. The objectives of the AMP are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements and (ii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species.

Overall, the intent of this AMP is to:

- Create an adaptive management plan for ongoing SWP operations, as it operates in coordination with the CVP that will assist DWR in complying with applicable California law, including CESA.
- Develop and implement a monitoring protocol necessary to implement the adaptive management plan, working in coordination with CSAMP and the DSP as appropriate.
- Identify the scope of the AMP, that is, the operations and activities that will be subject to adaptive management.
- Describe the decision-making and governance structure that will be used to implement the AMP including adaptive management changes.
- Describe the mechanisms that will be used to communicate among the Implementing Entities (defined as DWR, DFW and SWC) as will be identified in the AMP, and with the broader stakeholder community regarding implementation of the AMP.
- Describe funding for the AMP.
- Describe the relationship between the AMP and real-time operations.

Each existing operation and activity and each adaptive management change must be accompanied by (1) a set of criteria that the implementing entities can use to determine whether the action is having the anticipated impacts (e.g., take limits derived from salvage data) and (2) monitoring that will provide the data necessary in order to determine whether the performance measures are being met. It may be necessary to undertake additional monitoring and research that builds on existing efforts in order to carry out this adaptive management program. The AMP would draw upon the Collaborative Science and Adaptive Management Program (CSAMP) and the Delta Science Program (DSP), where appropriate, to assist with these monitoring and research efforts as well as program evaluation.

The AMP extends to specified SWP operations and activities undertaken by DWR concomitant to those operations. They include the following:

- Operation of Harvey O. Banks Pumping Plant to comply with OMR flow requirements
- Delta Smelt Summer-Fall Habitat Action, including food enhancement actions
- Cultured Delta Smelt studies
- Installation of the South Delta temporary barriers
- Spring outflow actions
- Additional summer-fall actions
- Clifton Court Forebay predator management
- Monitoring associated with all of the foregoing

While the AMP described in this document pertains only to specified SWP operations and activities undertaken by DWR concomitant to those operations and will be used to support the 2081 permit issued for operation of the SWP, upon unanimous agreement among the Implementing Entities, it may be (1) expanded in the future to include other operations and activities, or (2) implemented in a coordinated manner with other adaptive management programs covering such operations and activities. These may include ongoing operations of the CVP and implementation of voluntary agreements or other activities associated with the SWP operations.

3.3.16.1 Adaptive Management Across Wetter and Drier Years

DWR intends to better understand how the management of water and habitat across various hydrologic conditions. The real-time operations of Banks Pumping Plant is one important component of this concept, allowing for exports when impacts to fish can be avoided, minimized or fully mitigated. The other important aspect of this concept is improving conditions during drier periods, and the SWP can contribute to that through the shifting of exports to wetter conditions. To that end, DWR proposes to maintain its current spring outflow contribution across most water year types, allow for increased exports during some wet conditions per the real-time operations described in 3.3.1 *OMR Management*, and to provide additional water for outflow in some dry summer-fall periods.

Export Curtailments for Spring Outflow

The maintenance of the current SWP outflow contribution will be made available through SWP export curtailments as described below. In Wet years, real-time operations as described in Section 3.3.1 *OMR Management* may result in exports greater than what could occur under the 2008/2009 permits. If the increase in exports occurs, that increased export amount[5] of up to 150 TAF may be developed for use in the summer – fall of the following year, except if the following year is Critical, for purposes of using wet year water into a second year for Delta Smelt, and to test the efficacy of doing so. The AMP would be used to determine the appropriate amount and timing of this application of water in the summer and fall. If a spring outflow block is deferred for use in the following year, it will be subject to spill and will not be available if spilled. The spring outflow block from Wet year can be deferred only to the following year. This water would be dedicated to outflow for the term of the permit, by pursuing an instream flow dedication under Section 1707 of the California Water Code as well as agreements for the protection of this flow from other diverters. This water could be provided through water purchases or SWP project water.

In addition to the OMR management described in Section 3.3.1 *OMR Management*, the SWP will curtail its exports to maintain the current SWP spring outflow contribution. One way to achieve this is by operating to its proportional share of San Joaquin River Inflow to Export Ratio (SJR I:E ratio) defined by the 2009 NMFS BiOp RPA Action IV.2.1 from April 1 – May 31[6]. Another way to achieve this is through export reductions by the SWP up to 150TAF in AN, BN, and Dry years consistent with the current VA proposal, which roughly reflects 50% of the current long-term average contribution of incidental spring outflow by the under the 2008/2009 BiOps. 50% is assumed to be SWP's contribution.

[5] Increased SWP export amount in wet years is difference between actual April – May SWP exports and SWP exports under its share of SJR i-e ratio with 44,500 cfs off-ramp.

[6] The SJR I:E ratio was not included in the NMFS BiOp that was issued on October 21, 2019, and therefore it is not a requirement for CVP operations. Consequently, the benefits of reduced SWP exports may be diminished if CVP operations are not bound by the same constraint, notwithstanding DWRs efforts to protect these flows.

The purpose of the SJR I:E ratio was intended to reduce the risk of entrainment of CV steelhead into the south Delta channels (2009 NMFS BiOp at p. 641), and this export constraint has resulted in incidental Delta outflow over and above the outflow required during April and May. However, it only takes into account San Joaquin River conditions and therefore may not be the most appropriate way to manage total Delta outflow.

The 2009 NMFS BiOp identifies the SJR I:E ratio to be measured at Vernalis for combined CVP and SWP operations, as shown in Table 3-6 (see NMFS BiOp RPA Action IV.2.1, pp. 643-644).

Table 3-6. Vernalis flow CVP/SWP Combined export ratios

San Joaquin Valley Classification	Vernalis flow (cfs): CVP/SWP Combined export ratio
Critically dry year	1:1
Dry year	2:1
Below normal year	3:1
Above normal year	4:1
Wet year	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs

Note:
cfs = cubic feet per second

Exception for high Delta outflow: This action will not be implemented in wet years. Also, if the 3-day average Delta outflow is greater than 44,500 cfs, then this action will be suspended until the flows drop below 44,500 cfs on a 3-day average. The off-ramp at Delta outflow greater than 44,500 cfs is consistent with recent permits issued by CDFW, although this threshold would be subject to the AMP.

Exception procedure for multiple dry years: If the previous 2 years plus current year of the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and Indicator as defined in D-1641 and provided in following table (Table 3-7), is 6 or less, AND, the New Melones Index is less than 1 MAF, SWP shall be limited to its proportional share of a 1:1 ratio with San Joaquin River inflow, as measured at Vernalis.

Table 3-7. Water Year Hydrologic Classification and Indicator

San Joaquin Valley Classification	Indicator
Critically dry year	1
Dry year	2
Below normal year	3
Above normal year	4
Wet year	5

Exception for Health and Safety: These ratios will not prohibit DWR from achieving its minimum SWP health and safety export needs, of 600 cfs. SWP export is defined under D-1641 as CCF diversions minus Byron Bethany Irrigation District demand.

Additional Summer – Fall Actions for Adaptive Management

Historically, the long-term trend in Delta outflow in the summer is positive (Hutton et. al., 2017a p. 8). Since the 1950s, Delta outflow in July and August has increased, with June and September outflow showing no long-term trend (Hutton et. al., 2017b p. 7). The positive outflow change is attributed primarily to the effects of the SWP and CVP operations, which have more than fully attenuated impacts of diversions by non-SWP/CVP diversion (Hutton et. al., 2017b p 7). Moreover, as shown in the DEIR, the Proposed Project is not expected to decrease June through August outflow as compared to baseline. Therefore, there is no mitigation required for SWP related changes in summer outflow.

However, there is a recognized lack of understanding of factors influencing Delta smelt survival in the summer. To study habitat effects on Delta Smelt survival, DWR may take additional summer-fall actions as described below. This water would also be for the purposes of testing and evaluating components identified in the Delta Smelt Resiliency Strategy by studying outflow effects on Delta smelt habitat.

Provide an adaptively-managed 100 TAF block of Delta outflow in June through November in Wet and Above Normal years, as managed through the AMP. This 100 TAF block for Wet and Above Normal years may instead be used:

- as additional outflow in June – November of the following year, except if the following year is Critical, OR
- to offset impacts to the Delta water quality standards in June – September while operating the SMSCG for up to 60 days in the following year, if it is a Dry year.

If the 100 TAF block is deferred for use in the following year, it will be subject to spill and will not be available if spilled. The water block from Wet or Above-Normal year can be deferred only to the following year.

Initially, this water will be used in August of wet and above normal years to maintain a monthly average X2 of 80 km to the extent possible to test hypotheses and narrow uncertainty. However, subject to the AMP, CDFW may define an alternative purpose of this volume of water within the June through November period of the identified year types. This water would be dedicated to outflow for the term of the permit, by pursuing an instream flow dedication under Section 1707 of the California Water Code as well as agreements for the protection of this flow from other diverters. This water could be provided through water purchases or SWP project water.

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4 ANALYSIS OF TAKE AND EFFECTS

4.1 APPROACH TO TAKE AND EFFECTS ASSESSMENT

The California Endangered Species Act (CESA) defines take as hunting, pursuing, catching, capturing, or killing a listed species, or the attempt of any such act (California Fish and Game Code Section 86). California Department of Fish and Wildlife (CDFW) incidental take permit (ITP) regulations require an analysis of whether and to what extent the project or activity could result in the taking of the covered species, and the impacts of the proposed taking on the species (14 California Code of Regulations [CCR] 783.2(a)(5) and 783.2(a)(6)). This section provides this analysis for each of the covered fish species.

Based on available information, the applicant, the California Department of Water Resources (DWR) believes the CESA-listed species discussed in this permit application occupy or potentially occur in the project area and that the proposed project may result in incidental take of, and effects on, these species.

The take and effects analysis first describes potential operations effects of the proposed project in relation to a current operations ("Existing Conditions") scenario. The analysis also considers the potential for take and effects from maintenance activities. The take and effects analysis in this section is then followed by consideration of minimization and mitigation measures in Section 5, "Take and Effect Minimization and Mitigation Measures." Section 6, "Analysis of Potential for Jeopardy," then provides an analysis of potential for jeopardy for each of the species, in consideration of cumulative effects in addition to Proposed Project effects; this includes estimation of take in subsections entitled *Level of Take* for each species. The quantitative methods used to conduct some of the analyses in Section 4.2 *Operations Effects* are provided in Appendix D, and this and other appendices are cross-referenced in the text as necessary.

This section includes consideration of both take and (non-take) effects of the Proposed Project, with the latter essentially being effects on habitat. The potential mechanisms of take and effect that are assessed are:

- Take
    - Delta Smelt: entrainment (Banks Pumping Plant [including during water transfers], Barker Slough Pumping Plant, and Suisun Marsh operations); South Delta Temporary Barriers operations; maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)
    - Longfin Smelt: entrainment (Banks Pumping Plant [including during water transfers], Barker Slough Pumping Plant, and Suisun Marsh operations); Delta outflow–abundance relationship; South Delta Temporary Barriers operations; maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun

Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)

  - Winter-run Chinook Salmon: entrainment (Banks Pumping Plant [including during water transfers], Barker Slough Pumping Plant, and Suisun Marsh operations); through-Delta survival (flow-survival relationships); South Delta Temporary Barriers operations; maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)
  - Spring-run Chinook Salmon: entrainment (Banks Pumping Plant [including during water transfers], Barker Slough Pumping Plant, and Suisun Marsh operations); through-Delta survival (flow-survival relationships); South Delta Temporary Barriers operations; maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)
- Effect
  - Delta Smelt: effects of State Water Project (SWP) operations on food availability, predation, harmful algal blooms, size and location of the low salinity zone (summer-fall Delta Smelt habitat actions); South Delta Temporary Barriers (e.g., habitat effects on food availability); food enhancement summer-fall actions.
  - Longfin Smelt: Food enhancement summer-fall actions
  - Winter-run Chinook Salmon: Food enhancement summer-fall actions
  - Spring-run Chinook Salmon: Food enhancement summer-fall actions

4.2 OPERATIONS EFFECTS

Analysis of operations-related effects is presented by species and life stage based on relevant operations-related effects identified in conceptual models. Biological modeling methods are provided in Appendix D. Biological modeling relies largely on CalSim and DSM2 modeling, for which descriptions and assumptions are described in Appendix E, with hydrology and water quality modeling results provided in Appendix B.

Quantitative and qualitative analyses attempt to account for the SWP portion of impacts by considering factors such as entrainment only at SWP facilities (e.g., entrainment into the CCF), but in some cases, such as effects based on Delta outflow, the analyses reflect SWP and CVP operations. Specifically, CalSim II and DSM2 simulations include operations of both the SWP and CVP because the models are simulating combined SWP and CVP operations. Therefore, many of the analyses would overestimate impacts of the SWP if model results were examined without consideration of the contribution of only the SWP to the modeled parameters (e.g., flow at Freeport).

Isolating the SWP contribution to hydrologic and hydrodynamic changes in the Delta was conducted based on the premise that under excess Delta conditions, the joint operations are typically governed by the exports at the SWP and CVP pumping facilities, and under balanced conditions, the SWP and CVP responsibility are defined in the COA. The COA identifies two types of balanced conditions, in-basin use (IBU) and unstored water for export (UWFE). In estimating the SWP proportion of impacts, the following principles were used:

- For months with IBU balanced conditions, the sharing ratio assigned to the SWP in the COA is the SWP's proportion of an impact.
- For months with UWFE balanced conditions and excess conditions, the proportion of exports at Banks Pumping Plant of the total exports at Banks and Jones pumping plants is the SWP's proportion of an impact. All exports, including any water transfers at the Banks Pumping Plant, are used in this estimation.

These principles were applied to each month in the 82-year CalSim simulation period, and the SWP's proportions were identified for each month. Table 4-1 presents the percentage of combined SWP and CVP Delta water operations for which the SWP is responsible (see the additional description in Attachment 1-5, provided in Appendix E). The cumulative effects accounting for both SWP and CVP is considered again in each species' cumulative effects assessment in Section 6, "Analysis of Potential for Jeopardy."

Table 4-1. State Water Project Responsibility for State Water Project and Central Valley Project Combined Delta Water Operations for the Proposed Project, Averaged by Water Year Type and Month

Month	Wet Year	Above Normal Year	Below Normal Year	Dry Year	Critical Year	Total
October	49%	47%	44%	43%	42%	45%
November	64%	51%	57%	54%	48%	56%
December	50%	56%	56%	54%	49%	53%
January	50%	43%	43%	44%	43%	45%
February	56%	48%	46%	41%	40%	48%
March	57%	46%	49%	41%	39%	48%
April	49%	47%	51%	45%	47%	48%
May	46%	44%	40%	37%	37%	42%
June	42%	31%	29%	35%	40%	36%
July	39%	20%	25%	35%	40%	33%
August	43%	20%	25%	30%	36%	33%
September	28%	23%	52%	40%	39%	36%
Total	48%	40%	43%	42%	42%	44%

Source: Attachment 1-5 of Appendix E

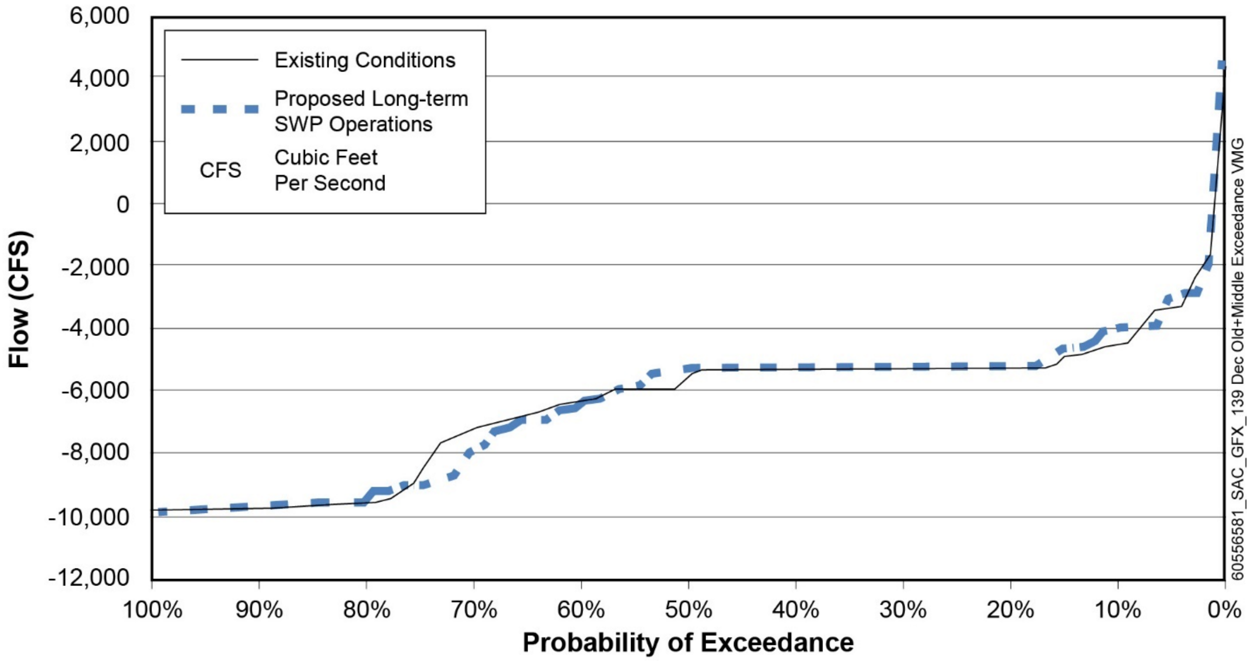
4.2.1 DELTA SMELT

4.2.1.1 ENTRAINMENT

Consideration of Old and Middle River Flows

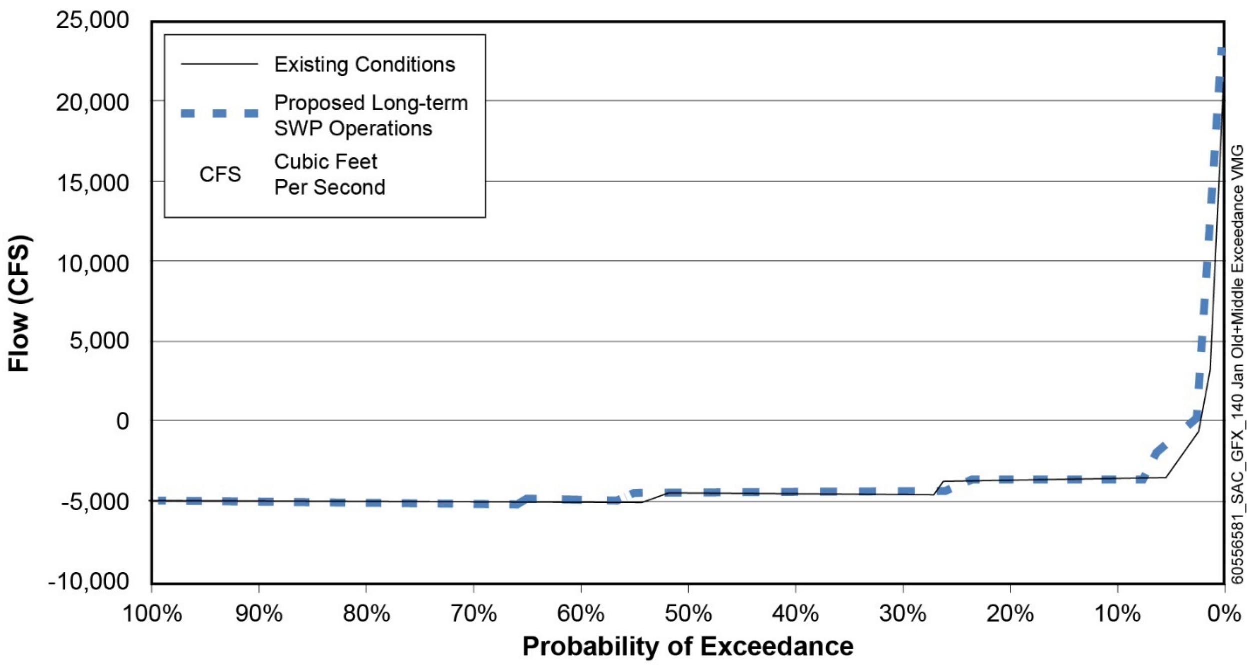
Old and Middle River (OMR) flows are an important indicator of Delta Smelt entrainment risk (Grimaldo et al. 2009; 2017a). During the main period of adult entrainment risk (December–March; USFWS 2008), CalSim modeling indicates that the Proposed Project would be expected to have generally similar OMR flows to the Existing Conditions scenario (Figures 4-1, 4-2, 4-3, and 4-4), suggesting that adult entrainment risk considering only OMR flows would be similar under both the Proposed Project and Existing Conditions scenarios. As noted in the project description, the first flush protection action would be triggered more often under the Proposed Project criteria than under the Existing Conditions criteria (Figure 4-5), thereby potentially providing additional protection under the Proposed Project; the first flush protection is represented in the CalSim modeling in the same way for both the Proposed Project and Existing Conditions scenarios because it is not possible to model the different turbidity triggers. Other factors such as turbidity are also important influences on entrainment risk but are not readily modeled; the CalSim modeling reflects assumptions regarding "turbidity bridge"[7] avoidance actions, but cannot simulate real-time structured decision making that would limit entrainment risk, for example. OMR management for adult Delta Smelt would be expected to result in low levels of entrainment loss similar to those achieved during the implementation of the USFWS (2008) BiOp, which has limited loss below the authorized incidental take limit of ~5% of the adult population. The effects on OMR flows discussed herein depend on combined SWP and CVP operations; during the period of December through March, the period of adult Delta Smelt entrainment concern, the SWP would be responsible for around 40% to 60% of Delta water operations, depending on water year type and month (Table 4-1).

[7] A turbidity bridge is an area of high turbidity water spanning the Central Delta to the South Delta, with increased turbidity being associated with increased risk of south Delta entrainment (Grimaldo et al. 2009).



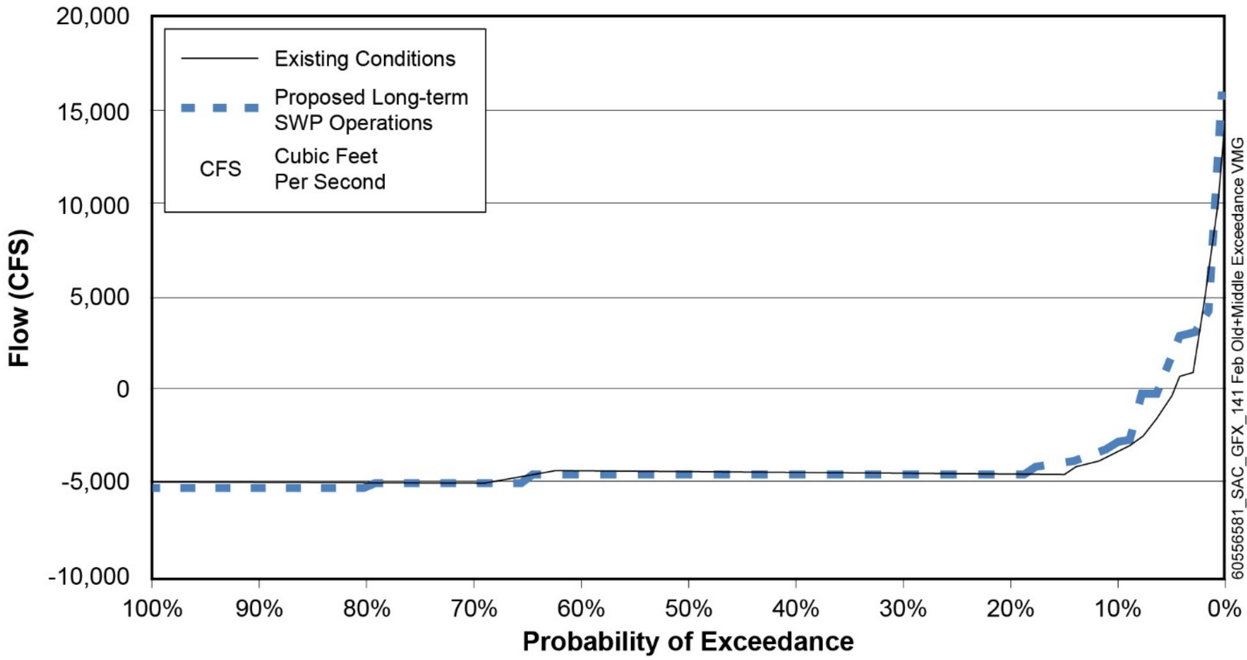
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-1. Mean Modeled Old and Middle River Flow, December



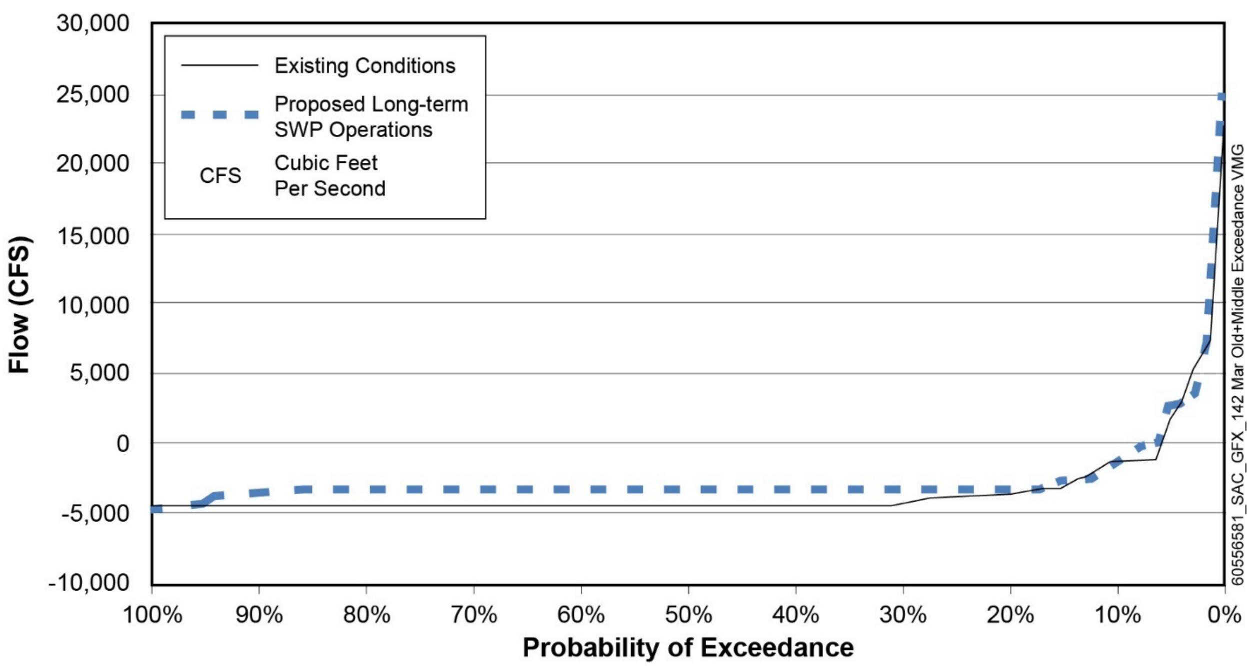
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-2. Mean Modeled Old and Middle River Flow, January



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

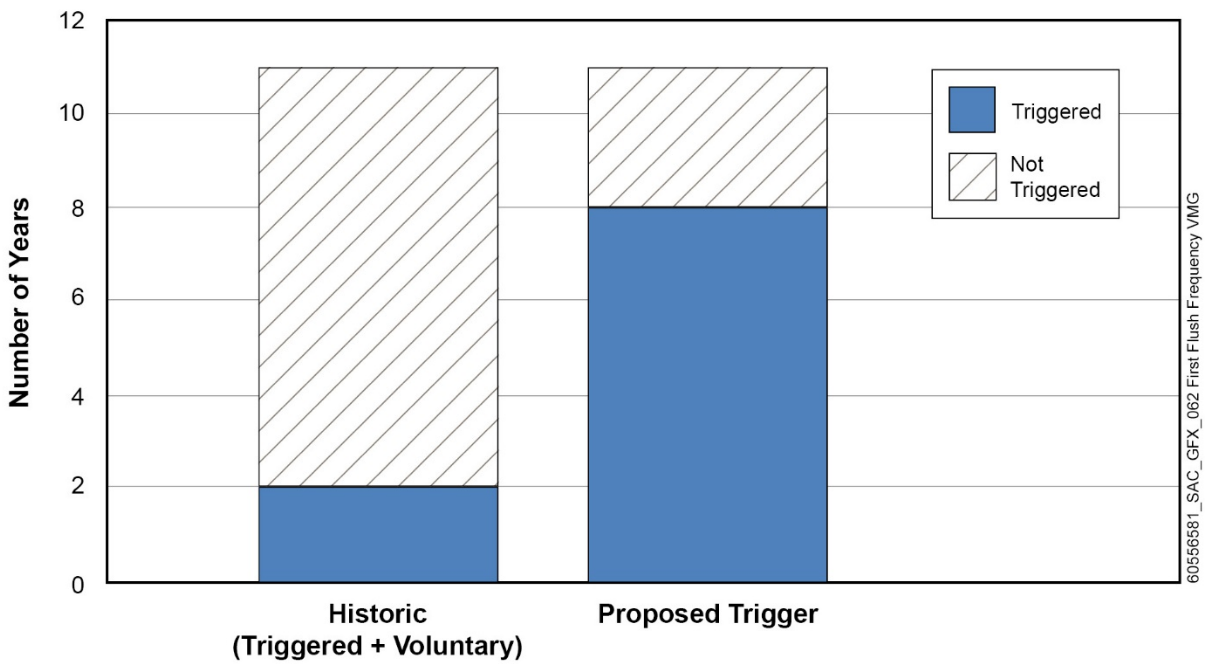
Figure 4-3. Mean Modeled Old and Middle River Flow, February



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

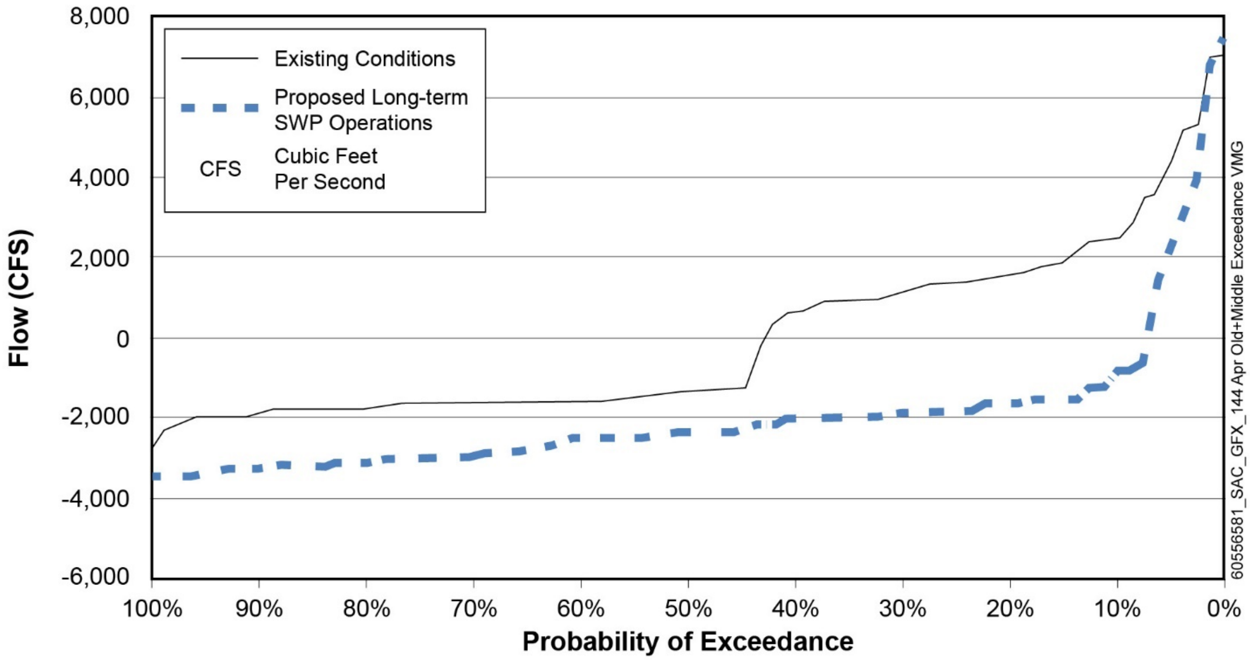
Figure 4-4. Mean Modeled Old and Middle River Flow, March

During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would tend to be more negative under the Proposed Project scenario compared to the Existing Conditions scenario in April and May, but similar in March and June (Figures 4-4, 4-6, 4-7, 4-8). Flows in both scenarios would be above the -5,000 cfs inflection point at which entrainment tends to sharply increase (i.e., less negative than -5,000 cfs or positive) (Grimaldo et al. 2017a). OMR flows from CalSim modeling do not include proposed larval and juvenile Delta Smelt entrainment protections. As part of real-time operational decision-making process to implement OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval and juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained; DWR will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Such OMR management is not reflected in the CalSim modeling. The real-time management would be intended to limit entrainment risk to low levels similar to the levels achieved following implementation of the USFWS 2008 Biological Opinion, during which time loss of juvenile Delta Smelt was within authorized incidental take limits. As previously noted, the effects on OMR flows discussed herein depend on combined SWP and CVP operations; during the period from March through June, the period of larval and early juvenile Delta Smelt entrainment concern, the SWP generally is responsible for around 30% to 60% of Delta water operations, depending on water year type and month (Table 4-1).



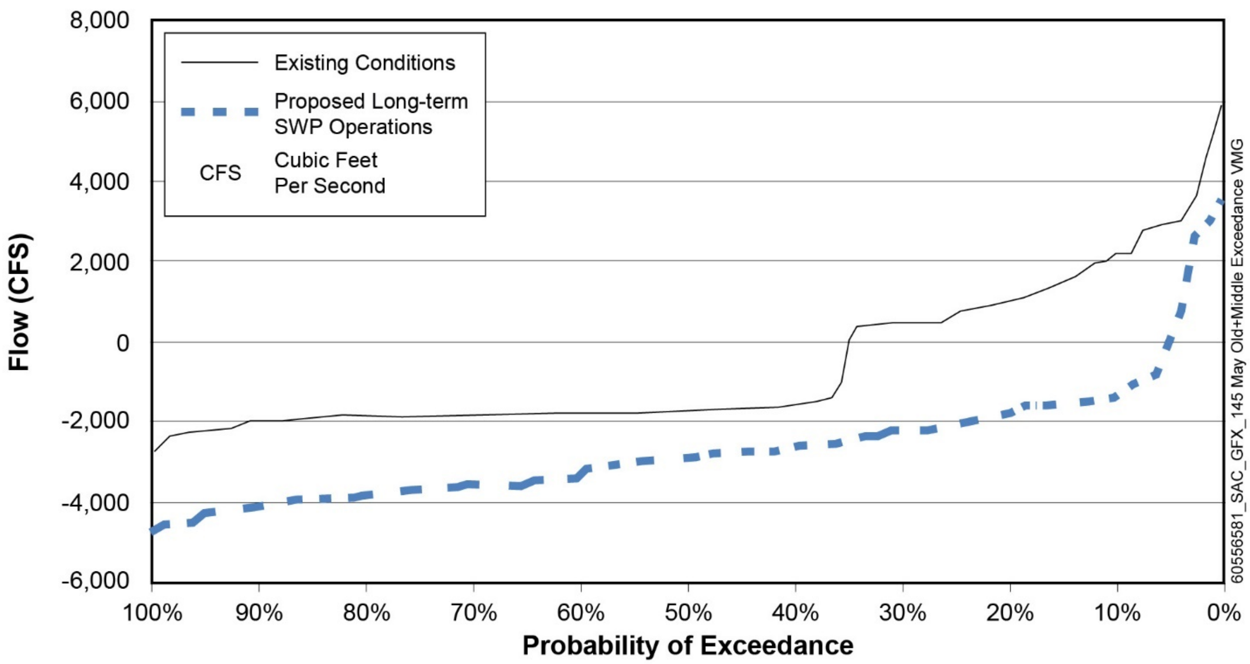
Source: Adapted from <PP_OMR_Actions_8-6-19.pptx>

Figure 4-5. Number of Years During 2009–2019 That First Flush Action Was Triggered Historically or Would Have Been Triggered Under the Proposed Project



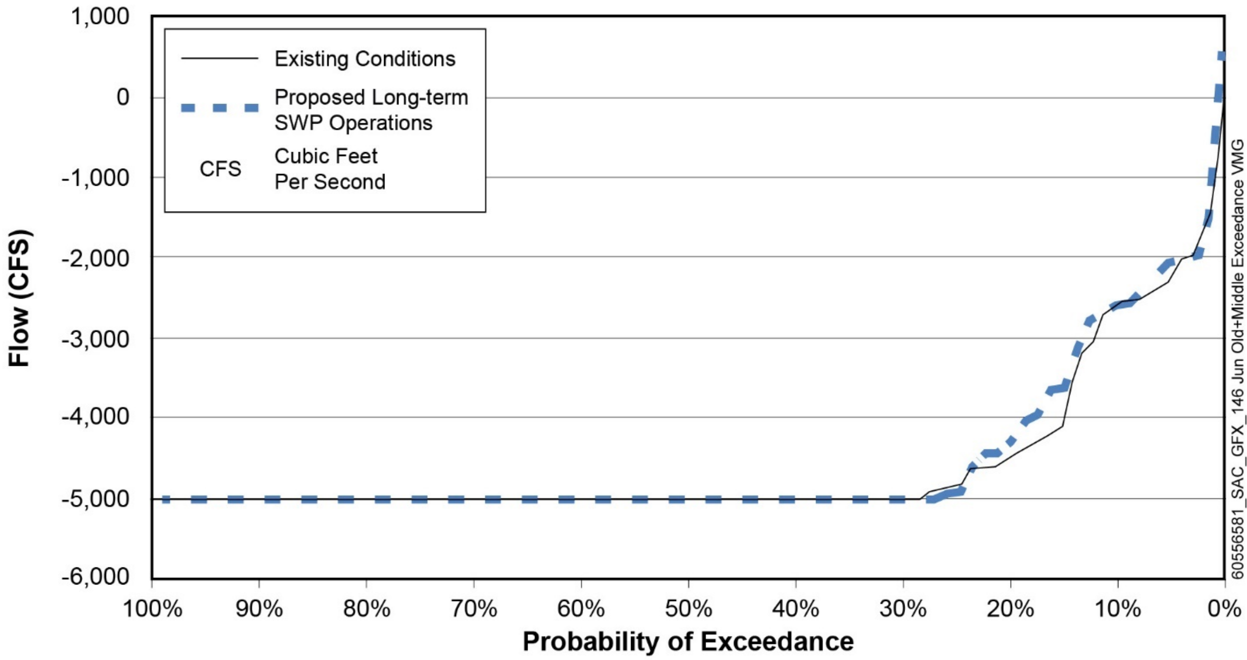
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-6. Mean Modeled Old and Middle River Flow, April



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-7. Mean Modeled Old and Middle River Flow, May



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-8. Mean Modeled Old and Middle River Flow, June

Particle Tracking Modeling

For the present effects analysis, the most recent version of DSM2-PTM was used to illustrate potential differences in the percentage of Delta Smelt larvae entrained by the SWP water diversions (Clifton Court Forebay and the NBA Barker Slough Pumping Plant), considering only modeled flows. Detailed information regarding the method is provided in Appendix D, Section D.2.2 *Particle Tracking Modeling (Larval Entrainment)*. This approach assumed that the entrainment susceptibility of Delta Smelt larvae can be represented by entrainment of passive particles, based on existing literature (Kimmerer 2008, 2011). Results of the PTM simulations do not represent the actual entrainment of larval Delta Smelt that could occur under the Existing Conditions and Proposed Project scenarios, but rather should be viewed as a comparative indicator of the relative risk of larval entrainment under the Existing Conditions and Proposed Project scenarios, without consideration of much of the real-time risk management measures put forth in the Proposed Project. The latest version of DSM2-PTM allows agricultural diversions to be excluded as sources of entrainment (while still being included as water diversion sources). For this effects analysis, these agricultural diversions were excluded, given the relative coarseness of the assumptions in DSM2 related to specific locations of the agricultural diversions, the timing of water withdrawals by individual irrigators, and field observations that the density of young Delta Smelt entrained by these diversions is relatively low (Nobriga et al. 2004) and not thought to be of population-level importance (Nobriga and Herbold 2009:25–26).

The DSM2-PTM analysis suggested the potential for appreciable relative increases under the Proposed Project scenario compared to the Existing Conditions scenario in larval and early juvenile Delta Smelt entrainment at Clifton Court Forebay during April and May (Table 4-2), reflecting greater differences in OMR flows during this time period (see *Consideration of Old and Middle River Flows* section above). However, as previously noted, OMR flows from CalSim modeling do not include proposed larval and juvenile Delta Smelt entrainment protections and would reduce differences in South Delta exports between Proposed Project and Existing Conditions scenarios. DSM2-PTM does not include real-time operational decision-making, modeling, and OMR management, which would be used by DWR to minimize entrainment under the Proposed Project. As part of real-time operational decision-making OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval and juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment, such as OMR flows. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Actual management of larval and juvenile Delta Smelt entrainment during implementation of the 2008 USFWS Biological Opinion, which the Existing Conditions modeling scenario represents, limited entrainment well below authorized protective take limits. Although the Proposed Project modeling suggests an increase in entrainment relative to the Existing Conditions scenario, entrainment would be expected to be maintained at protective levels, (i.e., within limits to avoid jeopardy to the species) as a result of implementing real-time structured decision making and OMR management actions.

Table 4-2. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay and Barker Slough Pumping Plant – Table 4-2 a and 4-2 b

Table 4-2 a. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	3.28	2.92	-0.36 (-11%)
March	Above Normal	3.66	3.15	-0.51 (-14%)
March	Below Normal	9.63	8.05	-1.58 (-16%)
March	Dry	10.53	9.15	-1.38 (-13%)
March	Critical	7.74	8.16	0.42 (5%)
April	Wet	0.75	2.50	1.75 (235%)
April	Above Normal	1.69	5.05	3.36 (199%)
April	Below Normal	3.36	9.04	5.68 (169%)
April	Dry	3.48	6.85	3.37 (97%)
April	Critical	3.32	4.35	1.03 (31%)
May	Wet	1.31	4.90	3.59 (274%)
May	Above Normal	2.61	10.29	7.69 (295%)
May	Below Normal	2.47	10.39	7.92 (321%)
May	Dry	3.46	7.39	3.93 (114%)
May	Critical	3.25	4.11	0.85 (26%)
June	Wet	9.20	9.42	0.22 (2%)
June	Above Normal	8.48	8.73	0.25 (3%)
June	Below Normal	9.49	9.52	0.03 (0%)
June	Dry	10.26	10.24	-0.01 (0%)
June	Critical	6.09	6.20	0.11 (2%)

Table 4-2 b. Percentage of Particles Entrained Over 30 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	0.08	0.09	0.00 (4%)
March	Above Normal	0.06	0.06	0.00 (-2%)
March	Below Normal	0.11	0.11	0.00 (2%)
March	Dry	0.05	0.04	0.00 (-4%)
March	Critical	0.02	0.03	0.01 (40%)
April	Wet	0.08	0.07	0.00 (-4%)
April	Above Normal	0.17	0.16	-0.01 (-6%)
April	Below Normal	0.07	0.07	0.00 (-1%)
April	Dry	0.18	0.18	0.00 (0%)
April	Critical	0.07	0.06	-0.01 (-14%)
May	Wet	0.09	0.09	0.00 (1%)
May	Above Normal	0.15	0.15	0.00 (-2%)
May	Below Normal	0.21	0.20	-0.02 (-8%)
May	Dry	0.15	0.12	-0.03 (-17%)
May	Critical	0.04	0.03	-0.01 (-26%)
June	Wet	0.13	0.13	0.00 (0%)
June	Above Normal	0.32	0.31	-0.01 (-2%)
June	Below Normal	0.26	0.26	0.00 (-1%)
June	Dry	0.20	0.19	-0.01 (-5%)
June	Critical	0.02	0.02	0.00 (-5%)

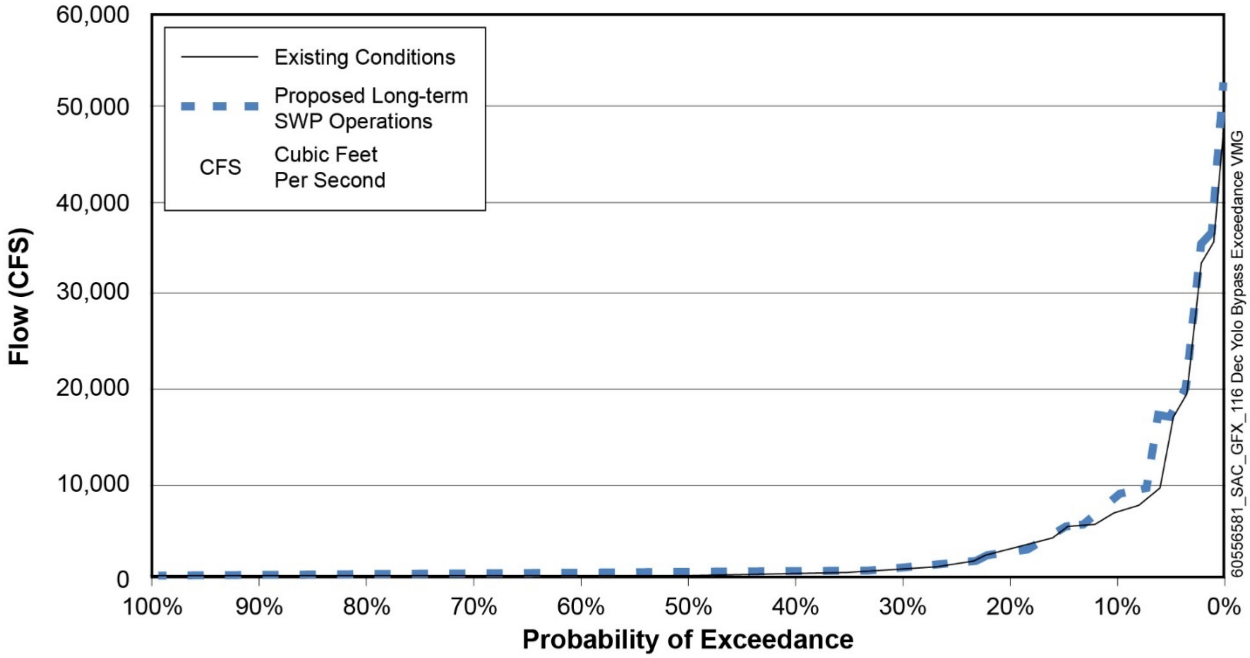
Source: ptm_fate_results_30day_Mar-Jun_qa_ITP_EX_20191030.dat; ptm_fate_results_30day_Mar-Jun_qa_ITP_PP_20191030.dat

The DSM2-PTM results suggested that there would be little difference in the potential for entrainment of Delta Smelt at the Barker Slough Pumping Plant between the Existing Conditions and Proposed Project scenarios (Table 4-2). Very minor differences in operational criteria are proposed for the Proposed Project scenario relative to the Existing Conditions scenario, and the potential for entrainment also would be limited by the incidental take limit from the USFWS (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation (ROC on LTO) of the Central Valley Project and State Water Project Biological Opinion and the minimization measures to be developed through work with the USFWS by the end of the 2019 calendar year (see Section 3.3.11 *Barker Slough Pumping Plant Operations*). No Delta Smelt larvae were collected during recent entrainment monitoring in January–June, 2015–2016 (Yip et al. 2019).

4.2.1.2 FOOD AVAILABILITY

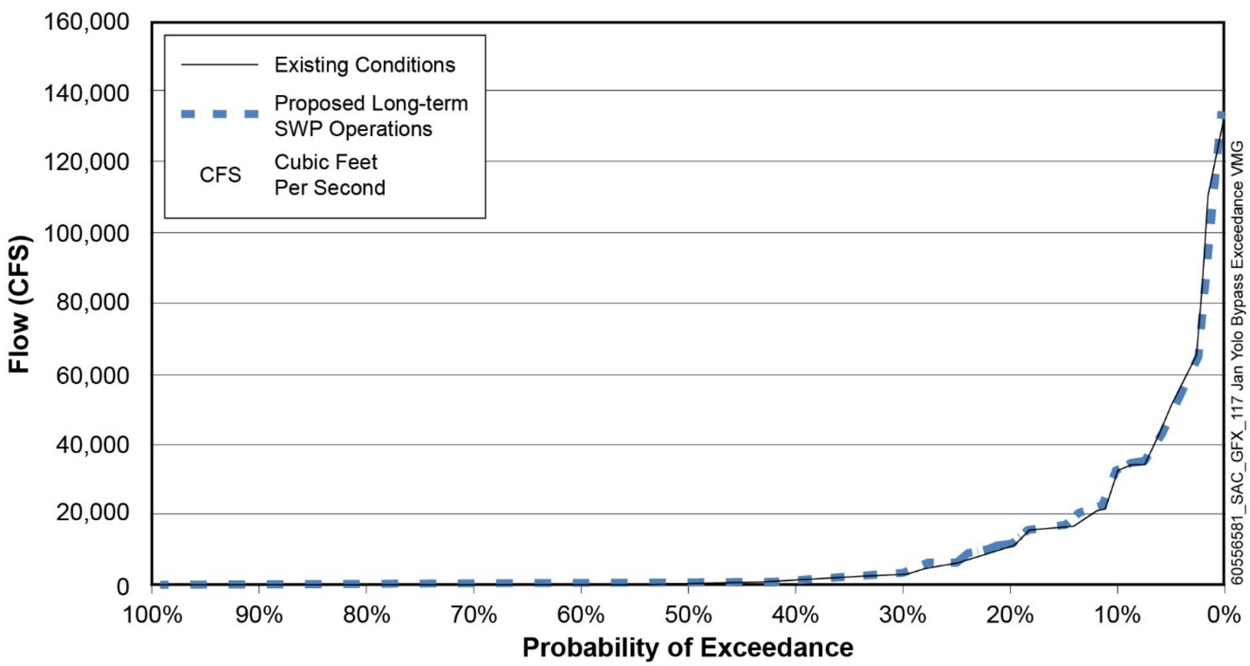
Adults to Eggs and Larvae (December–March)

Although food availability during other life stages has been suggested to be important based on various statistical and modeling analyses (e.g., Miller et al. 2012; Kimmerer and Rose 2018), food availability is also posited by the IEP MAST (2015) conceptual model to affect the probability of Delta Smelt adults spawning and transitioning to egg/larval production, and inundation of the Yolo Bypass could increase food web productivity and benefit growth and survival of Delta Smelt adults occurring downstream of Yolo Bypass (DWR and Reclamation 2019:8-117 to 8-118). Delta Smelt food sources and availability likely vary by region, and the proportion of Delta Smelt food availability originating in the Yolo Bypass is unclear. Therefore, the analysis of Yolo Bypass inundation and resulting impacts on food availability for Delta Smelt is uncertain. Nonetheless, modeling suggests that there would be little difference in flow through the Yolo Bypass between the Proposed Project and Existing Conditions scenarios (Figure 4-9 to 4-14), suggesting that food availability would also be similar.



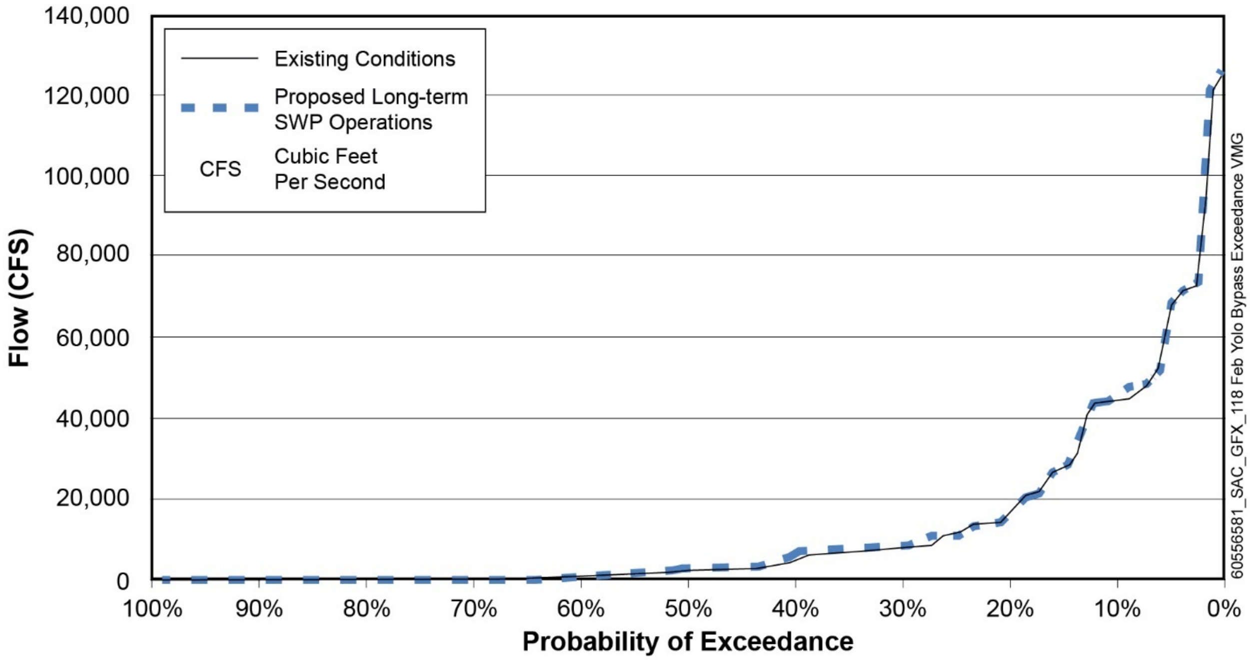
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-9. Mean Modeled Flow Through Yolo Bypass, December



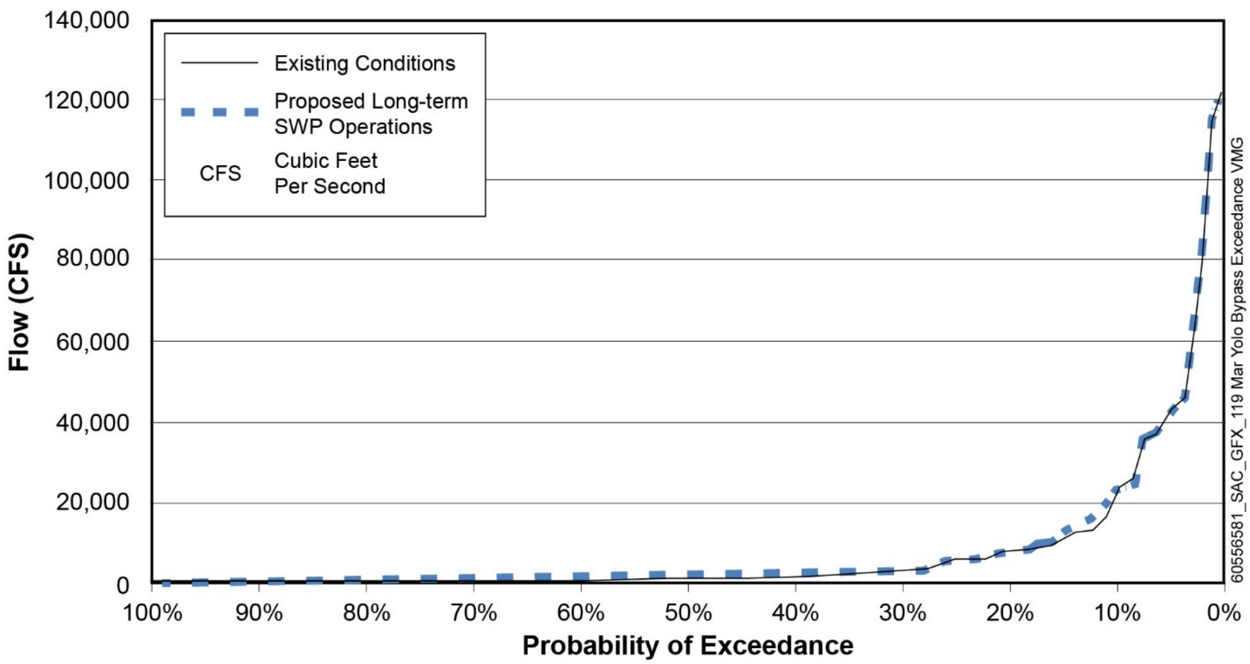
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-10. Mean Modeled Flow Through Yolo Bypass, January



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-11. Mean Modeled Flow Through Yolo Bypass, February



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-12. Mean Modeled Flow Through Yolo Bypass, March

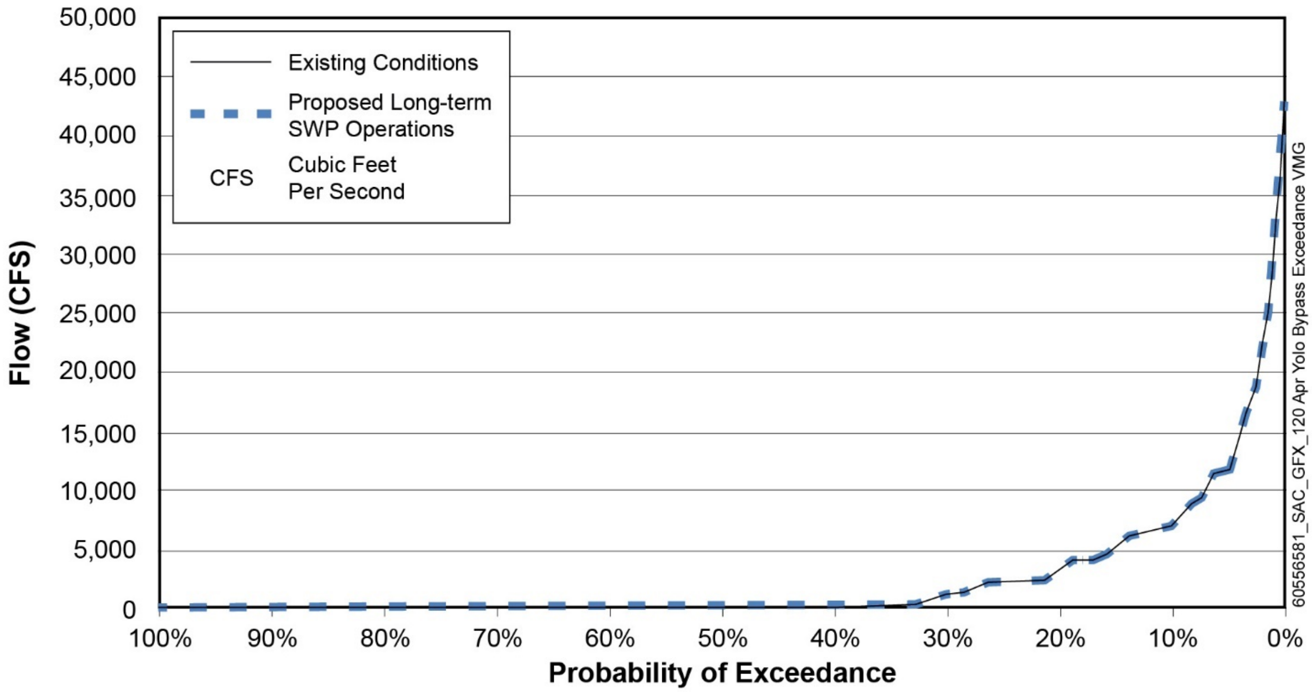


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Figure 4-13. Mean Modeled Flow Through Yolo Bypass, April

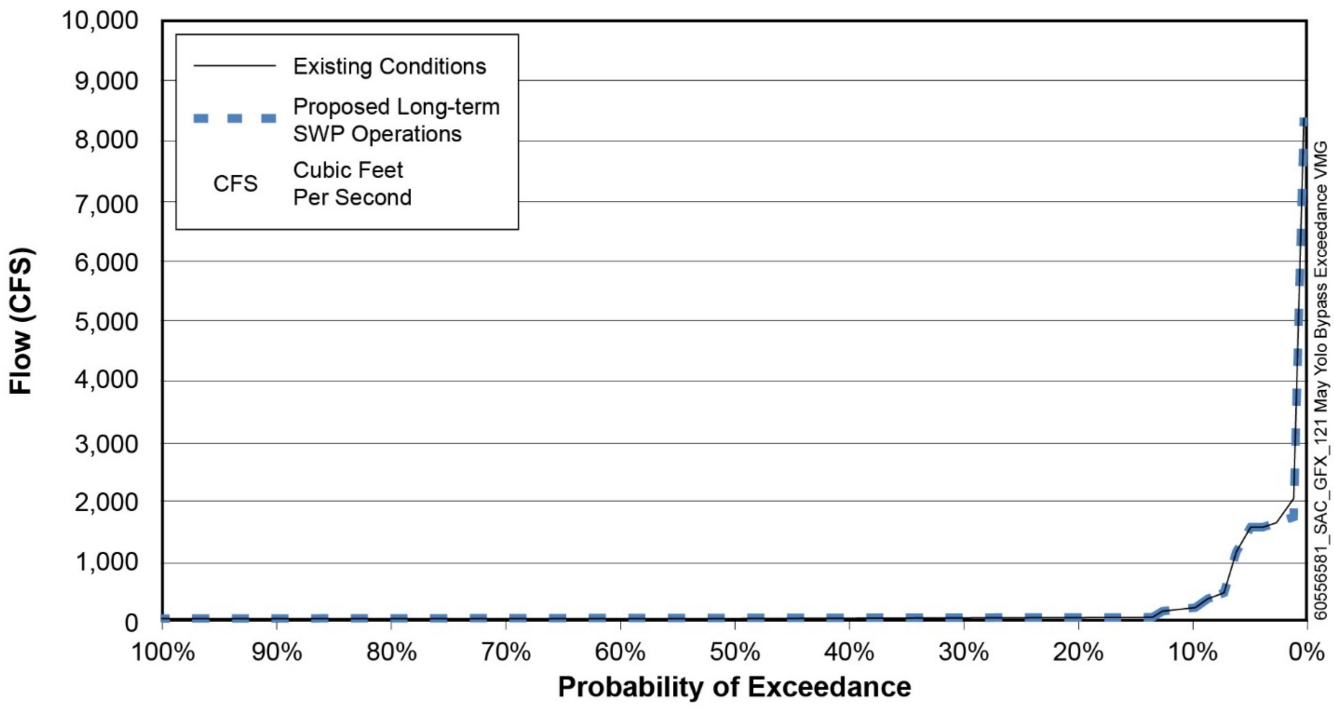

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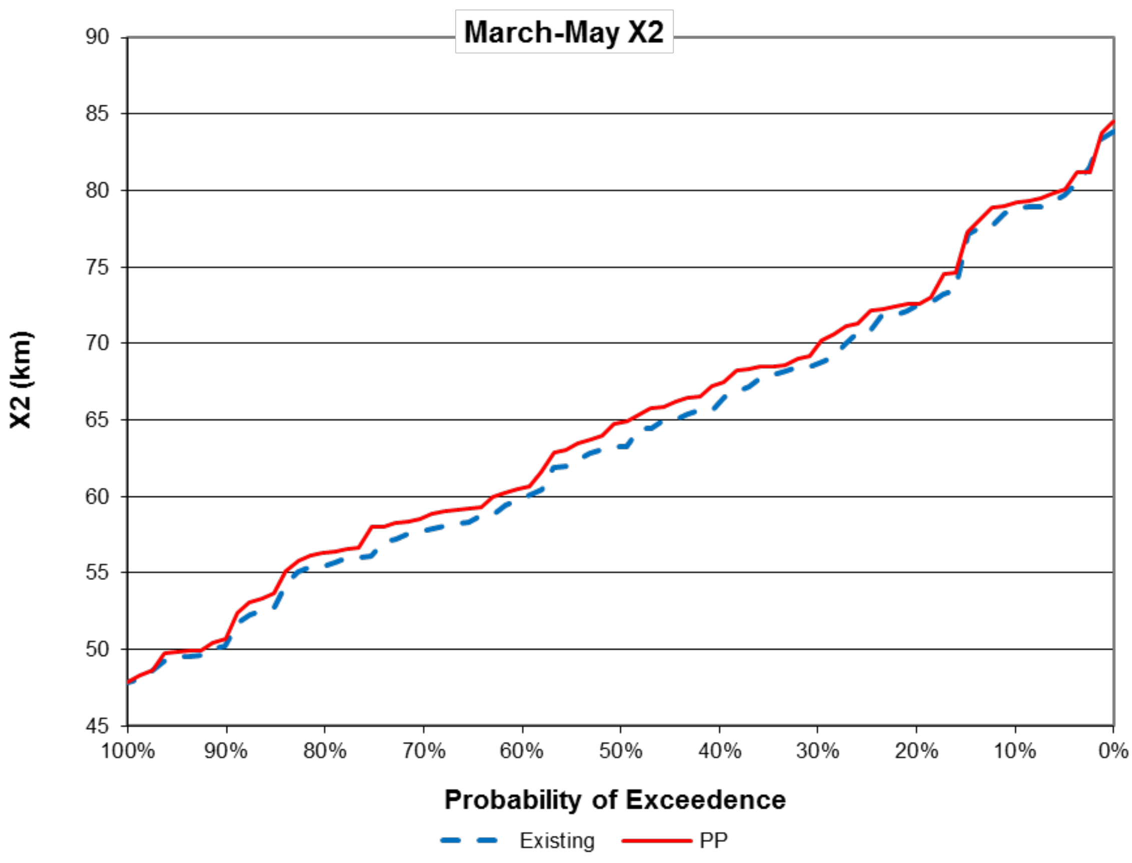
Figure 4-14. Mean Modeled Flow Through Yolo Bypass, May

Eggs and Larvae to Juveniles (March–June)

The IEP MAST (2015) conceptual model suggests that South Delta exports could affect food availability for larval Delta Smelt. There is a positive correlation between the density of the important Delta Smelt larval/juvenile zooplankton prey *Eurytemora affinis* in the low salinity zone and Delta outflow (as indexed by X2) during the spring (March–May; Kimmerer 2002, Greenwood 2018). Also, outflow is required to subsidize *P. forbesi*, in that region a relatively recent important Delta Smelt food source, from freshwater to the low salinity zone (Kimmerer et al. 2018), where it may be consumed by larval and juvenile Delta Smelt that move into the low salinity zone during April and May (Nobriga 2002; Slater and Baxter 2014). Therefore, the mechanism suggested by the conceptual model for the effects of South Delta exports on food availability could be related to hydrodynamic effects of Delta outflow. As shown in Figure 4-15, Delta outflow would be lower under the Proposed Project scenario than under the Existing Conditions scenario, and therefore X2 would be greater (i.e., further upstream). Based on the negative relationship between *E. affinis* density and X2, the modeling results suggest that *E. affinis* under the Proposed Project could be negatively affected relative to the Existing Conditions scenario, which could potentially affect individual Delta Smelt growth and survival per the IEP MAST conceptual model.



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-15. Mean Modeled X2, March–May

To illustrate the magnitude of potential effect, a regression of March–May X2 versus *E. affinis* density in the low salinity zone was used to compare the Existing Conditions and Proposed Project scenarios; the method is described in Appendix D, Section D.2.2. This analysis suggested that there is appreciable uncertainty in the predictions of *E. affinis* density as a function of X2, with 95% prediction intervals spanning several orders of magnitude (Figure 4-16). The difference between the Proposed Project and

Existing Conditions scenarios in mean estimates of *E. affinis* was small, on the order of 2 % to 4% (Table 4-3). As previously noted, the modeling of operations effects using CalSim modeling do not include proposed larval and juvenile Delta Smelt entrainment protections, which would increase Delta outflow relative to the Proposed Project results presented herein, thereby reducing the predicted difference in *E. affinis* density between scenarios. In addition, as described in Section 3.3.16.1 *Adaptive Management Across Wetter and Drier Years*, adaptive management of spring outflow will be implemented by curtailing SWP south Delta exports, e.g., per the SWP portion of the San Joaquin River I:E ratio from the NMFS (2009) BiOp, which would reduce the difference in spring Delta outflow between Existing Conditions and the Proposed Project. Overall, the analysis suggests that while there may be the potential for *E. affinis* density in the low salinity zone to be less under the Proposed Project scenario than under the Existing Conditions scenario, this is uncertain and the predicted mean difference is small.

Other factors such as clam grazing add uncertainty to the potential for effects (Kimmerer and Thompson 2014; Dugdale et al. 2016). The potential effects on *E. affinis* as a function of X2 reflect combined SWP and CVP operations; during the period from March through May, the period of potential effects on *E. affinis*, the SWP would be responsible for around 40% to 60% of Delta water operations under the Proposed Project, depending on water year type and month (Table 4-1).

Table 4-3. Mean Predicted *Eurytemora affinis* Density in the Low Salinity Zone under the Proposed Project and Existing Conditions Modeling Scenarios, and Differences between the Scenarios Expressed as a Numerical Difference and Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
Wet	204	198	-5 (-3%)
Above Normal	177	171	-6 (-3%)
Below Normal	136	131	-5 (-4%)
Dry	112	109	-3 (-3%)
Critical	82	80	-1 (-2%)

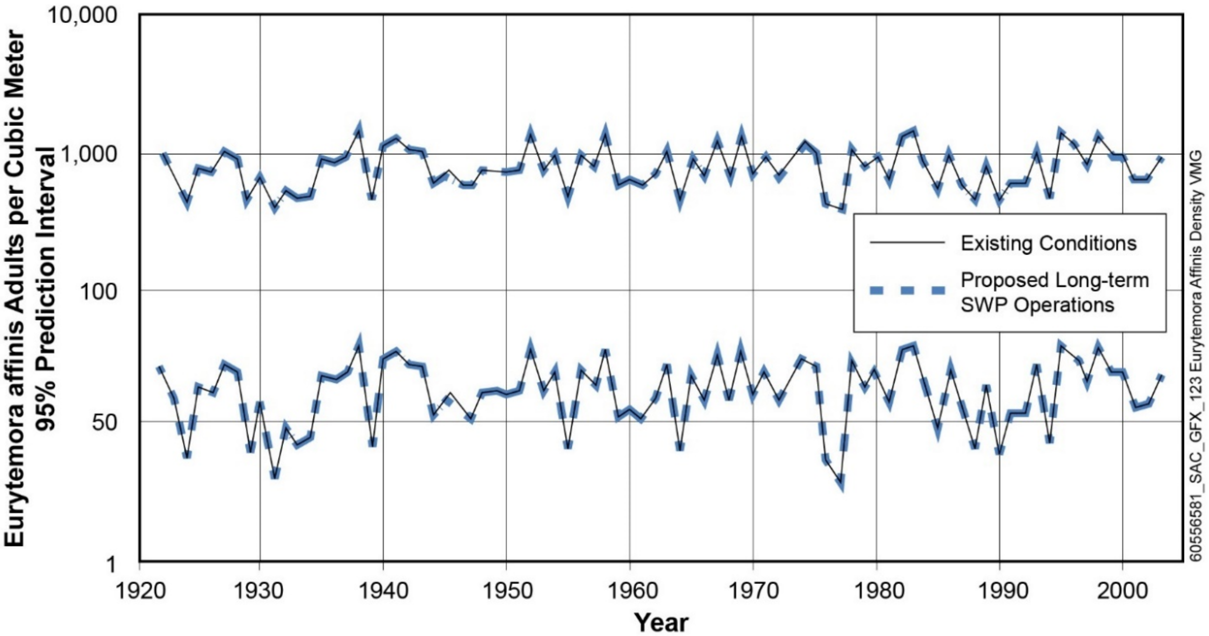
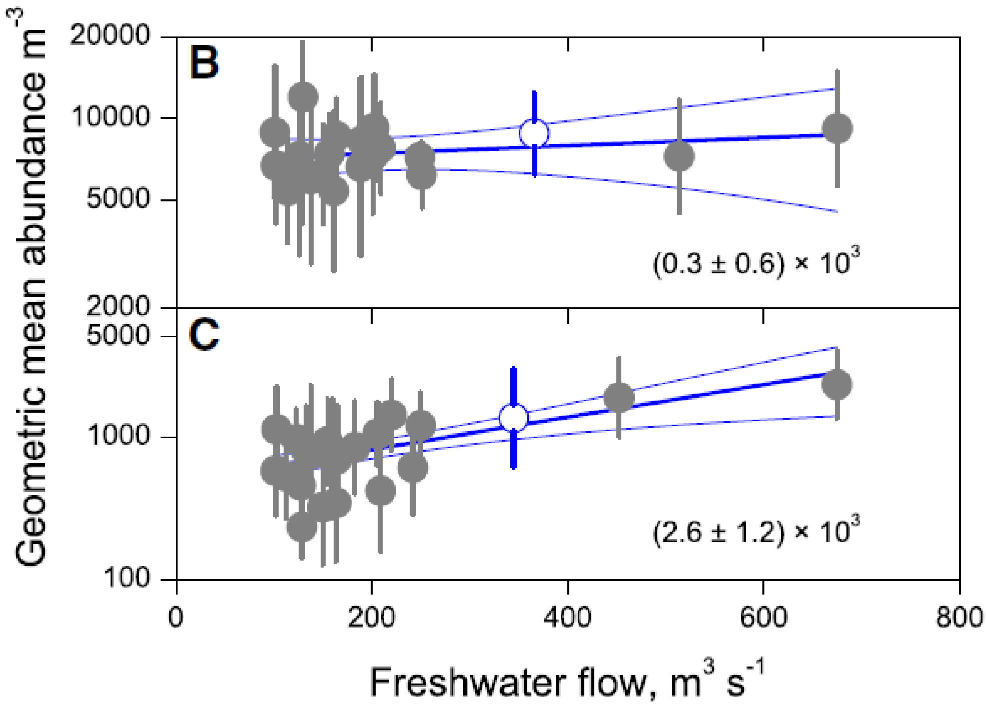


Figure 4-16. *Eurytemora affinis* Density in the Low Salinity Zone 95% Prediction Interval, for the 1922-2003 Modeled Period

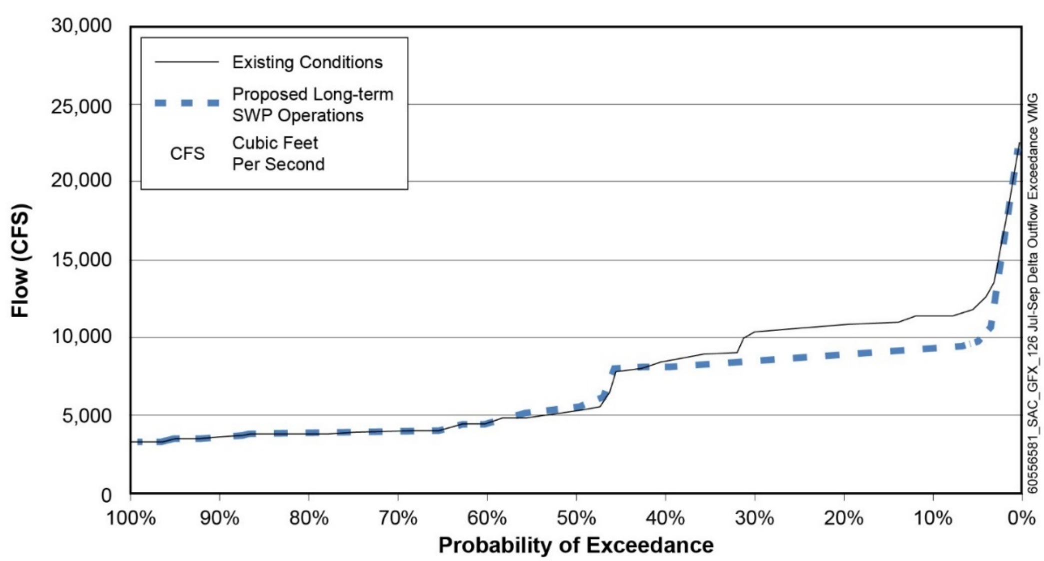
Juveniles to Subadults (June–September)

The IEP MAST (2015) conceptual model describes food availability and quality as key components of the June through September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals. Freshwater inflows (Delta outflow) influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018), and these potential negative effects are possibly of particular importance on the San Joaquin River side of the Delta, given the high density of *P. forbesi* there (Kimmerer et al. 2018). South Delta exports may entrain *P. forbesi* (USFWS 2008:228; Kimmerer et al. 2019), resulting in a positive correlation between July–September Delta outflow and *P. forbesi* density in the low salinity zone (Kimmerer et al. 2018; panel C in Figure 4-17). July–September Delta outflow generally would be similar between the Proposed Project and Existing Conditions scenarios, except for differences attributable to inclusion of fall X2 criteria (beginning in September) under the Existing Conditions scenario, which would result in an approximately 2,000-cfs difference between scenarios at an approximately 5% to 30% exceedance (~10,500 to 11,500 cfs for the Existing Conditions scenario and ~8,500 to 9,500 cfs for the Proposed Project scenario; see Figure 4-18; see also Figures 4-19, 4-20, and 4-21) in September of wet years. Such differences, amounting to 50 cumecs—the unit used by Kimmerer et al. [2018] in Figure 4-17—would be predicted to give a *P. forbesi* density that is lower under the Proposed Project scenario than under the Existing Conditions scenario, although there is statistical uncertainty in the relationship, as indicated by the 95% confidence interval on the regression (Panel B in Figure 4-17). However, this does not account for adaptive management of summer-fall Delta outflow, including initial use of a 100-TAF block of water in August to maintain X2 of 80 km in wet and above normal years (see Section 3.3.16.1 *Adaptive Management of Wetter and Drier Years*): this would have the potential to increase *P. forbesi* transport relative to Existing Conditions.



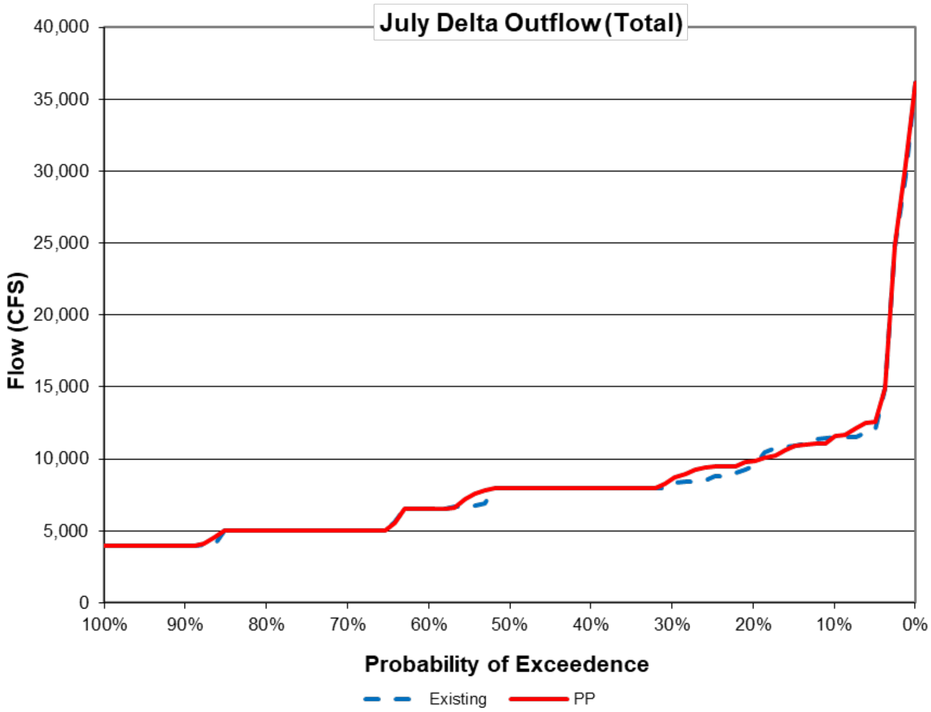
Source: Kimmerer et al. (2018). Note: Error bars are 95% confidence limits based on all samples from the selected stations, and points for 2011 are shown as open circles. Lines with error bounds are from least-squares models of log of abundance versus flow, weighted by the inverse of variance. Values are slopes with 95% confidence intervals; only the slope for the low salinity zone stations was statistically significant.

Figure 4-17. July–September Geometric Mean Abundance of *Pseudodiaptomus forbesi* Copepodites and Adults for 1994–2016 in (B) Freshwater Stations (Salinity < 0.5) and (C) Low Salinity Zone Stations (Salinity 0.5–5), Excluding Suisun Marsh and the Central to Eastern Delta



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-18. Mean Modeled Delta Outflow, July–September



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-19. Mean Modeled Delta Outflow, July

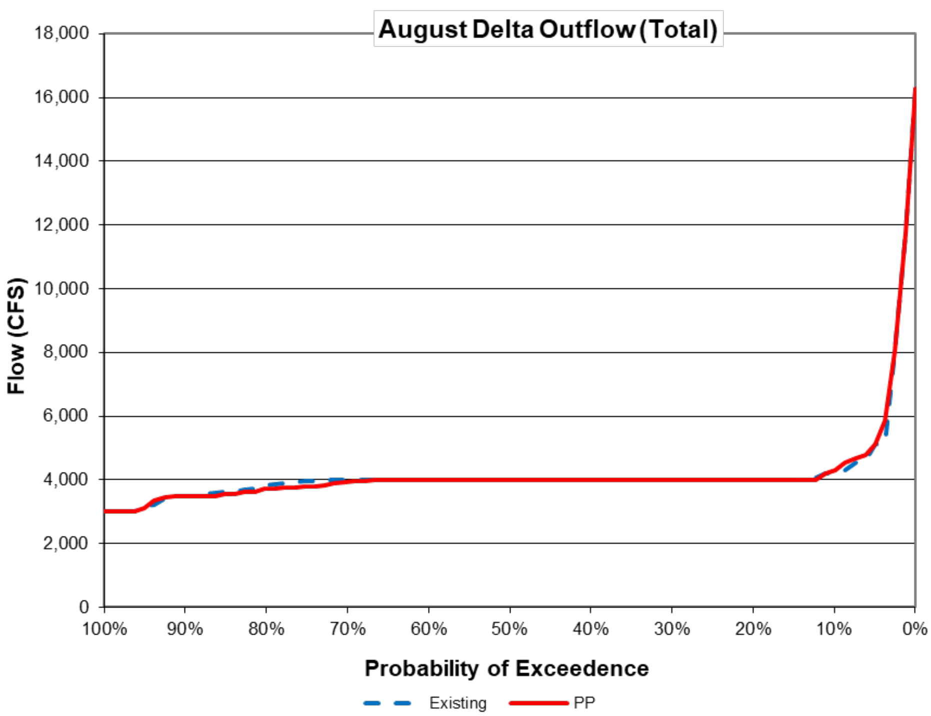


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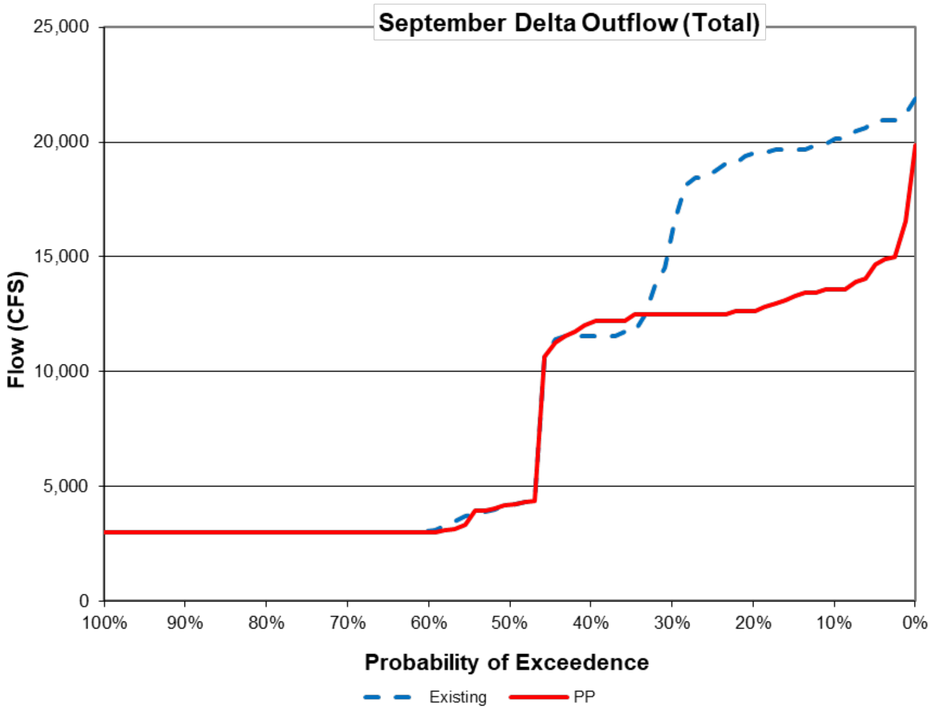
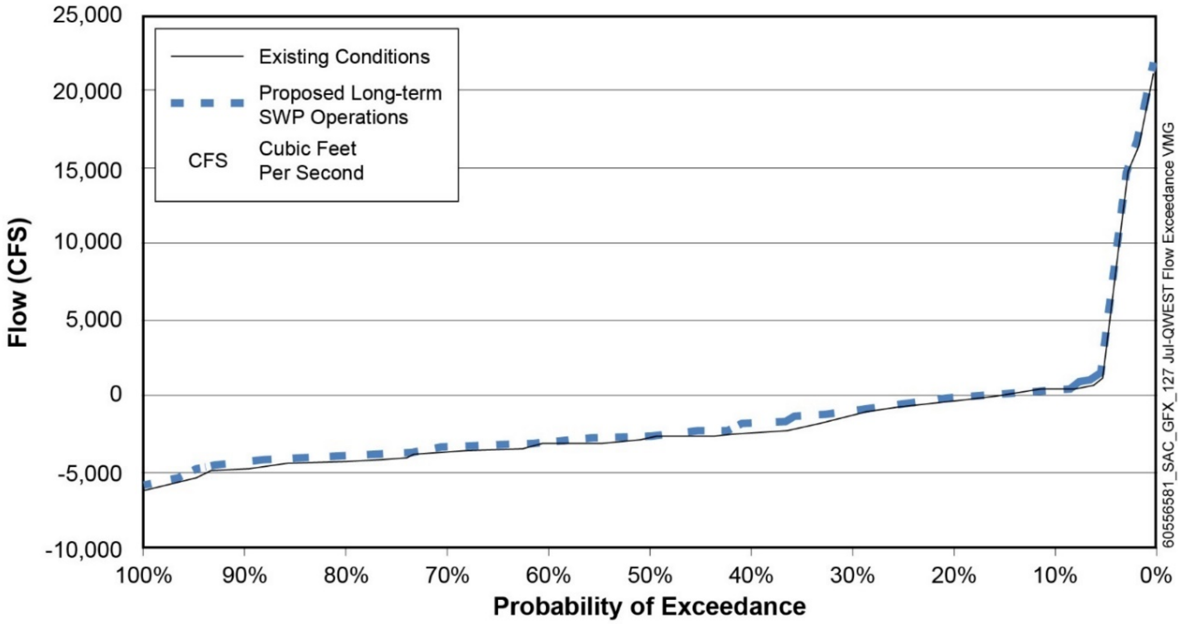
Figure 4-20. Mean Modeled Delta Outflow, August



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

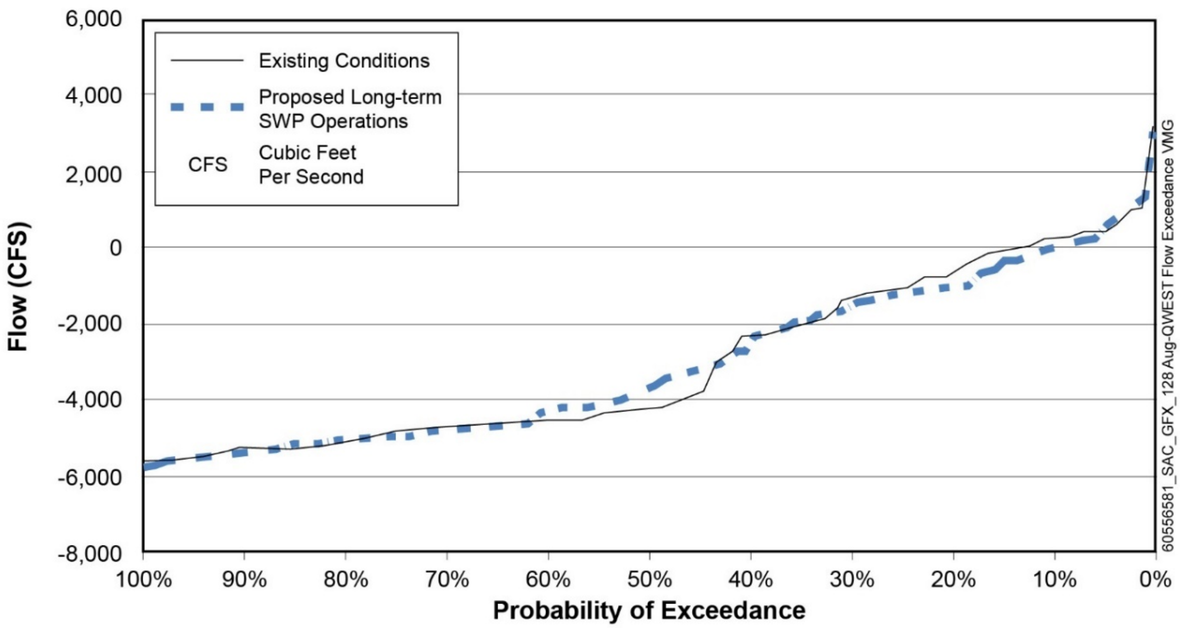
Figure 4-21. Mean Modeled Delta Outflow, September

Net positive QWEST provides an indicator of downstream *P. forbesi* subsidy potential from the lower San Joaquin River to the low salinity zone, given the high density of *P. forbesi* in the lower San Joaquin River (Kimmerer et al. 2018) and modeled losses to entrainment by the South Delta export facilities (Kimmerer et al. 2019). QWEST flows suggest that the potential for subsidy of *P. forbesi* to the low salinity zone may be similar under the Proposed Project and Existing Conditions scenarios in July and August. July and August have similar percentage of negative QWEST under both scenarios (Figures 4-22 and 4-23). However, in September the percentage of years with positive QWEST was somewhat greater (~20%) under the Proposed Project scenario than under the Existing Conditions scenario (~10%) (Figure 4-24). Uncertainty exists regarding the extent to which changes in the food subsidy to the low salinity zone would be of consequence should these even occur as a result of lower San Joaquin River flow differences, given the high rate of grazing in the low salinity zone (Kayfetz and Kimmerer 2017; Kimmerer et al. 2019) and the distribution of an appreciable portion of Delta Smelt upstream of the low salinity zone (i.e., an average of 23% [range 2% to 47%]) during the 2005–2014 period (Bush 2017). Monthly average QWEST would be negative under both Proposed Project and Existing Conditions scenarios, possibly indicating potential downstream subsidy of *P. forbesi* would be very limited regardless of scenario, but downstream subsidy potential may be somewhat greater under the Proposed Project scenario relative to the Existing Conditions scenario.



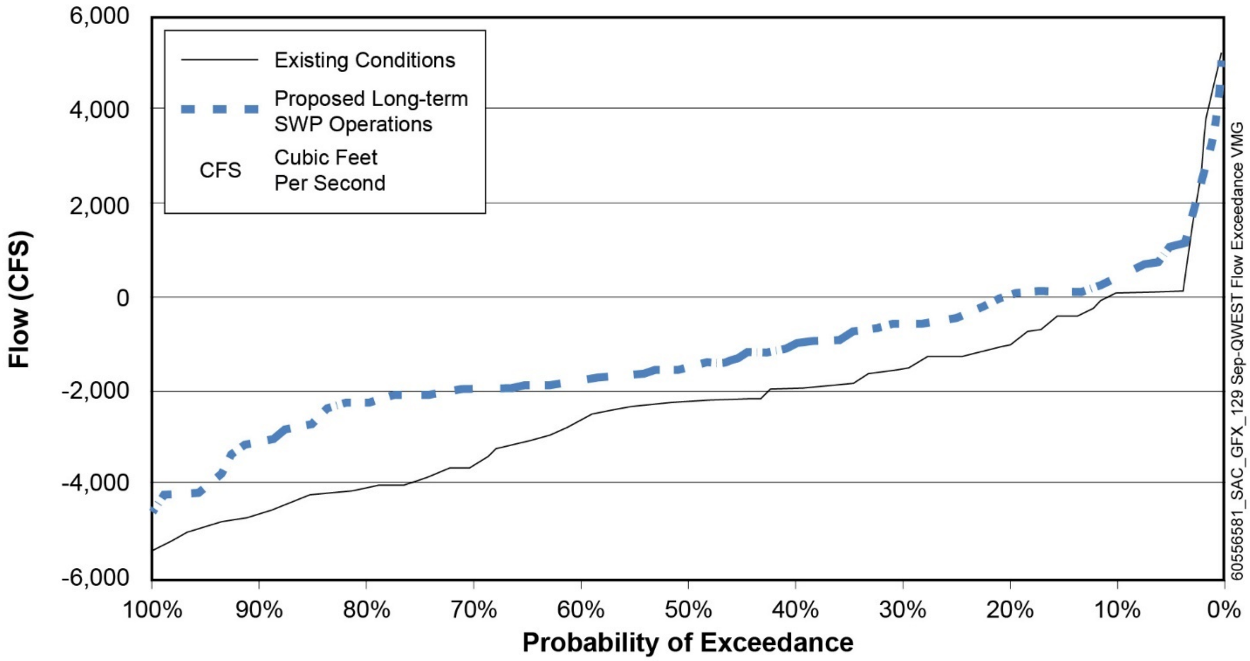
Source: <ITP_PP_0819.dss> and <2020D09EDV.dss>

Figure 4-22. Mean Modeled QWEST Flow, July



Source: <ITP_PP_0819.dss> and <2020D09EDV.dss>

Figure 4-23. Mean Modeled QWEST Flow, August



Source: <ITP_PP_0819.dss> and <2020D09EDV.dss>

Figure 4-24. Mean Modeled QWEST Flow, September

The potential effects on *P. forbesi* food subsidy described above in relation to Delta outflow and QWEST reflect combined SWP and CVP operations; during September, the main month of potential effect on *P. forbesi* subsidy to the low salinity zone, the SWP would be responsible for an average of ~23% to 28% of Delta water operations in the wet and above normal years (Table 4-1).

Subadults to Adults (September–December)

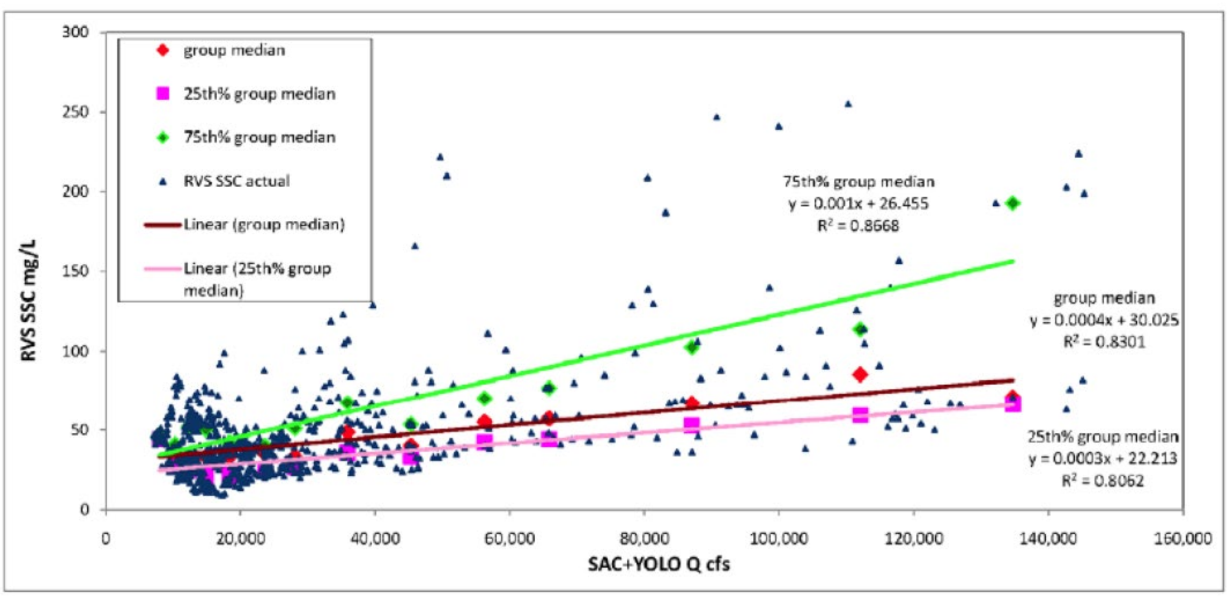
As discussed in the previous section for juvenile Delta Smelt, seasonal South Delta export operations have the potential to affect Delta Smelt food availability through changes in *P. forbesi* subsidy to the low salinity zone rearing habitat occupied by most Delta Smelt reaching adulthood. Although the FLaSH investigations predicted that Delta Smelt food availability (as represented by calanoid copepods) in the fall low salinity zone would be greater with lower X2 (i.e., higher outflow) (Brown et al. 2014:25), this was not found to be the case either for the post-*Potamocorbula amurensis* invasion period (1988–2015/2016; see Figures 5.16-27, 5.16-28, 5.16-29, 5.16-30, 5.16-31, and 5.16-32 in Reclamation 2019) or for the period following onset of the Pelagic Organism Decline (2003–2015/2016) (ICF 2017:78–82). Therefore, as described for juvenile Delta Smelt, there is some evidence for potential positive effects on *P. forbesi* transport to the low salinity zone as a result of the Proposed Project scenario relative to the Existing Conditions scenario, but not for overall calanoid copepod density in the low salinity zone (ICF 2017:78–82).

4.2.1.3 PREDATION

Adults to Eggs and Larvae (December–March)

The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting Delta Smelt egg survival, with flows interacting with erodible sediment supply to affect turbidity. In general, greater turbidity is hypothesized to lower the risk of predation on Delta Smelt (Bennett 2005; Moyle et al. 2016). Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action (Schoellhamer et al. 2014; Bever et al. 2018). Cloern et al. (2011, their Figure S1) developed a rating curve of the Sacramento River at Rio Vista suspended sediment concentration as a function of Sacramento River at Freeport plus Yolo Bypass flows to the Delta (reproduced and shown in Figure 4-25). Based on this curve, differences between the Proposed Project and Existing Conditions scenarios in suspended sediment concentration as a function of mean winter-spring Rio Vista flows would be expected to be limited, given that the flows generally are similar between the two scenarios (see Figures 4-26, 4-27, 4-28, 4-29, 4-30, and 4-31).

Available estimates of sediment removal by the South Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in the 1999–2002 period (Wright and Schoellhamer 2005). Given the limited expected difference in suspended sediment entering the Delta under the Proposed Project scenario relative to the Existing Conditions scenario (as suggested by the Rio Vista flows discussed above) as well as the small percentage of sediment that would be expected to be removed by the South Delta export facilities, the potential effect of the Proposed Project on turbidity generally would be expected to be low. The IEP MAST (2015) conceptual model hypothesizes that high turbidity relates to low predation risk for Delta Smelt, as supported by mesocosm studies (Ferrari et al. 2014). There is uncertainty in this conclusion, given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012, their Figure 7), and the fact that quantitative analyses of the effects of exports on predation risk and turbidity have not been conducted (IEP MAST 2015:52).



Source: Cloern et al. (2011; their Figure S1).

Figure 4-25. Sediment Rating Curve for the Sacramento River at Rio Vista, 1998-2002

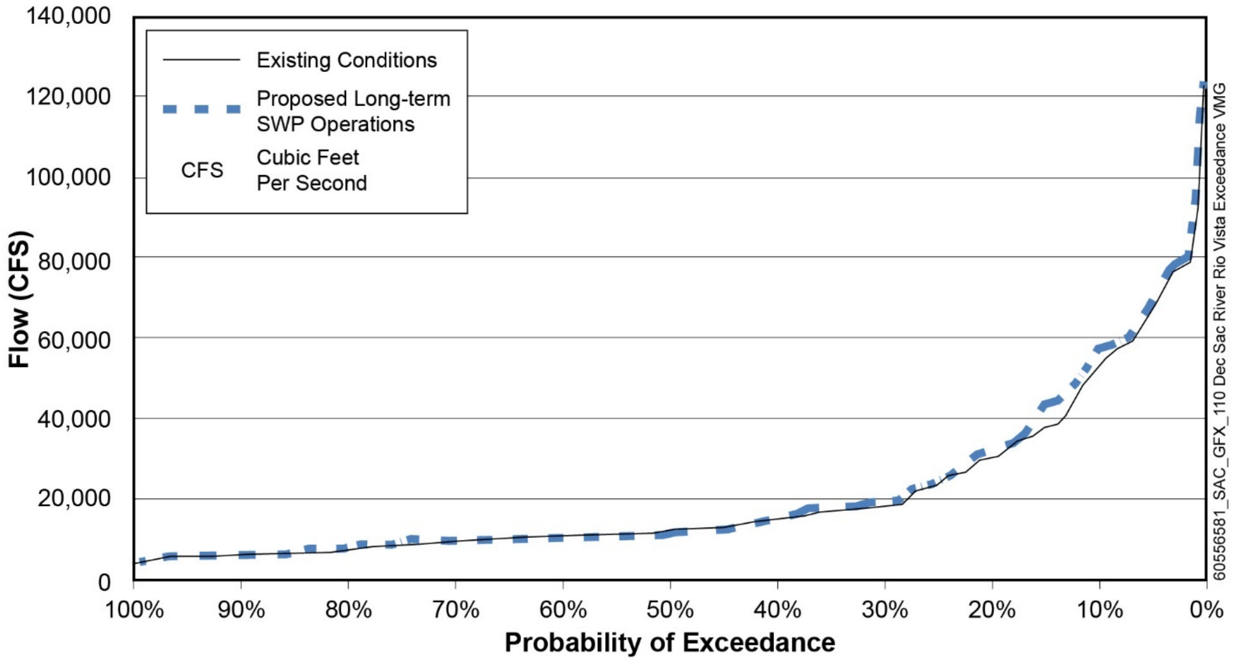


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Figure 4-26. Mean Modeled Sacramento River Flow at Rio Vista, December

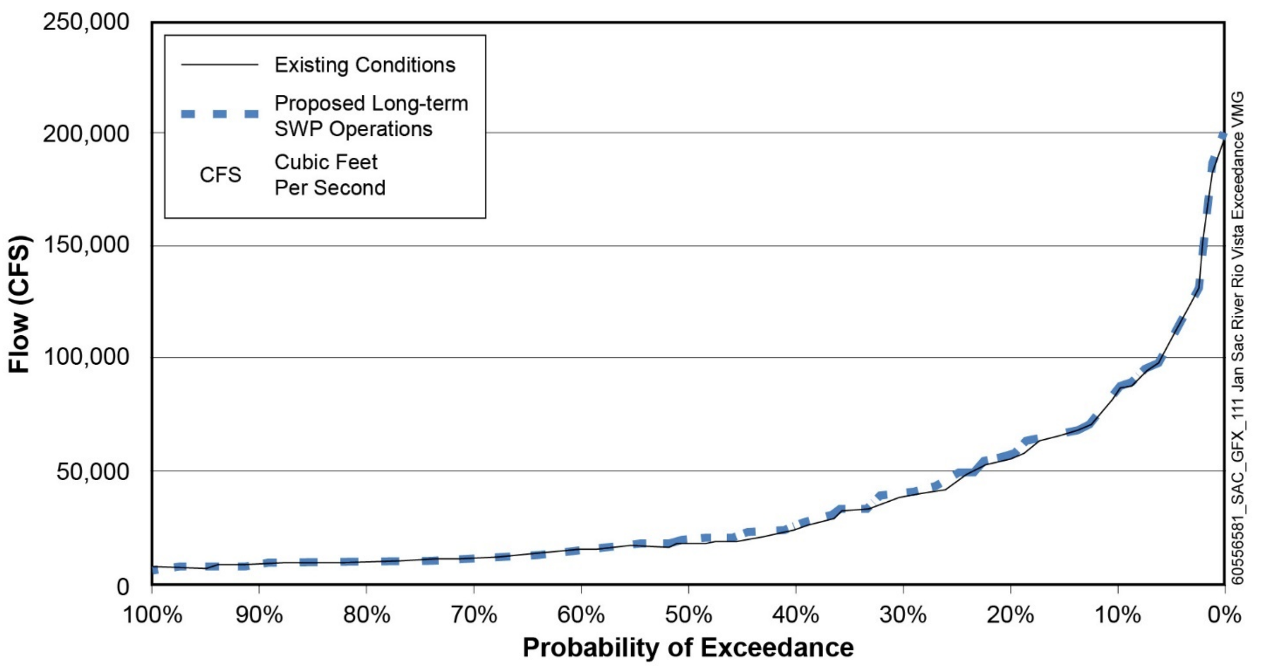

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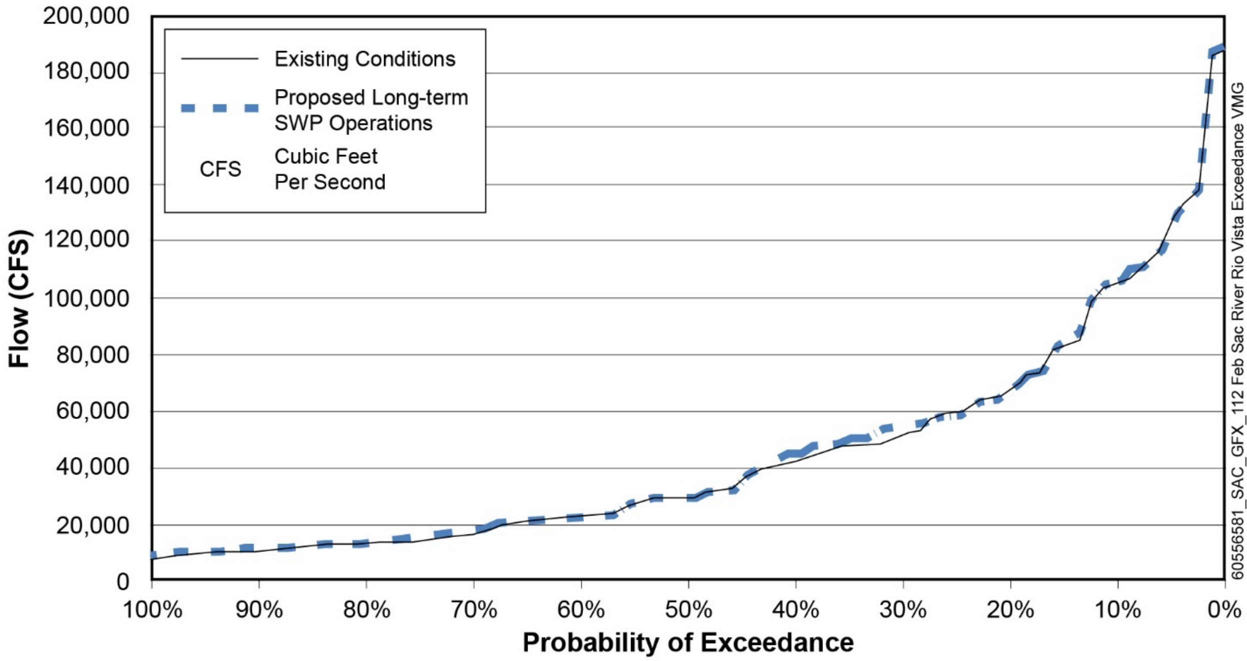
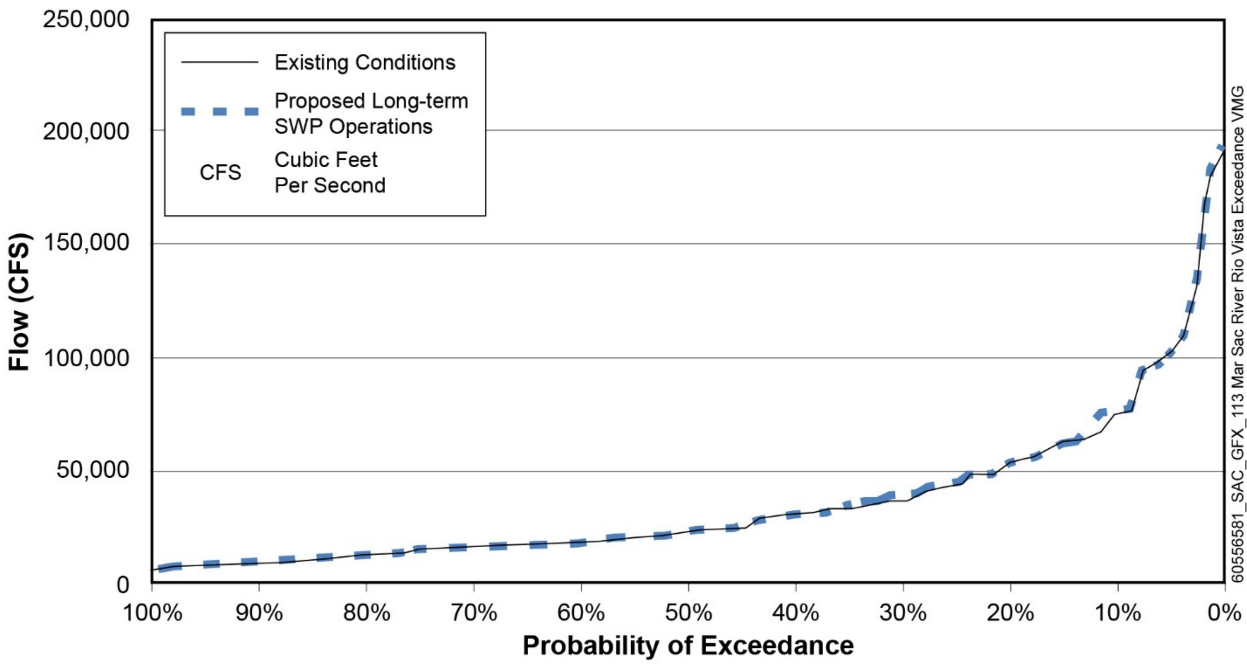
Figure 4-27. Mean Modeled Sacramento River Flow at Rio Vista, January



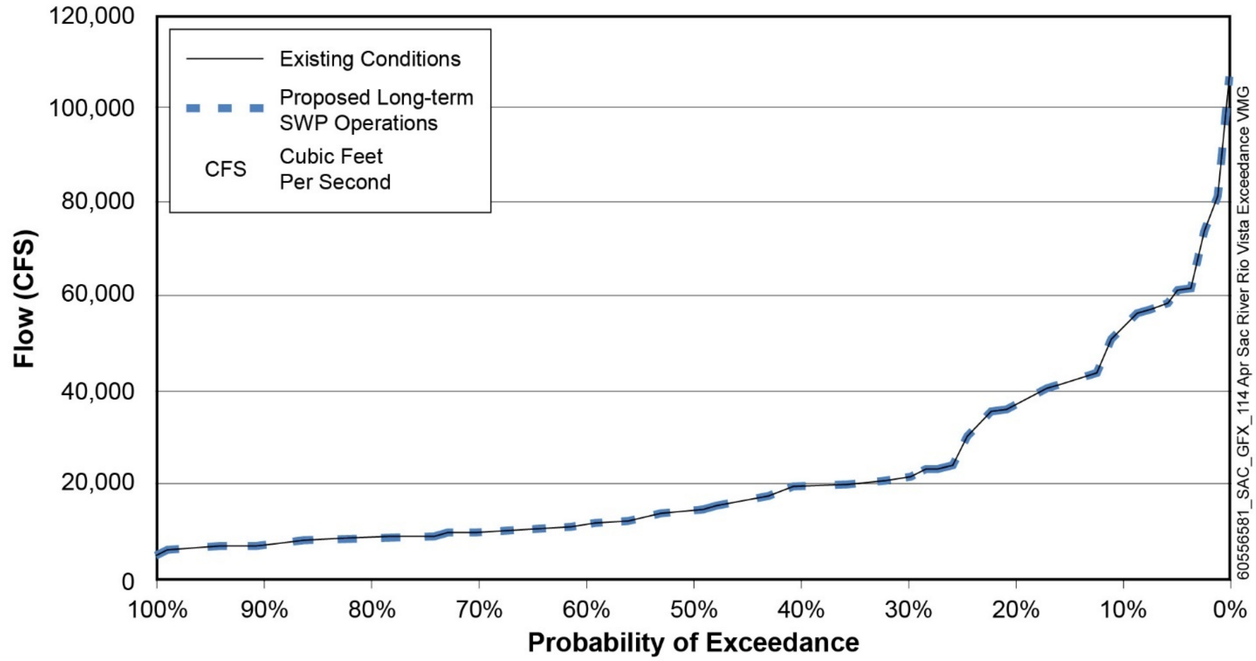
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-28. Mean Modeled Sacramento River Flow at Rio Vista, February



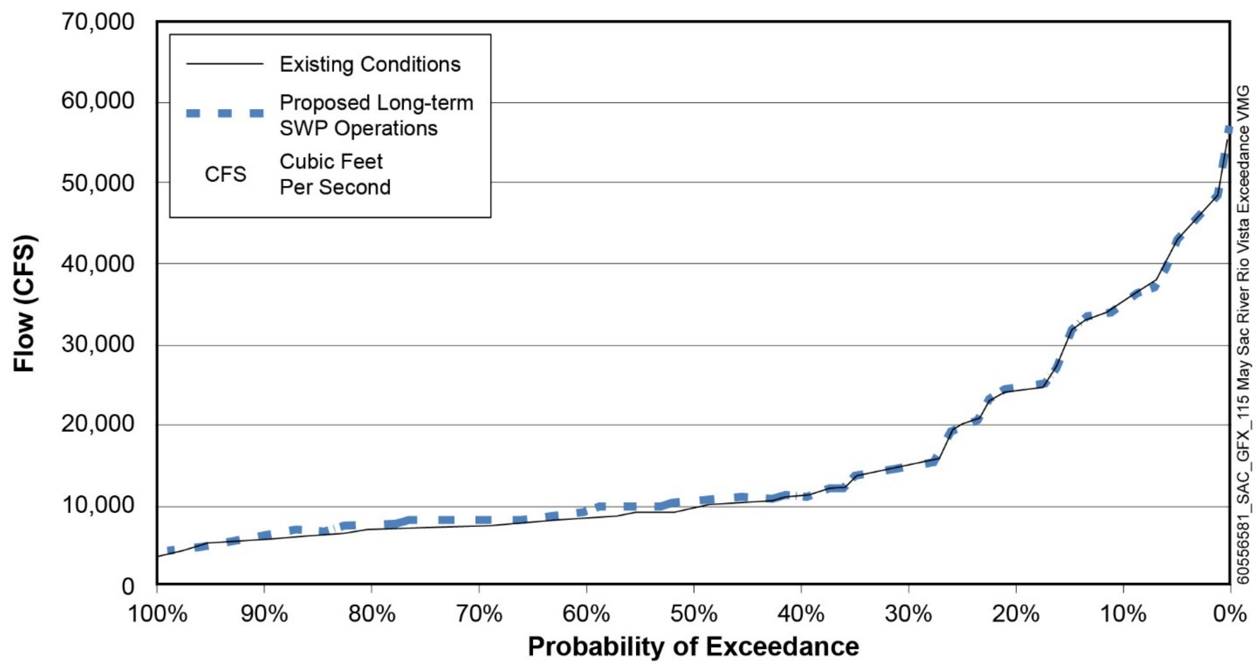
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-29. Mean Modeled Sacramento River Flow at Rio Vista, March



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-30. Mean Modeled Sacramento River Flow at Rio Vista, April



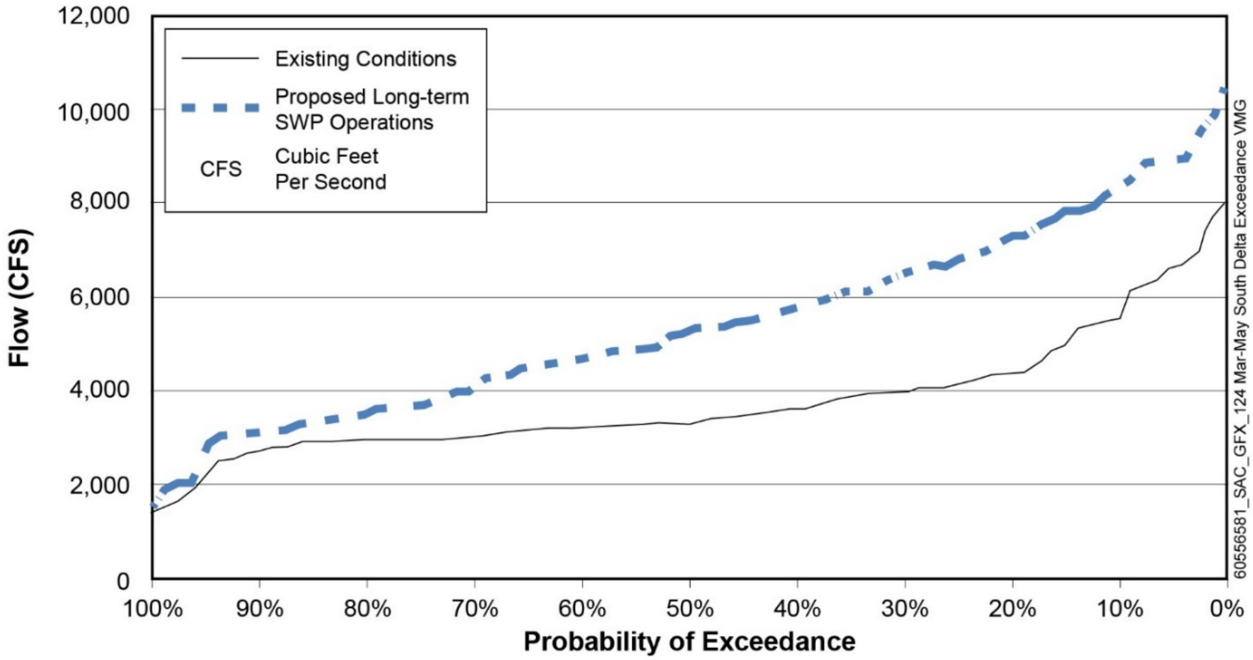
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4-31. Mean Modeled Sacramento River Flow at Rio Vista, May

Eggs and Larvae to Juveniles (March–June)

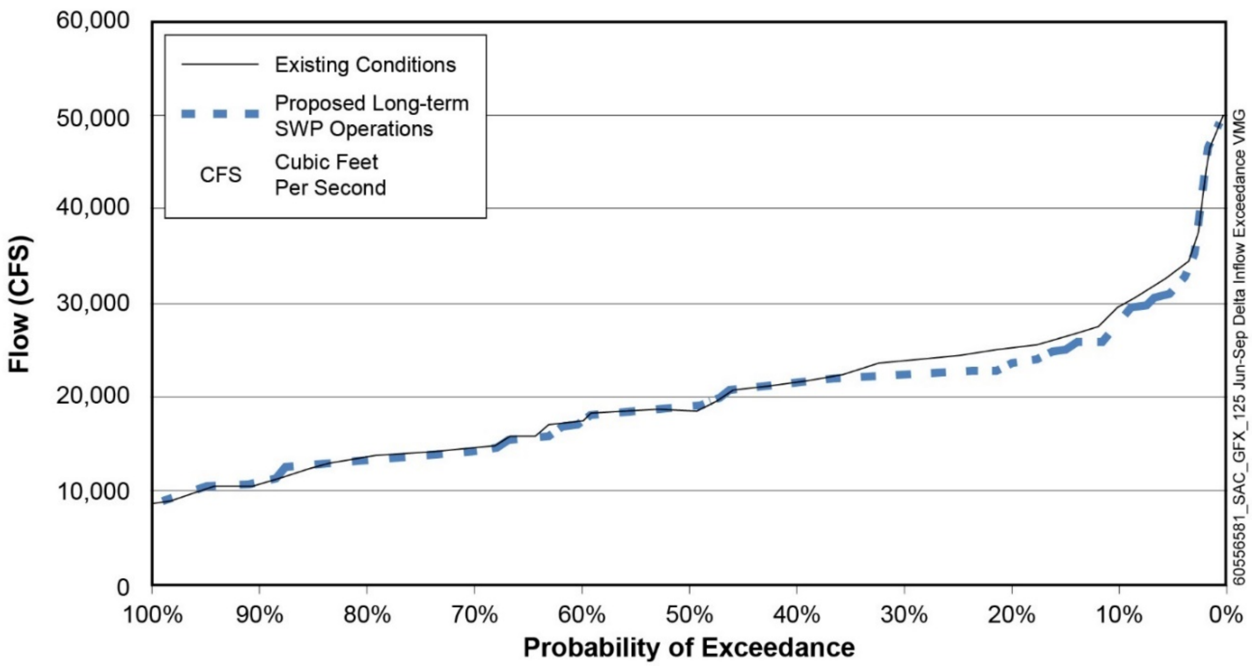
The IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides). The relationship between these factors is not well understood based on empirical research. As previously described for adult Delta Smelt in relation to Rio Vista flows, potential effects of the Proposed Project on turbidity as a result of reduced upstream supply and removal by South Delta exports are concluded to be low, although this is uncertain. Wild detection of Delta Smelt embryos and larvae is rare, which reduces the certainty of any conclusions, although silversides have been found with Delta Smelt in their guts during the larval period (Schreier et al. 2016). As discussed by USFWS (2017:274), water temperature in the San Francisco Estuary is driven mainly by air temperature and even in the Delta the water temperature is only slightly affected by freshwater inflow; flow-related effects of the Proposed Project on Delta water temperature are expected to be minor (Wagner et al. 2011).

With respect to silversides, Mahardja et al. (2016) found in a multivariate model that summer (June–September) Delta inflow and spring (March–May) South Delta exports had the strongest correlations with silverside cohort strength; both relationships were negative. These relationships do not imply causality, given that the mechanisms could not be identified (Mahardja et al. 2016:12). In addition, beach seines (used in the study) only sample upstream of the confluence, so if high flow moves silversides downstream, then the inverse correlation of flow and abundance is misleading. In other words, the observed pattern might simply be a result of a redistribution of silverside rather than increased production in wetter conditions. Recognizing this uncertainty, the Proposed Project scenario has greater South Delta exports in March-May (mainly in April-May) than the Existing Conditions scenario (Figure 4-32), which would be expected to correlate with lower silverside cohort strength under the Proposed Project, whereas the Proposed Project has similar or somewhat lower June – September Delta inflow (only in September of wet years) than the Existing Conditions scenario (Figure 4-33), which would be expected to correlate with similar or somewhat higher silverside cohort strength under the Proposed Project. Given that exports and inflow have opposing effects in terms of the potential effects on silverside cohort strength relative to the changes predicted for the Proposed Project, it is uncertain what the net effect of these changes would be, which adds to the uncertainty in whether the magnitude of any change would be of consequence given that a causal relationship between cohort strength and inflow or exports has not been established (Mahardja et al. 2016).



Source: <ITP_PP_0819.dss>, <2020D09EDV.dss>.

Figure 4-32. Mean Modeled South Delta Exports, March–May



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>. Note: Delta inflow is represented by flow at Sacramento River at Freeport + through Yolo Bypass + Mokelumne River + San Joaquin River at Vernalis.

Figure 4-33. Mean Modeled Delta Inflow, June–September

The potential effects on silversides and therefore Delta Smelt larval predation as a function of Delta inflow and South Delta exports reflect combined SWP and CVP operations; during March–May, the period of potential effects on silversides from South Delta exports, the SWP would be responsible for around 40–60% of Delta water operations under the Proposed Project, depending on water year type and month, whereas during September of wet years, the main period correlated with potential inflow effects on silversides, the SWP would be responsible for 28% of Delta water operations (Table 4-1).

Juveniles to Subadults (June–September)

The IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators, turbidity, and water temperature. As previously discussed for larval Delta Smelt, effects on water temperature from the Proposed Project relative to the Existing Conditions scenario would be expected to be negligible. Turbidity during the low-flow summer and fall periods is partly a function of sediment delivery during the high-flow winter/spring periods, for it influences the amount of sediment for available (see summary by IEP MAST 2015:50). As discussed previously for adult Delta Smelt, differences in winter/spring Rio Vista flow and sediment delivery, together with only small amounts of sediment lost to entrainment, suggest little difference between the Proposed Project and Existing Conditions scenarios in terms of turbidity and therefore predation risk. Note, however, that the summer-fall habitat action (see below) and operation of the Suisun Marsh Salinity Control Gates is designed to increase access to generally higher turbidity habitat of Suisun Marsh (relative to the lower Sacramento River, for example; ICF 2019), so there may be reduced predation in years when that action is implemented.

Subadults to Adults (September–December)

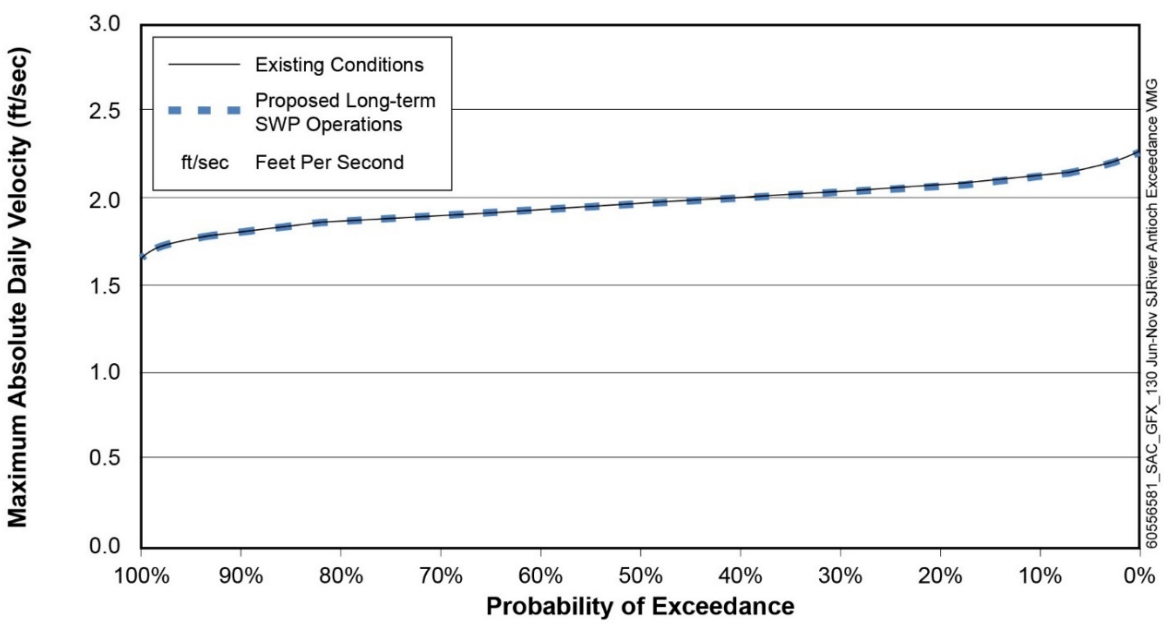
As noted for other Delta Smelt life stages, changes in sediment supply during the winter/spring could change sediment for resuspension during the fall subadult period; however, as discussed for adults, such differences are limited between the Proposed Project and Existing Conditions scenarios. With greater (more upstream) X2 under the Proposed Project in the fall relative to the Existing Conditions scenario in wet water years, the low salinity zone potentially could overlap areas with greater water clarity (i.e., lower turbidity) (ICF 2017:105–115) that are less likely to have wind-wave sediment resuspension (IEP MAST 2015:50), which could then translate into greater predation risk based on the posited negative correlation between predation risk and turbidity. In above normal water years, the more downstream low salinity zone under the Proposed Project (i.e., X2 of 80 km in September/October vs. X2 of 81 km under the Existing Conditions scenario) could slightly reduce predation risk under the Proposed Project scenario. The extent to which observed negative correlations between fall X2 and water clarity in the low salinity zone are the result of antecedent conditions (i.e., sediment supply during high-flow months) is uncertain (ICF 2017:106), although recent science indicates that wind may control turbidity to a considerable extent (Bever et al. 2018) and water operations would not affect wind-related suspension of sediment.

As previously described for other life stages, water temperature would not be expected to be greatly affected by the Proposed Project relative to the Existing Conditions scenario, as illustrated by the low to non-existent correlation between water temperature in the low salinity zone and X2 (see Figure 5.16-39 in Reclamation 2019:5-401). Any differences between scenarios would be expected to be within the tolerance of subadult Delta Smelt (Komoroske et al. 2014), thereby limiting the potential for differences in predation risk.

4.2.1.4 HARMFUL ALGAL BLOOMS

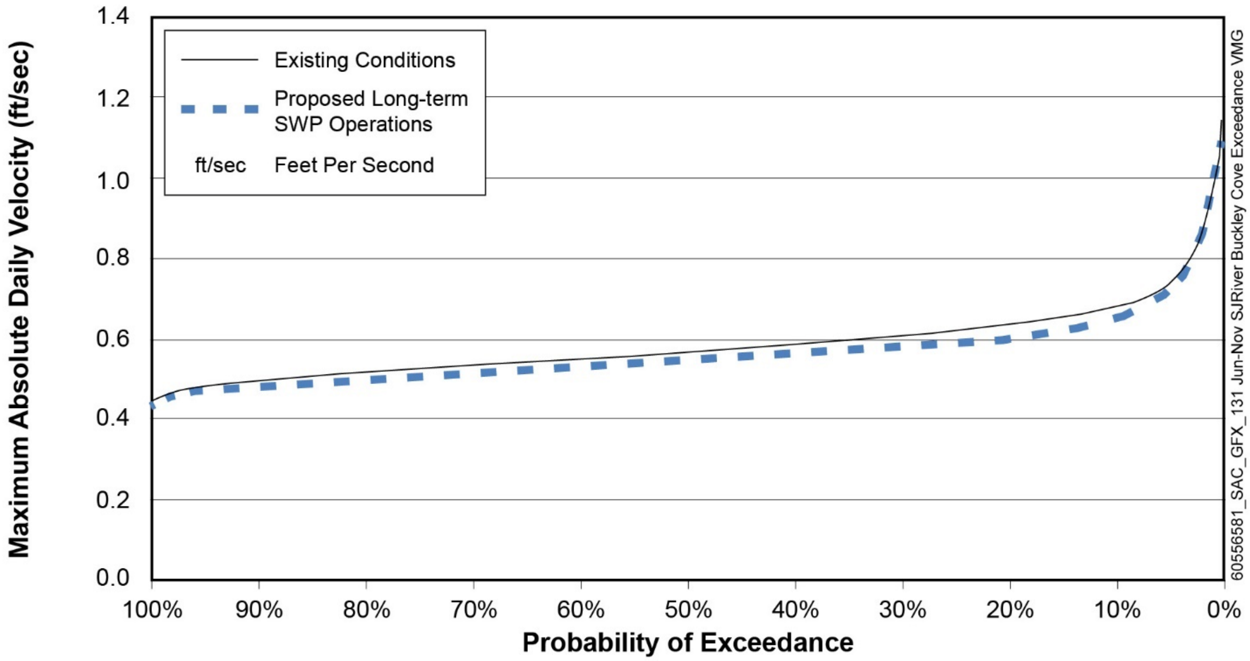
Juveniles to Subadults (June–September)

The IEP MAST (2015) conceptual model posits a linkage between various factors (nutrients, summer hydrology, and air temperature) and toxicity from harmful algal blooms to Delta Smelt and their prey. Based on this conceptual model (see also the additional discussion in IEP MAST 2015:85–86), differences in flows could influence harmful algal blooms (Lehman et al. 2018); operations would not be expected to affect nutrients or temperature. The harmful algal bloom species *Microcystis* has been observed at a range of flows (Lehman et al. 2013), although it is unclear the extent to which the species may occur beyond the range of flows observed by Lehman et al. (2013). A previous analysis by RBI (2017) focused on an analysis of maximum daily absolute velocity to assess exceedance of a 1 foot per second (ft/s) threshold above which turbulent mixing may disrupt *Microcystis* blooms. There is uncertainty in this threshold given that it was developed for a different system than the Bay-Delta (RBI 2017). Nevertheless, in the absence of more specific information, the same analysis was applied herein using results from DSM2-HYDRO modeling. It is acknowledged that there are other factors such as nutrients and water temperature that are likely to affect *Microcystis*, but only channel velocity is readily linked to water operations. The DSM2-HYDRO results suggested that there would be little difference between Proposed Project and Existing Conditions scenarios in velocity conditions in the Central and South Delta during summer and fall (June–November; Figures 4-34, 4-35, 4-36, 4-37, 4-38, 4-39, 4-40, and 4-41), which therefore also suggests little difference between the Proposed Project and Existing Conditions scenarios in the potential for velocity conditions affecting harmful algal blooms.



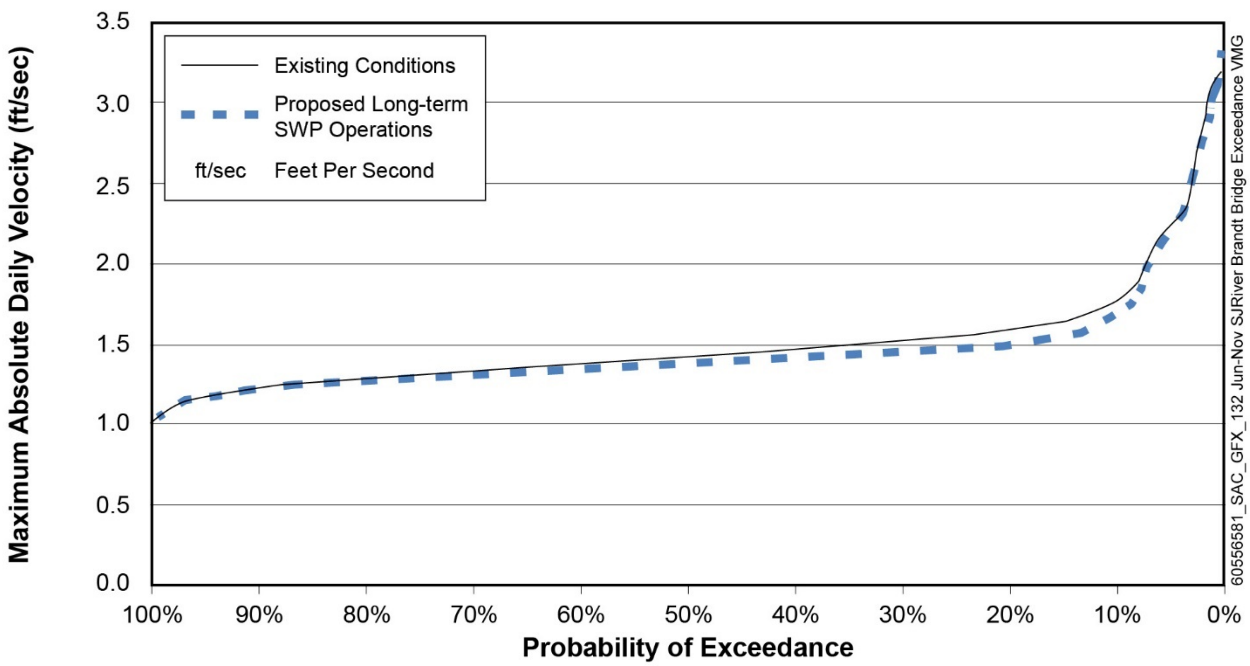
Source: <marin_absDmax.dss>.

Figure 4-34. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Antioch, June–November



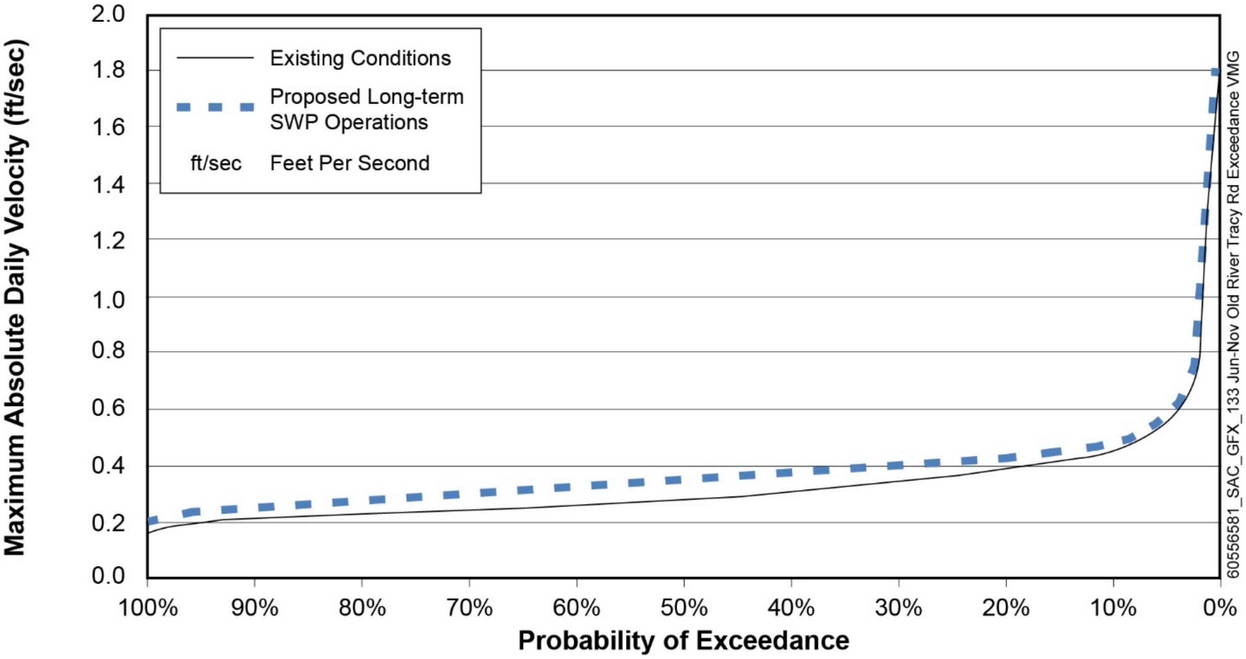
Source: <marin_absDmax.dss>.

Figure 4-35. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Buckley Cove, June–November



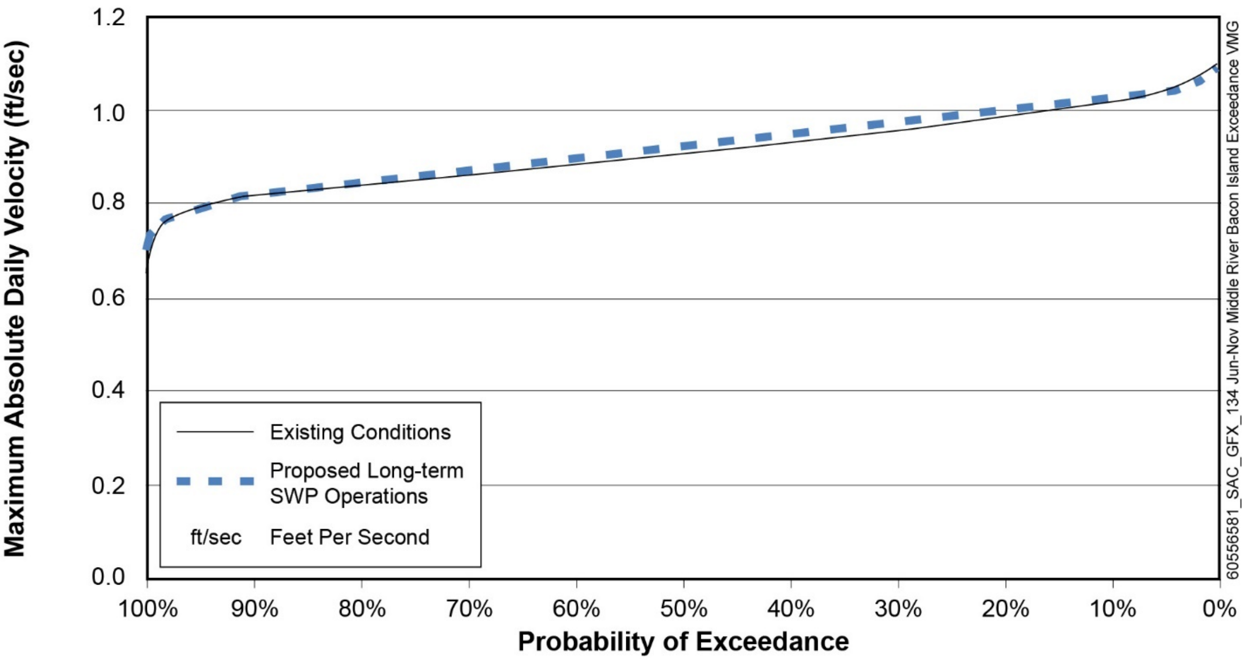
Source: <marin_absDmax.dss>.

Figure 4-36. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Brandt Bridge, June–November



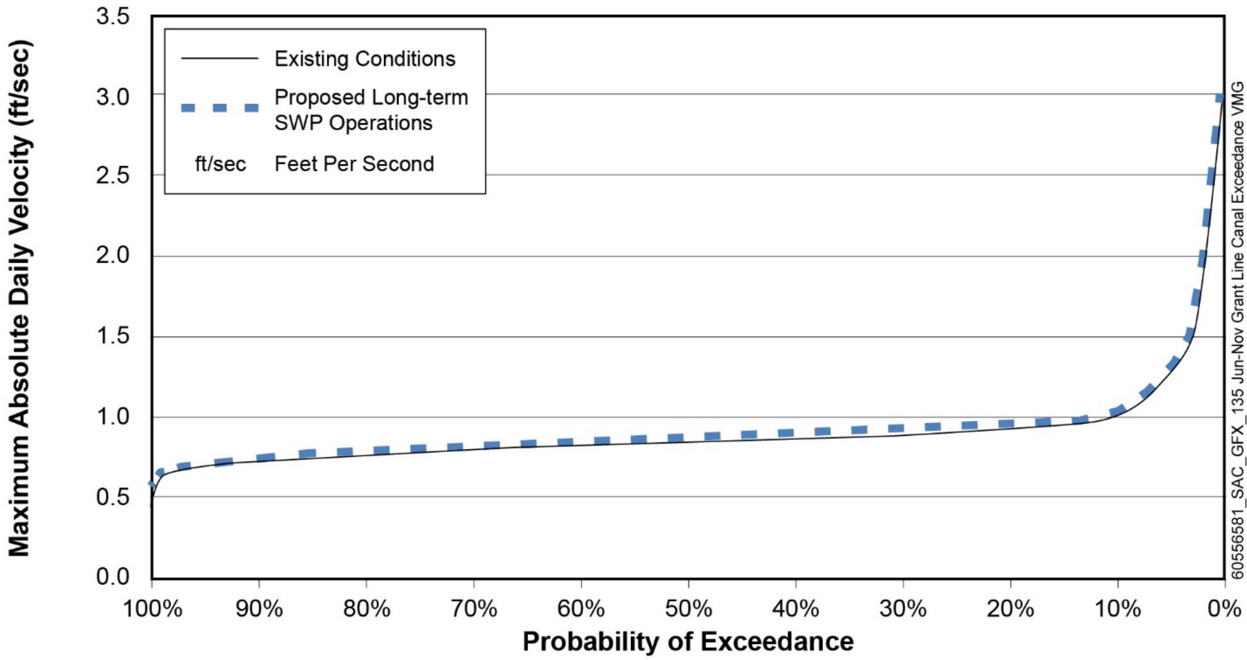
Source: <marin_absDmax.dss>.

Figure 4-37. Modeled Maximum Absolute Daily Velocity in Old River at Tracy Road, June–November



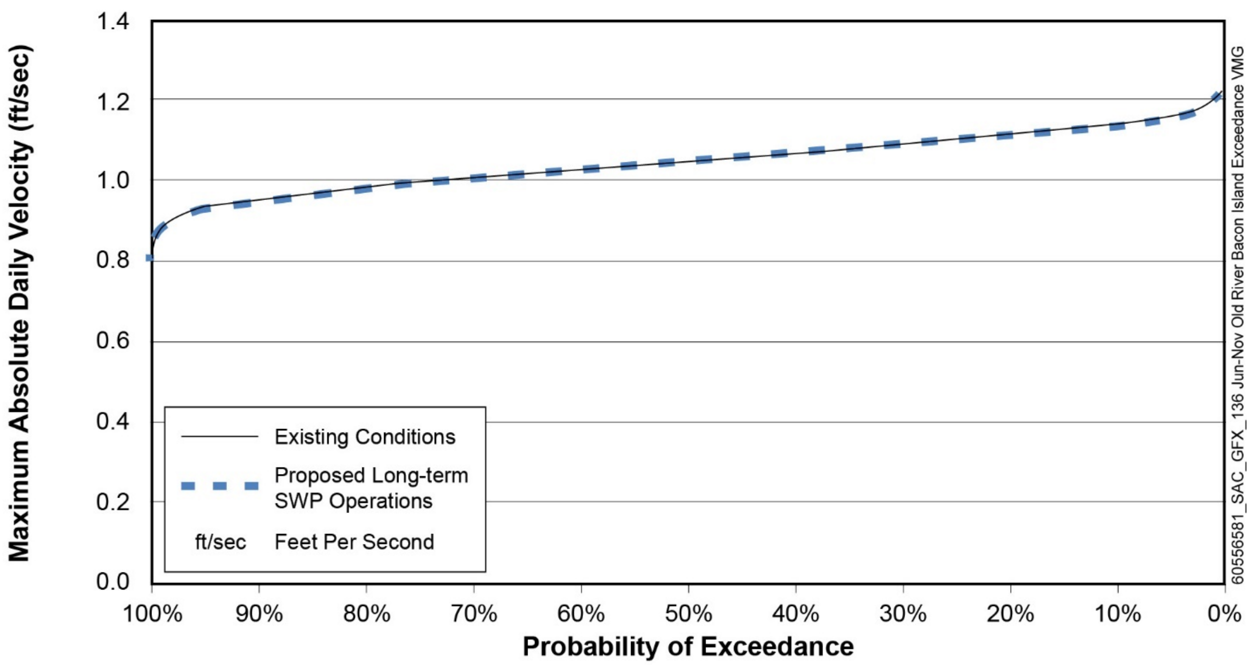
Source: <marin_absDmax.dss>.

Figure 4-38. Modeled Maximum Absolute Daily Velocity in Middle River at Bacon Island, June–November



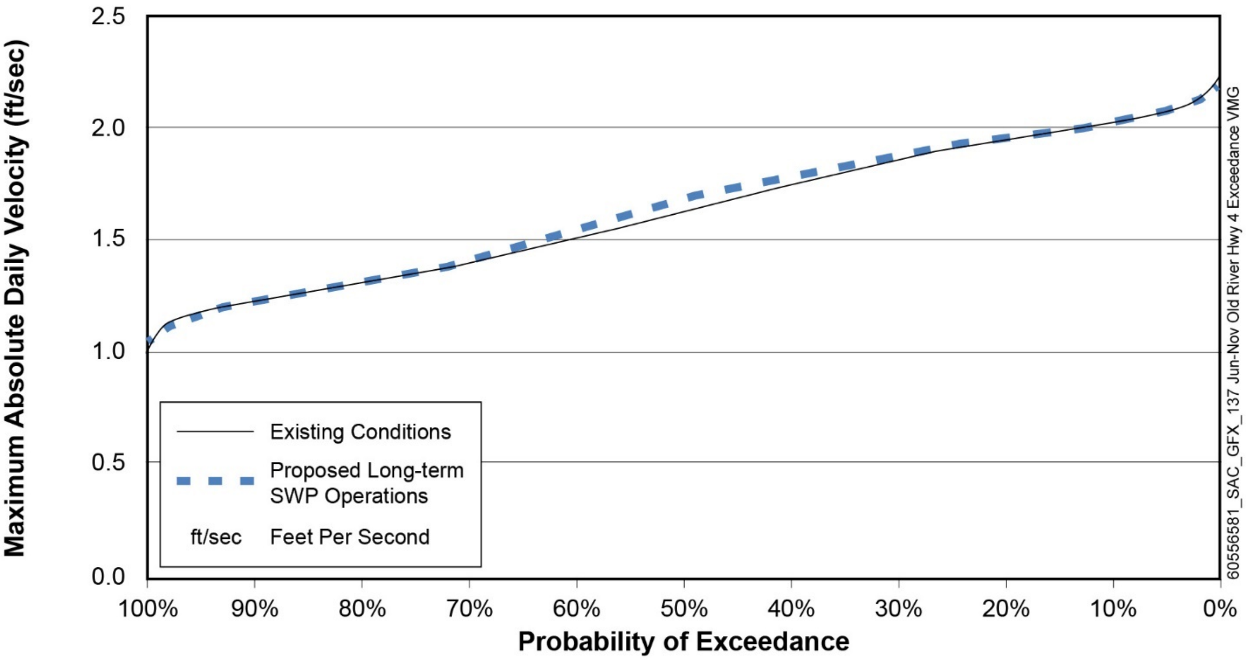
Source: <marin_absDmax.dss>.

Figure 4-39. Modeled Maximum Absolute Daily Velocity in Grant Line Canal Downstream of Temporary Barrier, June–November



Source: <marin_absDmax.dss>.

Figure 4-40. Modeled Maximum Absolute Daily Velocity in Old River at Bacon Island, June–November



Source: <marin_absDmax.dss>.

Figure 4-41. Modeled Maximum Absolute Daily Velocity in Old River at Highway 4, June–November

Subadults to Adults (September–December)

As discussed for juvenile Delta Smelt, application of the threshold velocity approach from RBI (2017) with DSM2-HYDRO modeling results suggests that there would be little difference between Proposed Project and Existing Conditions scenarios in velocity conditions in the Central and South Delta during summer and fall (June–November; Figures 4-34, 4-35, 4-36, 4-37, 4-38, 4-39, 4-40, and 4-41), which therefore also suggests little difference between Proposed Project and Existing Conditions scenarios in the potential for velocity conditions affecting harmful algal blooms.

4.2.1.5 Size and Location of the Low Salinity Zone (Summer-Fall Delta Smelt Habitat Actions)

Qualitative Analysis

The IEP MAST (2015) conceptual model posits that Delta Smelt abundance, survival, and growth are affected by the size and location of the low salinity zone during fall, with IEP MAST (2015:142) concluding: "The limited amount of available data provides some evidence in support of this hypothesis, but additional years of data and investigations are needed." Others have found that low salinity zone habitat may not be a predictor of Delta Smelt abundance and survival (Thomson et al. 2010, ICF 2017). Related to this, an additional argument in support of summer-fall habitat actions potentially being of importance to Delta Smelt is that having a broader distribution provides "bet-hedging" against the effects of environmental stressors (Hobbs et al. 2019). For example, if a species' distribution is too constrained, its extinction risk is elevated as compared to a broader distribution. Hence, habitat actions that help support a broad distribution can have long-term population benefits. Note that this logic is somewhat different than the goal of maximizing habitat area and may not occur in every year.

As described in the project description, the Proposed Project would use structured decision-making to implement summer/fall Delta Smelt habitat actions with the goal of achieving environmental and biological goals which are intended to improve Delta Smelt food supply and habitat. Whereas current management, as represented by the Existing modeling scenario, focuses on USFWS (2008) SWP/CVP BiOp fall criteria (i.e., X2 in September–October ≤ 74 km in wet years and ≤ 81 km in above normal years, with provisions to extend these requirements into November or December, if specific conditions are met), the Proposed Project includes X2 ≤ 80 km in September–October of wet and above normal years. Based solely on consideration of X2 and the typical distribution of the low salinity zone, this would tend to give a smaller area of low salinity habitat under the Proposed Project in wet years and somewhat larger area of low salinity habitat under the Proposed Project in above-normal years, relative to the Existing Conditions scenario. However, the Proposed Project also includes additional operation of the SMSCG relative to the Existing Conditions scenario, for up to 60 days in June through October of below normal, above normal, and wet years, expanding both the seasons and water year types when the action would be implemented. Evidence from a pilot 2018 application of the SMSCG action suggests that the Delta Smelt Summer-Fall Habitat Action would provide habitat benefits for Delta Smelt. The SMSCG were operated during August 2018 and it was found that Delta Smelt had access to more productive habitat; better water quality conditions (lower salinity) occurred, relative to the period before the gates were operated; and there was some evidence that the benefits extended beyond the period of gate operations (Sommer et al. 2018; although see ICF 2019). Thus, the proposed SMSCG action potentially increases Delta Smelt habitat suitability in an area with potential higher food availability (relative to adjacent areas such as Grizzly Bay; ICF 2019) and higher growth potential, as reflected by Delta Smelt individual-level responses such as stomach fullness generally being higher in Suisun Marsh than other areas of the Delta Smelt range (Hammock et al. 2015). The 2018 implementation of the pilot SMSCG action illustrated that the action could provide salinity conditions in Suisun Marsh during below normal years that, from the perspective of Delta Smelt juveniles, were similar to or better than in wet years (Sommer et al. 2018). The SMSCG action would have the potential to affect a sizable proportion of the Delta Smelt population (e.g., an average of 77% of Delta Smelt in the low salinity zone as observed in recent years [Bush 2017], with approximately 20% of juvenile Delta Smelt in Suisun Marsh as indicated by Enhanced Delta Smelt Monitoring (EDSM) surveys during the 2018 pilot action, albeit with considerable uncertainty because of overall low numbers caught in surveys).

As noted in the project description, additional Delta outflow to support the above Summer-Fall actions could come from export reductions, increased reservoir releases, or some combination of the two. From the perspective of summer-fall Delta Smelt habitat, the expected source of the outflow changes will not matter. For either operational approach, habitat area, habitat quality, and resulting geographic distribution should be similar. Adaptive management of summer-fall Delta outflow, including initial use of a 100-TAF block of water in August to maintain X2 of 80 km in wet and above normal years (see Section 3.3.16.1 *Adaptive Management of Wetter and Drier Years*), would have the potential appreciably increase the extent and area of the low salinity zone in August of wet and above normal years, relative to Existing Conditions.

In addition to X2 management and SMSCG operations, the Proposed Project's summer and fall habitat actions include food enhancement actions found in the Delta Smelt Resiliency Strategy (North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies [Roaring River distribution system reoperation]); these are discussed below in Section 4.2.1.10 *Food Enhancement Summer-Fall Actions*.

SCHISM Analysis

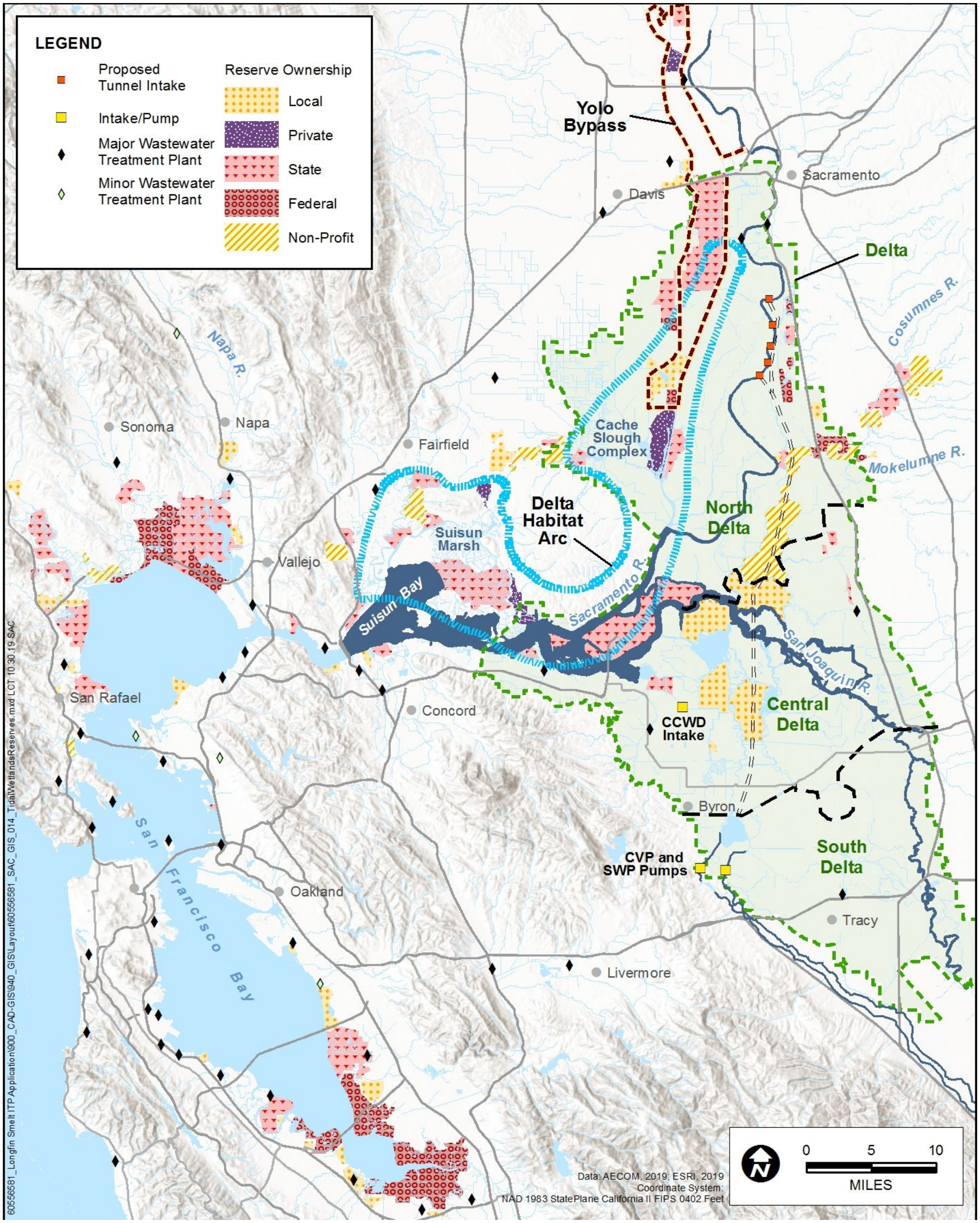
To illustrate the potential impacts of SMSCG operations and September and October X2 operations proposed for consideration as part of the Delta Smelt Summer-Fall Habitat Action, a hindcasting analysis based on historical conditions in 2012 (a representative below-normal water year) and 2017 (a representative wet water year) was undertaken using the SCHISM model, which is described in more detail in Appendix C. In each year, a base scenario simulated historical conditions; in 2017, an additional scenario with X2 of 74 km in the September–October period was run to provide a further point of comparison for context.

Moreover, this analysis focuses on habitat area which is only one facet of the potential effects on Delta Smelt. As noted previously, a separate consideration is the degree to which each alternative affects the overall range of the species. For example, a broader distribution provides a bet hedging function, which helps the species deal with adverse environmental conditions.

Two potential Proposed Project summer-fall habitat action scenarios were simulated for 2012. One scenario included 60-day SMSCG operations commencing on June 14, and the other scenario included 60-day SMSCG operations commencing on August 15. The mean area of low salinity (≤ 6 psu) was calculated for each day. In consideration of the importance of the North Delta arc of habitat for Delta Smelt (Hobbs et al. 2017; Figure 4-42), results were calculated for several generalized geographic regions: the North Delta arc, a corridor of channels from Cache Slough to Montezuma Slough, Suisun Marsh, and Suisun Bay (Figure 4-43). In addition to a summary of results considering salinity alone, a second analysis overlaid salinity with interpolated data for water temperature from various monitoring stations and turbidity (Secchi depth) from summer townet and fall midwater trawl surveys (ftp://ftp.wildlife.ca.gov/TownetFallMidwaterTrawl/). For each day, the average area of habitat meeting three criteria (salinity ≤ 6; temperature < 25C; Secchi depth >0.5 m [Bever et al. 2016]) was summarized. Appendix C provides additional details regarding the methods and results of the SCHISM modeling and analysis.

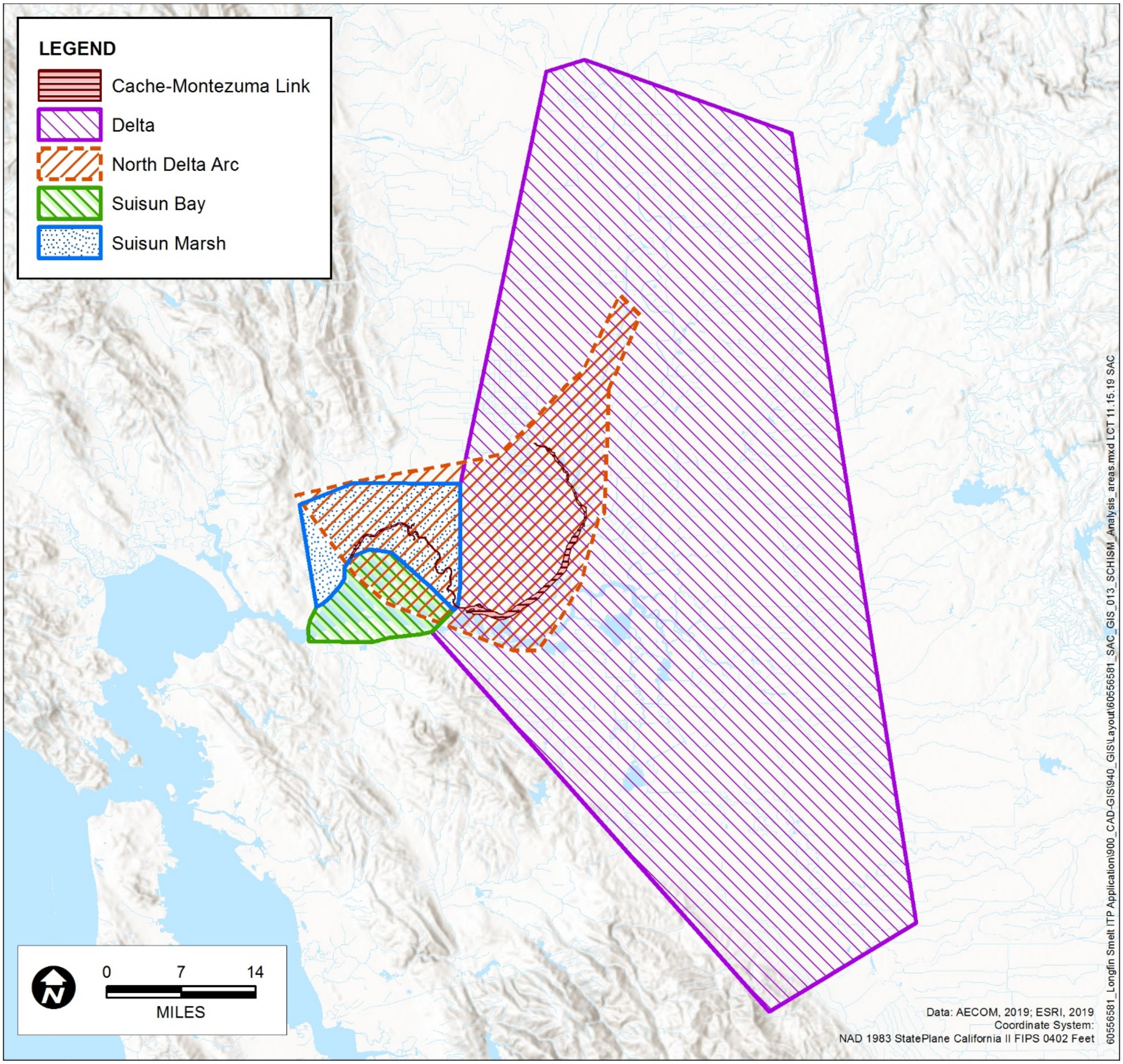
The 2012 SCHISM results illustrated that operation of the SMSCG would have yielded a greater extent of low-salinity habitat if undertaken for 60 days commencing on August 15 rather than June 14 (Figure 4-44). In general, D-1641 agricultural water quality standards are sufficient to protect low-salinity habitat in Suisun Marsh until August 15, when the standards no longer apply. At the scale of the overall North Delta arc or the Cache to Montezuma corridor, differences in low-salinity area between scenarios as a result of SMSCG operations would be expected to be modest (Figure 4-44). The greatest differences would occur within Suisun Marsh, for which SMSCG operations commencing on August 15 would be expected to result in appreciably greater extent of low-salinity habitat from August 15 through October 15, extending somewhat to the November–December time frame. Operation of the

SMSCG in this manner would be expected to result in a reduction in the extent of low-salinity habitat in Suisun Bay (including Grizzly Bay) relative to the scenario without SMSCG operation (Figure 4-44). The extent to which this reduction in Suisun Bay habitat could affect Delta Smelt would depend on the distribution of the species. However, sampling during the 2018 SMSCG action suggested a greater presence of Delta Smelt in Suisun Marsh than Suisun Bay (Figure 4-45), which may indicate greater potential for a positive rather than a negative impact of habitat changes resulting from the SMSCG operation, particularly considering that Suisun Marsh provides habitat in which Delta Smelt generally have appreciably better conditions than in Suisun Bay (Hammock et al. 2015).



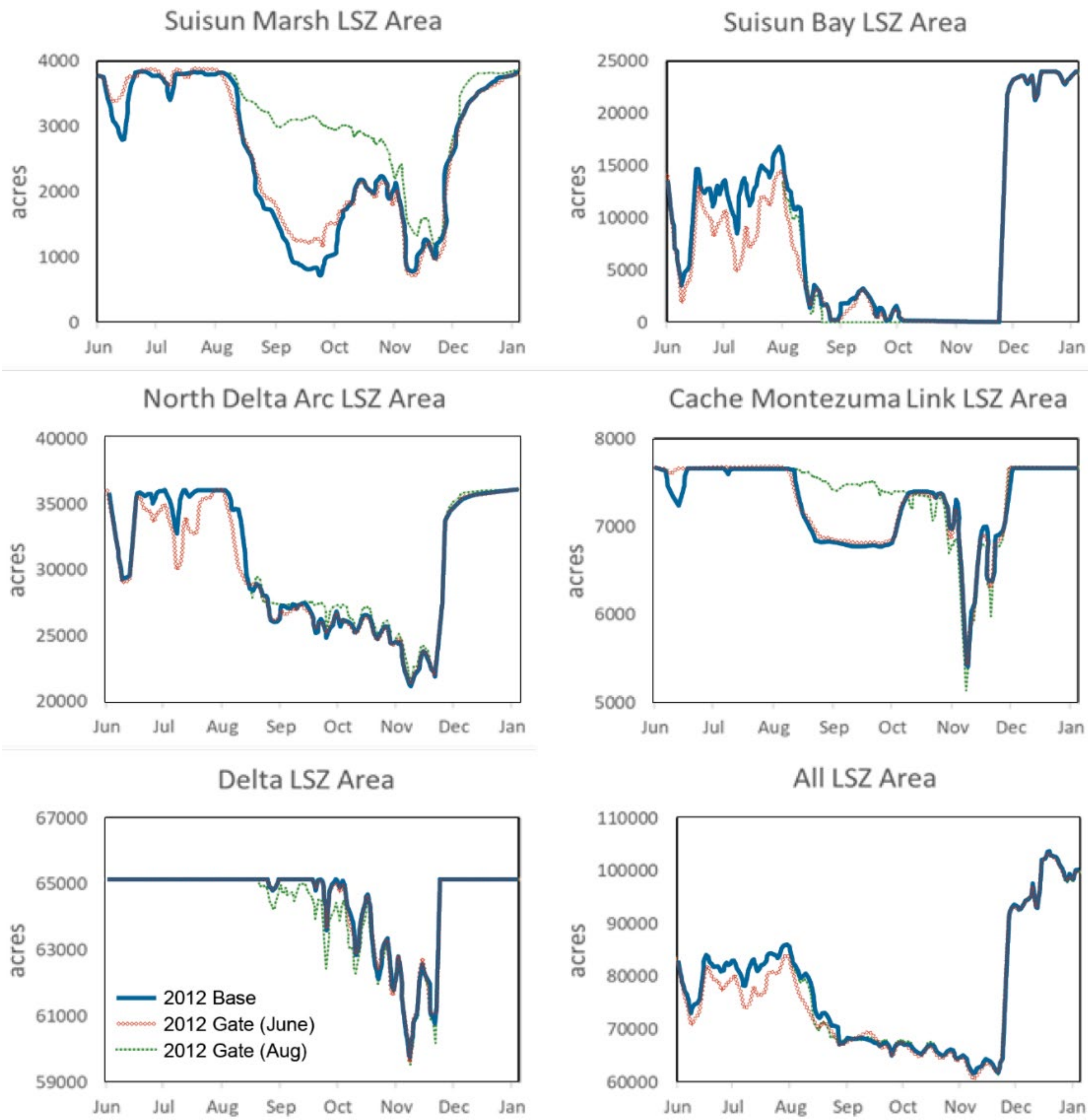
Source: Hobbs et al. (2017). Note: 'Proposed tunnel' represents previously considered facilities as part of Bay Delta Conservation Plan/California WaterFix planning process.

Figure 4-42. Tidal Wetland Reserve Ownership by Entity Including the North Delta Arc (Arc of Habitat outlined in blue), Islands in the Central Delta (yellow) and lands in the Napa–Sonoma Marsh, Petaluma River in the North Bay and Salt Ponds in South Bay (pink hues)



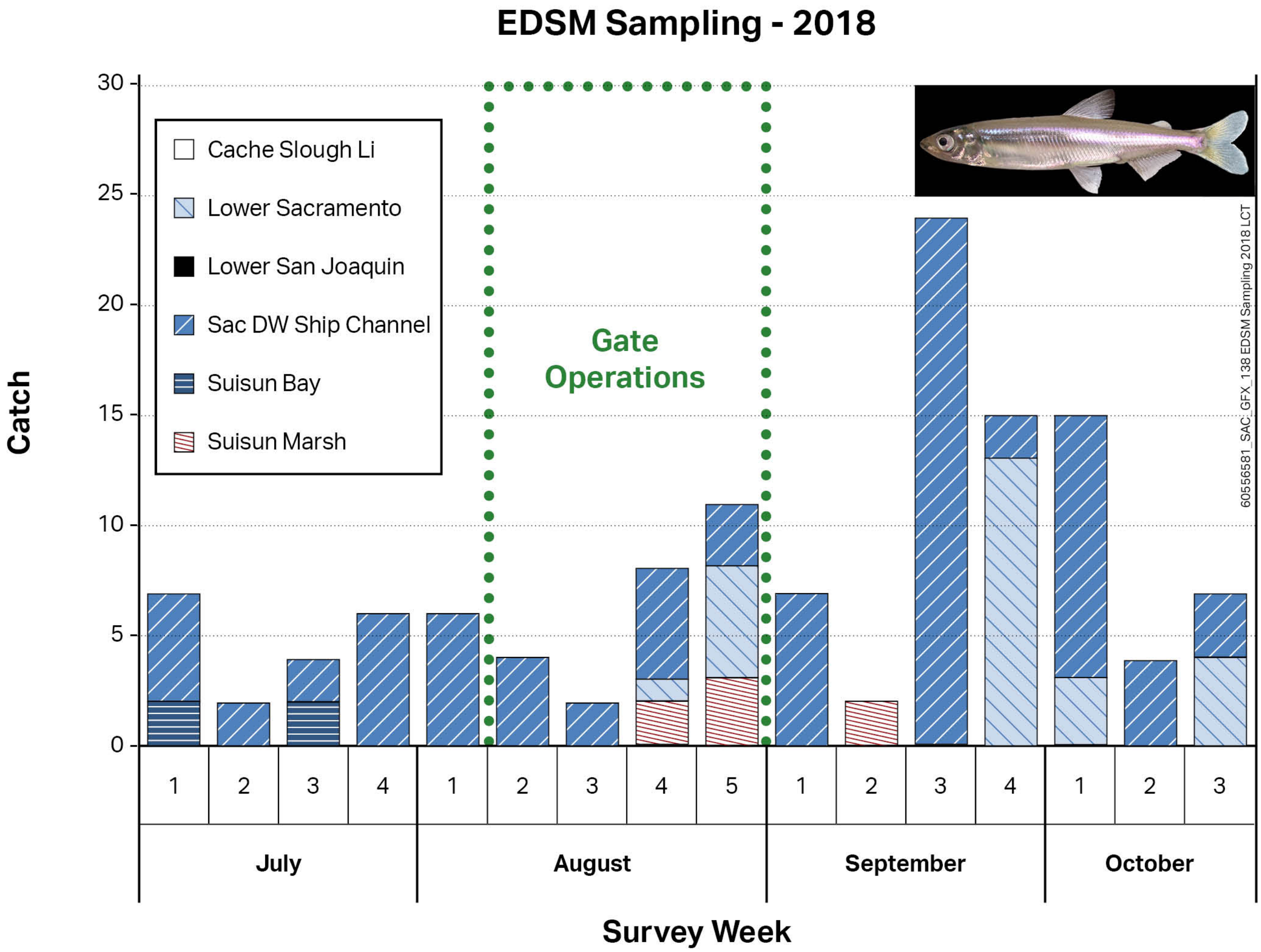
Source: Appendix C.

Figure 4-43. Regions Used in SCHISM Analysis



Note: "2012 Base" = historical 2012 operations; "2012 Gate (Jun)" = SMSCG operations for 60 days commencing June 14; "2012 Gate (Aug)" = SMSCG operations for 60 days commencing August 15. The "All LSZ Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

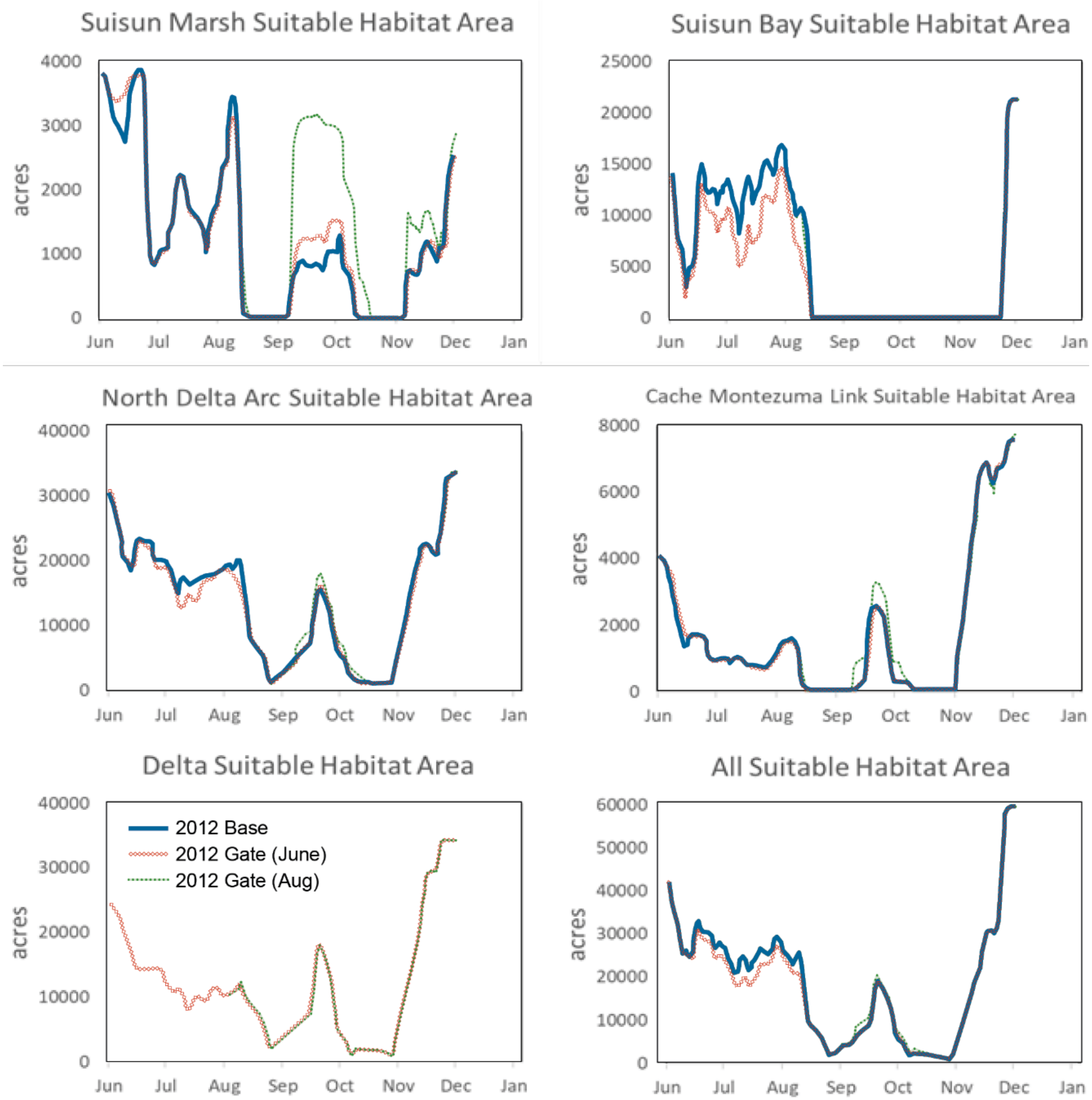
Figure 4-44. Area of Low-Salinity Habitat (≤6), June 2012–January 2013 Resulting from SCHISM Simulations



Source: Adapted from Sommer et al. (2018).

Figure 4-45. Catch of Delta Smelt By the Enhanced Delta Smelt Monitoring Program During the 2018 Pilot Suisun Marsh Salinity Control Gates Action

Considering temperature and turbidity (water clarity) in addition to salinity, focusing on the SMSCG operations commencing in August generally suggested a similar overall pattern to salinity alone, with respect to modest differences between scenarios at the scale of the North Delta arc or the Cache to Montezuma link corridor, and with greater differences in Suisun Marsh. However, in this scenario there was not less habitat meeting all three criteria in Suisun Bay (Figure 4-46). Notably different from the analysis considering salinity alone was that the area meeting the salinity, temperature, and Secchi depth criteria dropped to zero on a number of occasions, which reflected Secchi depth increasing slightly above the 0.5-meter threshold selected for analysis; the results are sensitive to a threshold-based approach of defining habitat criteria, particularly in Suisun Bay and Suisun Marsh, as discussed further in Appendix C.



Note: "2012 Base" = historical 2012 operations; "2012 Gate (Jun)" = SMSCG operations for 60 days commencing June 14; "2012 Gate (Aug)" = SMSCG operations for 60 days commencing August 15. The "All Suitable Habitat Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4-46. Area of Habitat with Salinity ≤ 6, Temperature < 25C, and Secchi Depth >0.5 m, June–December 2012 Resulting from SCHISM Simulation

The SCHISM analysis for 2017 considered both SMSCG operations (commencing September 1) as well as operations to maintain X2 at 80 km in September and October as a representation of Proposed Project operations. The relatively wet conditions in 2017 led to low-salinity habitat throughout much of the simulated area until October/November, after which time there was a residual impact of the combination of SMSCG operations and maintaining X2 of 80 km in November (Figure 4-43). This suggests the potential for the Proposed Project scenario to increase the area of low salinity relative to the Existing Conditions scenario if Existing Conditions operations were as undertaken historically in 2017, with the increase being greatest in Suisun Marsh and modest at the larger scale of the North Delta arc, a pattern also evident when considering the results from the combination of salinity, temperature, and water clarity (Figure 4-48). Additional considerations are provided in Appendix C, but overall, the modeling does not suggest that the extent of low-salinity habitat for Delta Smelt would be lower under the Proposed Project scenario than under the Existing Conditions scenario as historically operated in 2017. However, had the historical 2017 operations been adaptively managed to instead achieve X2 of 74 km in September and October, there would have been a generally greater extent of low salinity habitat and habitat meeting the low salinity, Secchi depth, and water temperature criteria than under the Proposed Project (Figures 4-47 and 4-48).

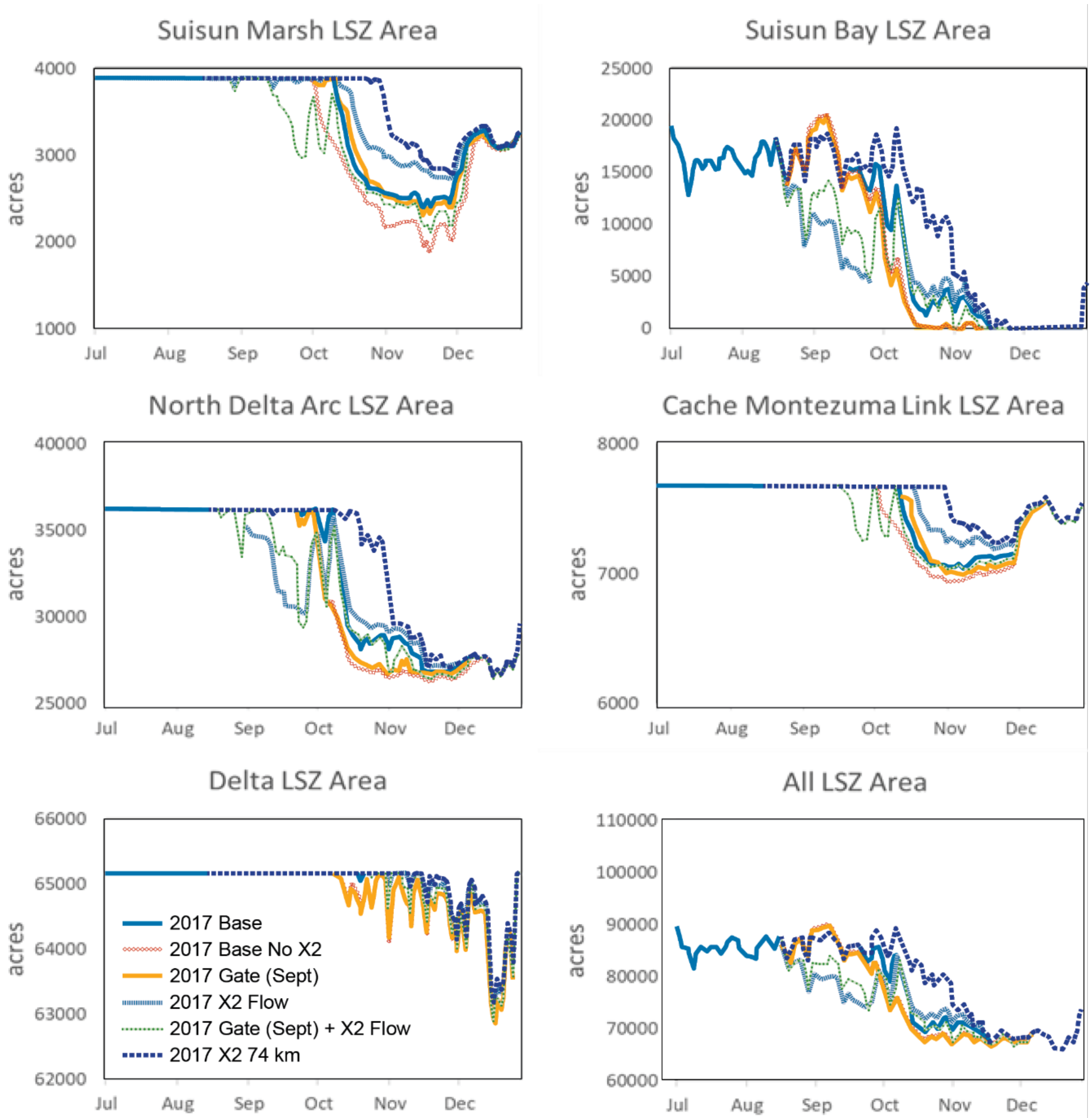
Operations-related effects on the size and location of the low salinity reflect combined SWP and CVP operations. During the June–October period of the Delta Smelt summer/fall habitat actions, the SWP's responsibility for water operations would be ~30–40% in June, ~20–40% in July and August, ~20–50% in September, and ~40–50% in October (Table 4-1).

4.2.1.6 Water Transfers

Expansion of the water transfer window to include July to November would be unlikely to affect Delta Smelt, given that the species is mostly downstream of the Delta, although upstream migrating adults could overlap the window if first flushes of precipitation of flow occur prior to December. This is unlikely given that the main period of potential entrainment is the December–March period (USFWS 2008).

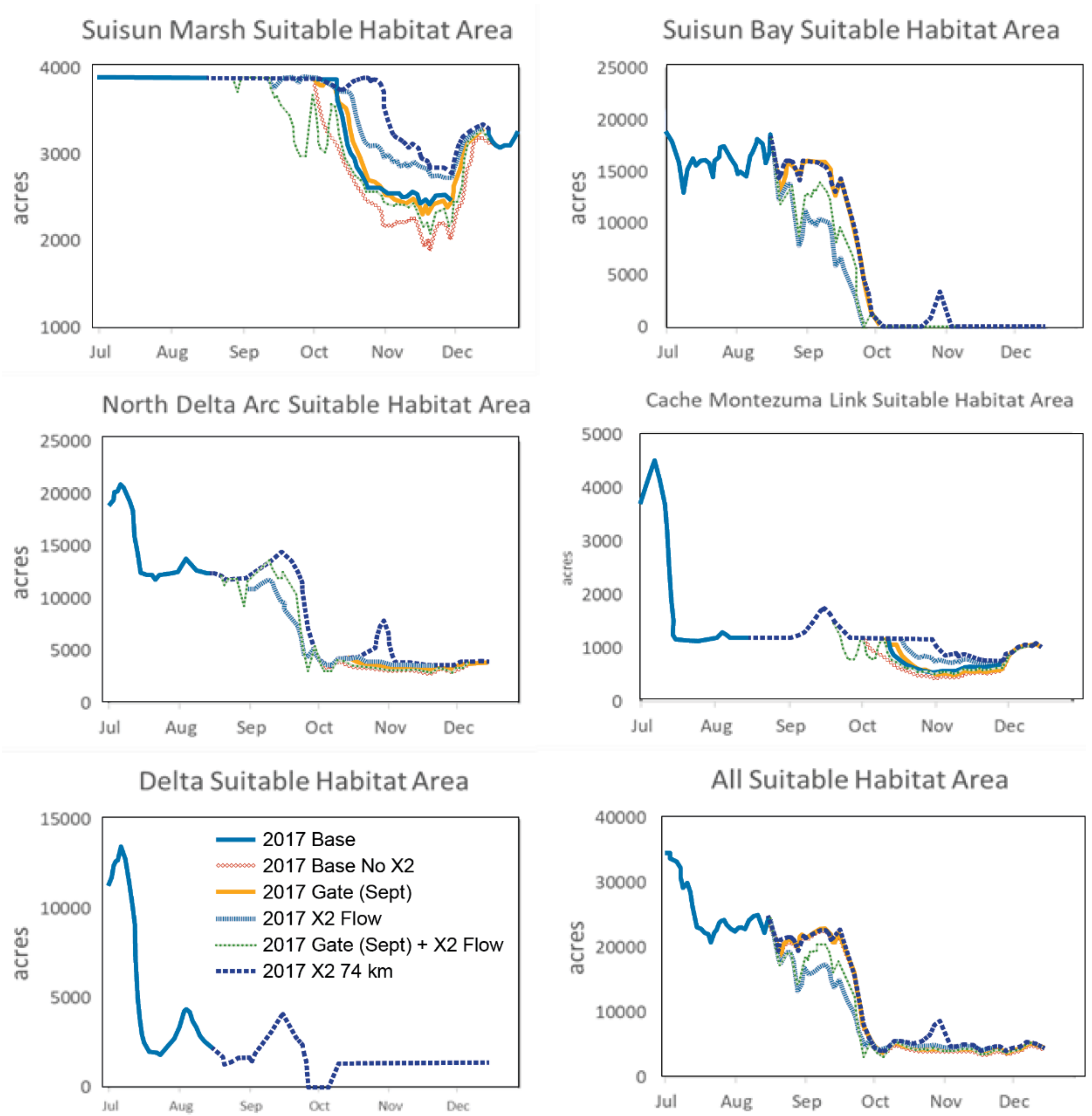
4.2.1.7 Barker Slough Pumping Plant

Potential entrainment effects of the Barker Slough Pumping Plant are discussed above in the *Particle Tracking Modeling* section of Section 4.2.1.1 *Entrainment*. Low levels of entrainment would be expected under both scenarios, based on recent available entrainment monitoring data (Yip et al. 2017, 2019). Estimates of take of Delta Smelt by entrainment at the NBA during 1995 to 2004 were made in response to the 1995 OCAP biological opinion monitoring requirements by multiplying pumping by the density of larvae at stations in the vicinity. Historical estimates of take by entrainment ranged from 375 larval Delta Smelt in 1995 to 32,323 larval Delta Smelt in 2001 (USFWS 2008:170). These estimates are not closely related to overall indices of Delta Smelt abundance from the 20-mm and FMWT surveys, although it would be expected that entrainment in the future would be less than previously occurred because of the apparent low abundance of the Delta Smelt population that currently exists relative to the 1995-2004 period for which the NBA estimates were made (ICF International 2016:4-190).Recent entrainment monitoring suggests very low levels of entrainment (only one Delta Smelt was collected during sampling in January–June, 2015–2016; Yip et al. 2017, 2019).



Note: “2017 Base” = historical 2017 operations; “2017 Base No X2” = historical 2017 operations without additional outflow to meet fall X2 requirements; “2017 Gate (Sep)” = SMSCG operations for 60 days commencing September 1; “2017 X2 80km” = operations to achieve X2 of 80 km in September and October; “2017 Gate (Sep) + X2 80km” = gate operations and flow to achieve X2 of 80 km as for the prior two scenarios; 2017 X2 74km = operations to achieve X2 of 74 km in September and October. The “All LSZ Area” represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4-47. Area of Low Salinity Habitat (≤6), June 2017–January 2018 Resulting from SCHISM Simulations



Note: "2017 Base" = historical 2017 operations; "2017 Base No X2" = historical 2017 operations without additional outflow to meet fall X2 requirements; "2017 Gate (Sep)" = SMSCG operations for 60 days commencing September 1; "2017 X2 80km" = operations to achieve X2 of 80 km in September and October; "2017 Gate (Sep) + X2 80km" = gate operations and flow to achieve X2 of 80 km as for the prior two scenarios; 2017 X2 74km = operations to achieve X2 of 74 km in September and October. The "All Suitable Habitat Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4-48. Area of Habitat with Salinity ≤ 6, Temperature < 25C, and Secchi Depth >0.5 m, June–December 2017 Resulting from SCHISM Simulations

4.2.1.8 South Delta Temporary Barriers

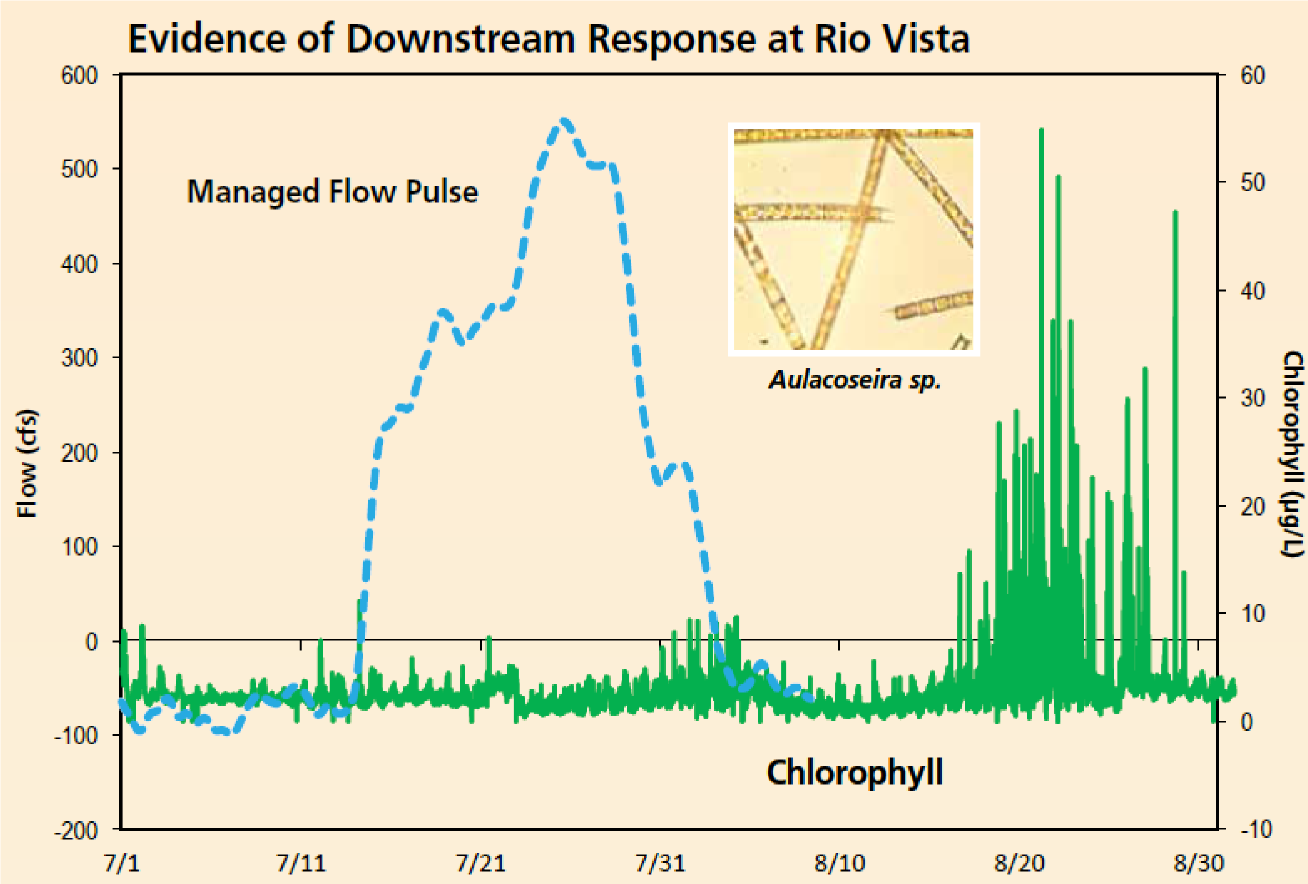
Installation of the South Delta Temporary Barriers Project's agricultural barriers in the South Delta would not differ between Proposed Project and Existing Conditions scenarios, so potential effects, such as hydraulic reduction in the flux of the Delta Smelt prey *P. forbesi*, on the low salinity zone (USFWS 2008:226) would be expected to be similar for the Proposed Project and Existing Conditions scenarios.

4.2.1.9 Suisun Marsh Operations

Other than the changes in SMSCG operations previously discussed above in Section 4.2.1.5 *Size and Location of the Low Salinity Zone (Summer-Fall Delta Smelt Habitat Actions)*, Suisun Marsh operations would remain the same between the Existing Conditions and Proposed Project scenarios. This could result in effects such as predation near facilities or entrainment at low levels into the RRDS and MIDS. Minimal take by entrainment of older Delta Smelt is expected at the MIDS intake on the basis of no observed entrainment during previous studies (2004-2006; Enos et al. 2007), and very little entrainment of larvae is expected based on PTM studies (Culberson et al. 2004). The screens on the RRDS intake minimize take of Delta Smelt to entrainment of larvae or smaller juveniles (< 30 mm). There are apparently no monitoring data from which to infer the level of take of larvae; the entrainment risk appears limited given that that DSM2-PTM modeling for the California Department of Fish and Game (2009a) Longfin Smelt incidental take permit application did not observe any particles entering RRDS.

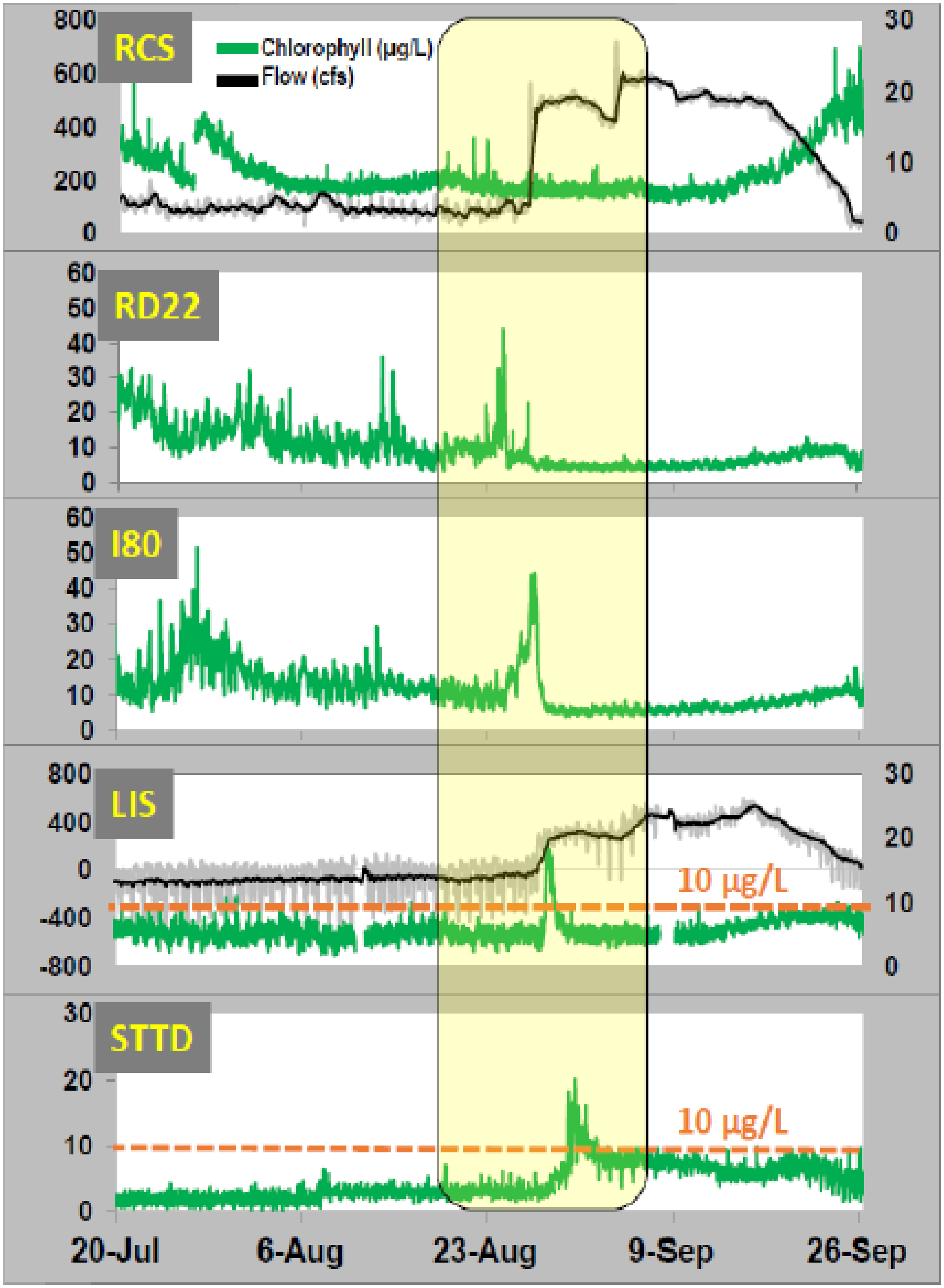
4.2.1.10 Food Enhancement Summer-Fall Actions

Augmentation of flow from the Colusa Basin drain during summer/early fall as part of the Delta Smelt Summer-Fall Habitat Action could increase transfer of food web materials to the North Delta, thereby potentially increasing the food availability habitat attribute suggested hypothesized to be important for juvenile Delta Smelt (IEP MAST 2015). An average of 23% of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The proportion of the population resident in the North Delta would be most likely to benefit from the North Delta food subsidies action. A pilot implementation of this action in 2016 found that primary production in the North Delta increased as a result of the action (Figure 4-49; as had been observed in previous years without pilot implementation; Frantzich et al. 2018), with enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018:2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action (Figure 4-50), could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass (Figure 4-50) and there was no increase at Rio Vista (Figure 4-51). Nonetheless, the 2018 action still showed downstream transport of chlorophyll in the Cache Slough Complex, a primary habitat area for Delta Smelt (DWR unpublished data).



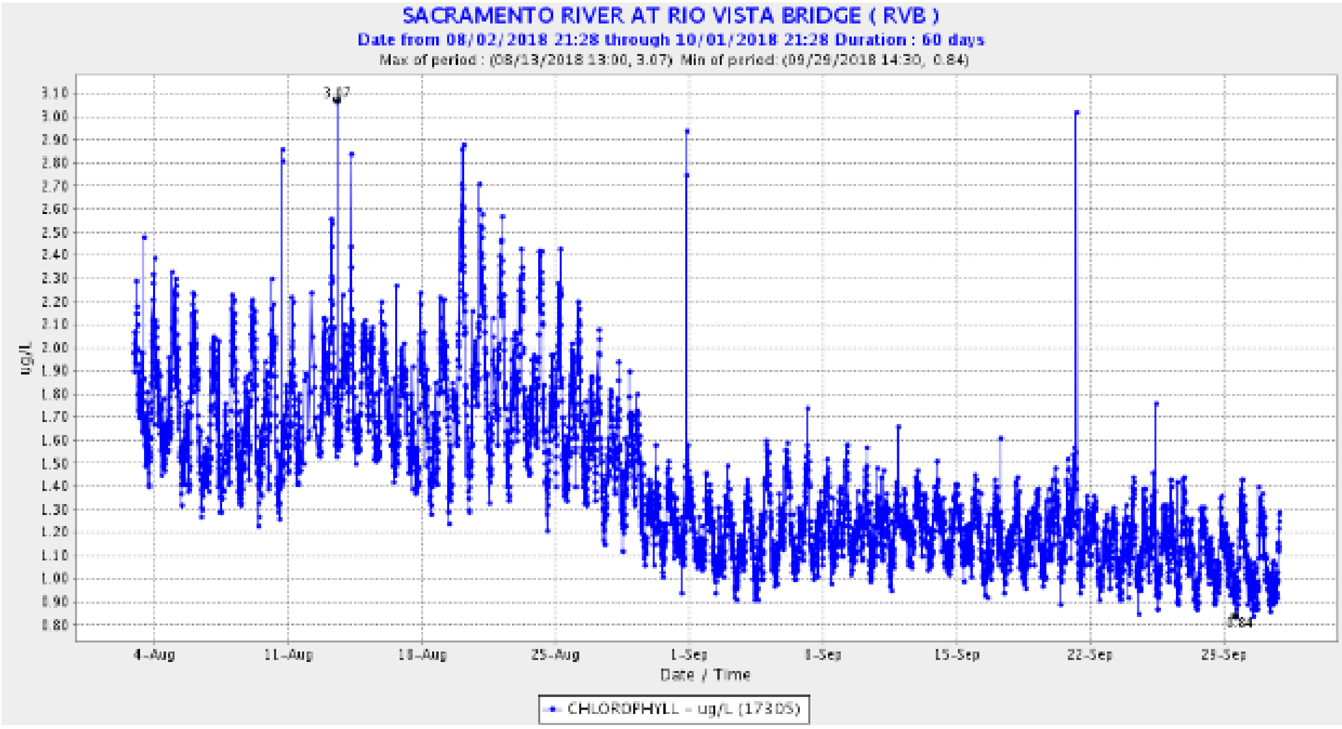
Source: California Natural Resources Agency (2017).

Figure 4-49. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration at Rio Vista During 2016 Pilot North Delta Food Subsidies Action



Source: NCWA (2018). Note: Yellow box indicates flow pulse into Yolo Bypass from Colusa Basin Drain.

Figure 4-50. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration from North (RCS) to South (STTD) in the Yolo Bypass During 2018 Pilot North Delta Food Subsidies Action



Source: California Data Exchange Center, http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=17305&end=10%2F01%2F2018+21%3A28&geom=huge&interval=60&cookies=cdec01, accessed January 2, 2019.

Figure 4-51. Chlorophyll Concentration at Rio Vista Before, During, and After 2018 Pilot North Delta Food Subsidies Action

Draining food-rich water from the Roaring River Distribution System into Grizzly Bay may augment Delta Smelt food supplies in that area and positively affect Delta Smelt, given that the area generally has good abiotic habitat characteristics (high turbidity and low current velocity, with salinity varying based on Delta outflow; Bever et al. 2016) but is part of the Suisun Bay region where food appears to be limited based on Delta Smelt characteristics such as stomach fullness (Hammock et al. 2015).

4.2.2 LONGFIN SMELT

4.2.2.1 ENTRAINMENT

Adult Entrainment

There is the potential for the Proposed Project to take adult Longfin Smelt, although take of adults is very limited relative to other life stages. Grimaldo et al. (2009) found that adult Longfin Smelt salvage at the South Delta export facilities was significantly negatively related to mean December–February Old and Middle River flows, but not to X2 (or other variables that were examined). As previously noted for Delta Smelt, modeling indicates that there would be little difference between the Proposed Project and Existing Conditions scenarios in Old and Middle River flows during this period (Figures 4-1, 4-2, and 4-3). As noted in the project description, from December 1 through February 28, additional real-time consideration of adult Longfin Smelt entrainment risk will be undertaken by DWR in association with DFW and WOMT to provide protection for adult Longfin Smelt. During the period from December through February, SWP responsibility for Delta water operations is approximately 40% to 60%, depending on water year type (Table 4-1). Historical estimates suggest that the percentage of the adult Longfin Smelt population lost to entrainment was very low (Table 4-4; note that the population estimates are based on the fall midwater trawl survey, which does not sample much of San Francisco Bay where Longfin Smelt are known to occur; MacWilliams et al. 2016).

Table 4-4. Entrainment Loss of Adult Longfin Smelt in Relation to December Population Abundance

Water Year	Entrainment Loss	Population Abundance (Mean)	Population Abundance (Lower 95% Confidence Limit)	Population Abundance (Upper 95% Confidence Limit)	Entrainment Loss as % of Population Abundance (Mean)	Entrainment Loss as % of Population Abundance (Lower 95% Confidence Limit)	Entrainment Loss as % of Population Abundance (Upper 95% Confidence Limit)
1994	515	2,121,299	1,539,453	2,923,767	0.02%	0.02%	0.03%
1995	1,256	762,931	492,457	1,185,366	0.16%	0.11%	0.26%
1996	794	1,897,507	1,280,158	2,626,755	0.04%	0.03%	0.06%
1997	43	2,505,703	1,707,191	3,556,312	0.00%	0.00%	0.00%
1998	86	356,804	169,092	623,598	0.02%	0.01%	0.05%
1999	43	-	-	-	-	-	-
2000	333	893,531	548,077	1,371,856	0.04%	0.02%	0.06%
2001	601	6,261,994	4,538,034	8,417,526	0.01%	0.01%	0.01%
2002	1,648	252,942	142,355	422,206	0.65%	0.39%	1.16%
2003	3,429	1,627,699	1,038,290	2,369,905	0.21%	0.14%	0.33%
2004	2,102	1,145,721	801,008	1,605,858	0.18%	0.13%	0.26%
2005	183	475,231	271,314	756,977	0.04%	0.02%	0.07%
2006	0	159,244	90,862	257,436	0.00%	0.00%	0.00%
2007	0	83,311	26,826	159,348	0.00%	0.00%	0.00%
2008	570	21,376	6,255	43,048	2.67%	1.32%	9.11%

Notes:

"-" = Insufficient trawl samples for an estimate.

Sources:

Entrainment loss: Fujimura (2009).

Population abundance: DFG (2009b: Appendix B, Attachment 2, Table 2).

Particle Tracking Modeling (Larval Entrainment)

There is potential for the Proposed Project to take larval Longfin Smelt through entrainment by water diversions in the Delta, including Clifton Court Forebay and the Barker Slough Pumping Plant, and winter (January–March) is of particular concern. A DSM2-PTM analysis was undertaken using the methods described in Appendix D, Section D.3.1. Staff observations from preliminary Longfin Smelt culture efforts at the UC Davis Fish Conservation and Culture Laboratory have suggested that larvae may not be buoyant in freshwater but are buoyant in brackish water (S. Acuña, pers. comm., 2019), which may add some uncertainty to the results from PTM analysis. Analysis of surface-oriented and neutrally buoyant particles provides information on two plausible behaviors, recognizing that the estimates are only order-of-magnitude comparisons that are best used in a relative fashion to compare different operational scenarios.

The DSM2-PTM results suggested that there would be relatively minor differences in the potential for Longfin Smelt larvae entrainment and passing Chipps Island between Existing Conditions and Proposed

Project scenarios (Tables 4-5 and 4-6). The same general conclusion also applies when focusing only on the seven stations analyzed by DFG (2009a); see Appendix D, Section D.3.1.4. PTM results are based on flows from CalSim modeling that do not include proposed larval and juvenile Longfin Smelt entrainment protections. Differences suggested by the PTM results would be expected to lower when the Proposed Project is implemented because real-time operational measures are included in the Proposed Project that would manage OMR flows for the protection of Longfin Smelt. Although the estimates of entrainment are intended to primarily be used comparatively, the weightings applied in the modeling are intended to represent a realistic distribution of larvae in the Delta and downstream and, as such, may provide some perspective on the magnitude of larval population loss, i.e., in the low single digit percentage for neutrally buoyant particles (Table 4-5) and ~2–11% for surface-oriented particles (Table 4-6). Note that these estimates likely overestimate entrainment loss because the Smelt Larval Survey providing the weighting for particle starting distributions does not sample the full extent of downstream areas where the species occurs (Lewis et al. 2019), as described in the discussion provided in Appendix D, Section D.3.1.

Table 4-5. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and Passing Chipps Island. Table 4-5 a – Table 4-5 c

Table 4-5 a. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.78	0.77	-0.01 (-1%)
January	Above Normal	1.21	1.23	0.02 (2%)
January	Below Normal	1.96	2.01	0.06 (3%)
January	Dry	2.59	2.93	0.34 (13%)
January	Critical	2.56	2.75	0.19 (7%)
February	Wet	0.53	0.51	-0.02 (-4%)
February	Above Normal	0.91	0.86	-0.06 (-6%)
February	Below Normal	1.28	1.29	0.01 (1%)
February	Dry	1.81	1.92	0.11 (6%)
February	Critical	2.19	2.25	0.05 (2%)
March	Wet	0.57	0.42	-0.15 (-26%)
March	Above Normal	0.71	0.52	-0.19 (-27%)
March	Below Normal	1.18	0.92	-0.26 (-22%)
March	Dry	1.32	1.09	-0.24 (-18%)
March	Critical	1.17	1.42	0.25 (22%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table 4-5 b. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.20	0.20	0.00 (-2%)
January	Above Normal	0.21	0.21	-0.01 (-3%)
January	Below Normal	0.23	0.23	-0.01 (-3%)
January	Dry	0.25	0.26	0.00 (1%)
January	Critical	0.21	0.20	-0.01 (-3%)
February	Wet	0.20	0.20	0.00 (1%)
February	Above Normal	0.21	0.20	-0.01 (-4%)
February	Below Normal	0.21	0.21	-0.01 (-3%)

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
February	Dry	0.17	0.16	0.00 (-3%)
February	Critical	0.14	0.14	0.00 (2%)
March	Wet	0.18	0.18	0.00 (1%)
March	Above Normal	0.18	0.18	-0.01 (-5%)
March	Below Normal	0.23	0.23	0.00 (-1%)
March	Dry	0.17	0.16	-0.01 (-5%)
March	Critical	0.09	0.10	0.01 (13%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table 4-5 c. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days Passing Chipps Island

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	46.31	46.44	0.12 (0%)
January	Above Normal	42.91	43.06	0.15 (0%)
January	Below Normal	38.53	38.74	0.20 (1%)
January	Dry	33.50	32.78	-0.72 (-2%)
January	Critical	30.95	30.15	-0.80 (-3%)
February	Wet	46.41	46.50	0.08 (0%)
February	Above Normal	45.04	45.31	0.26 (1%)
February	Below Normal	41.77	41.89	0.12 (0%)
February	Dry	37.96	37.77	-0.19 (-1%)
February	Critical	33.06	33.14	0.08 (0%)
March	Wet	46.52	46.72	0.20 (0%)
March	Above Normal	45.67	46.02	0.34 (1%)
March	Below Normal	43.76	44.34	0.59 (1%)
March	Dry	41.59	42.22	0.64 (2%)
March	Critical	38.80	38.03	-0.77 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table 4-6. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and Passing Chipps Island. Table 4-6 a – Table 4-6 c

Table 4-6 a. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.73	3.67	-0.06 (-2%)
January	Above Normal	6.30	6.16	-0.14 (-2%)
January	Below Normal	9.84	10.06	0.22 (2%)
January	Dry	10.76	11.40	0.64 (6%)
January	Critical	10.01	10.60	0.59 (6%)
February	Wet	2.55	2.34	-0.21 (-8%)
February	Above Normal	4.91	4.44	-0.47 (-10%)
February	Below Normal	7.27	6.67	-0.60 (-8%)
February	Dry	9.02	8.78	-0.25 (-3%)
February	Critical	8.89	9.09	0.20 (2%)
March	Wet	2.52	2.62	0.09 (4%)
March	Above Normal	3.26	3.17	-0.09 (-3%)
March	Below Normal	6.18	7.03	0.85 (14%)
March	Dry	6.76	7.45	0.69 (10%)
March	Critical	5.87	7.04	1.17 (20%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table 4-6 b. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.24	0.24	0.00 (-2%)
January	Above Normal	0.33	0.31	-0.02 (-5%)
January	Below Normal	0.39	0.38	-0.01 (-3%)
January	Dry	0.34	0.35	0.01 (2%)
January	Critical	0.21	0.22	0.01 (5%)
February	Wet	0.22	0.22	0.00 (-1%)
February	Above Normal	0.30	0.29	-0.01 (-3%)
February	Below Normal	0.33	0.32	-0.01 (-3%)
February	Dry	0.08	0.09	0.00 (2%)
February	Critical	0.04	0.06	0.02 (52%)
March	Wet	0.29	0.28	-0.01 (-2%)
March	Above Normal	0.34	0.33	-0.01 (-3%)
March	Below Normal	0.54	0.54	0.00 (0%)
March	Dry	0.14	0.12	-0.01 (-8%)
March	Critical	0.03	0.02	-0.01 (-20%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.datptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Table 4-6 c. Percentage of Surface-Oriented Particles Entrained Over 45 Days Passing Chipps Island

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	35.13	35.53	0.40 (1%)
January	Above Normal	22.86	23.34	0.48 (2%)
January	Below Normal	7.16	8.03	0.87 (12%)
January	Dry	2.31	2.25	-0.07 (-3%)
January	Critical	0.29	0.36	0.06 (22%)
February	Wet	38.29	38.77	0.48 (1%)
February	Above Normal	28.59	29.15	0.56 (2%)
February	Below Normal	16.96	18.03	1.08 (6%)
February	Dry	6.13	6.15	0.02 (0%)
February	Critical	1.08	1.10	0.02 (2%)
March	Wet	34.93	35.48	0.54 (2%)
March	Above Normal	29.32	30.73	1.41 (5%)
March	Below Normal	9.72	10.83	1.10 (11%)
March	Dry	4.65	5.40	0.75 (16%)
March	Critical	1.60	1.54	-0.06 (-4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.datptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Very minor differences in operational criteria for the Barker Slough Pumping Plant are proposed for the Proposed Project relative to the Existing Conditions scenario, and the DSM2-PTM results suggested little potential for difference in entrainment potential between the two scenarios for neutrally buoyant and surface-oriented particles (Tables 4-4 b and 4-6 b). The modeling does not reflect real-time operational adjustments that would be made if Longfin Smelt larvae were observed at SLS Station 716, i.e., 7-day average diversions of no more than 60 cfs at the Barker Slough Pumping Plant in dry and critical years. Although the 60-cfs real-time operational limit under the Proposed Project is greater than the 50-cfs real-time operational limit under Existing Conditions, the 10-cfs difference in the limit would be expected to result in minimal differences in take of larval Longfin Smelt. Estimated annual entrainment of larval and early juvenile Longfin Smelt < 25 mm at the NBA for 1995-2004 was 0% to 0.4% (ICF International 2016:4-292), indicating that low levels of take would occur under the Proposed Project and would be generally of similar magnitude as those under the Existing Conditions scenario. No Longfin Smelt larvae were collected during recent entrainment monitoring in the January 2015 to June 2016 period (Yip et al. 2017, 2019).

Juvenile Salvage-Old and Middle River Flow Analysis (Based on Grimaldo et al. 2009)

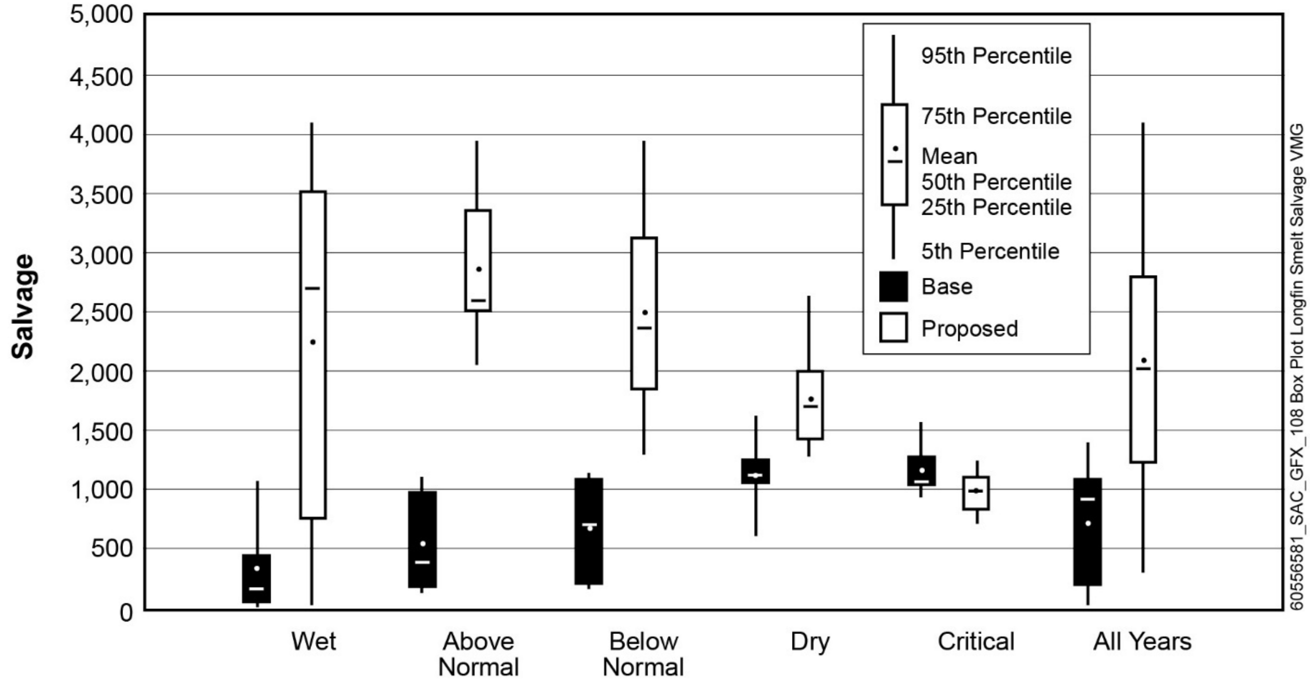
Grimaldo et al. (2009) found that juvenile Longfin Smelt salvage principally occurred in April–May, and was significantly negatively related to mean April–May Old and Middle River flow (and was not related to other factors such as X2). For this effects analysis, an evaluation of potential differences between Existing Conditions and Proposed Project scenarios in terms of entrainment (salvage) was undertaken by recreating and applying the Grimaldo et al. (2009) relationship between salvage and Old and Middle River flows. See Appendix D, Section D.3.2 (based on Grimaldo et al. 2009).

The analysis based on the Grimaldo et al. (2009) salvage-OMR flow regression suggested the potential for very large relative increases in entrainment under the Proposed Project compared to the Existing Conditions scenario, albeit with considerable uncertainty around the predictive estimates (Figures 4-52 and 4-53; Table 4-7). OMR flows from CalSim modeling do not include proposed larval and juvenile Longfin Smelt entrainment protections. Therefore, these results do not reflect real-time operational adjustments (based on factors including enhanced sampling) that would be undertaken for Longfin Smelt or other species, which would be expected to reduce the difference in entrainment between the Existing Conditions and Proposed Project scenarios. In absolute terms, take of juvenile Longfin Smelt by entrainment loss under the Proposed Project, even if greater than under the Existing Conditions scenario, is likely to represent a low percentage of the overall juvenile Longfin Smelt population because management of entrainment is estimated to have resulted in a very small percentage of the juvenile population being entrained in recent years (2009 onwards) under the operations regime that is reflected by the Existing Conditions modeling scenario (Table 4-8). Specifically, Longfin Smelt entrainment loss under the Proposed Project likely represents a low percentage of the overall juvenile Longfin Smelt population because the species is widely distributed in the San Francisco Bay and its tributaries, including the Napa and Petaluma rivers and the South Bay tributaries (Lewis et al. 2019).

Table 4-7. Mean Annual Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped By Water Year Type

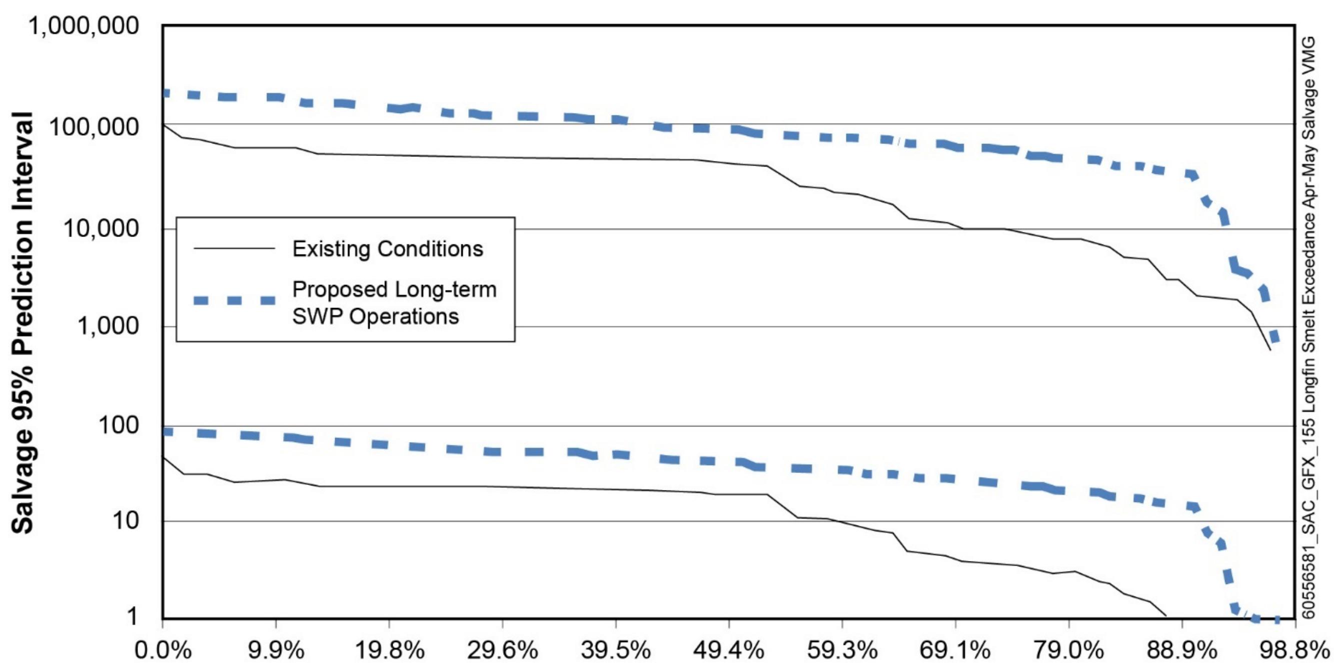
Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
Wet	333	2,251	1,918 (576%)
Above Normal	551	2,863	2,311 (419%)
Below Normal	670	2,494	1,824 (272%)
Dry	1,130	1,761	631 (56%)
Critical	1,171	991	-180 (-15%)

The above analysis of potential salvage-related effects on Longfin Smelt from differences in April–May Old and Middle River flows reflects combined SWP and CVP operations; during the period from April through May, the SWP would be responsible for around 40% to 50% of Delta water operations under the Proposed Project, depending on water year type and month (Table 4-1).



Note: Plot only includes mean responses and does not consider model uncertainty. Note: Base = Existing Conditions.

Figure 4-52. Box Plot of Longfin Smelt April–May Salvage, From the Regression Including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped By Water Year Type



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. Zero estimates are converted to 1 in this plot to allow plotting on a log scale.

Figure 4-53. Exceedance Plot of Longfin Smelt April–May Salvage Prediction Intervals, Based on the Analysis using the salvage-Old and Middle River Flow Regression Developed by Grimaldo et al. 2009

Table 4-8. Juvenile Longfin Smelt: Estimated Entrainment Loss Relative to Population Size, SWP South Delta Export Facility, 1995-2015

Water Year	Entrainment Loss	Population Abundance (Mean)	Population Abundance (Lower 95% Confidence Limit)	Population Abundance (Upper 95% Confidence Limit)	Entrainment Loss as % of Population Abundance (Mean)	Entrainment Loss as % of Population Abundance (Lower 95% Confidence Limit)	Entrainment Loss as % of Population Abundance (Upper 95% Confidence Limit)
1995	690	28,533,241	646,582	83,446,706	0.00%	0.00%	0.11%
1996	1,888	55,551,678	2,952,507	160,930,326	0.00%	0.00%	0.06%
1997	14,941	53,124,330	27,786,879	81,514,564	0.03%	0.02%	0.05%
1998	12,870	67,816,816	430,480	201,955,221	0.02%	0.01%	2.99%
1999	13,662	105,680,968	23,624,089	227,525,445	0.01%	0.01%	0.06%
2000	28,136	155,878,920	29,659,827	397,513,090	0.02%	0.01%	0.09%
2001	44,701	14,788,919	6,268,759	27,156,527	0.30%	0.16%	0.71%
2002	1,106,614	34,788,791	16,739,707	57,544,906	3.18%	1.92%	6.61%
2003	10,252	12,690,736	2,456,744	31,824,070	0.08%	0.03%	0.42%
2004	4,101	11,953,747	3,049,485	25,527,635	0.03%	0.02%	0.13%
2005	3,593	20,103,627	3,154,146	53,010,040	0.02%	0.01%	0.11%
2006	0	95,376,388	835,562	280,036,933	0.00%	0.00%	0.00%
2007	1,218	3,401,228	1,296,730	6,933,677	0.04%	0.02%	0.09%
2008	22,036	23,211,998	9,640,306	41,680,217	0.09%	0.05%	0.23%
2009	447	14,105,134	4,450,357	28,046,192	0.00%	0.00%	0.01%
2010	81	11,153,903	3,420,542	21,828,717	0.00%	0.00%	0.00%
2011	0	26,490,436	3,961,703	60,752,372	0.00%	0.00%	0.00%
2012	57,693	9,952,855	3,415,564	18,849,797	0.58%	0.31%	1.69%
2013	13,297	81,399,104	22,474,351	193,721,641	0.02%	0.01%	0.06%
2014	650	5,885,151	2,546,574	10,333,427	0.01%	0.01%	0.03%
2015	2,071	1,105,156	128,317	2,788,331	0.19%	0.07%	1.61%

Source: Entrainment loss estimated from observed juvenile salvage with DFG (2009a) loss multiplier (20.3) applied. Population abundance estimates from ICF International (2016).

4.2.2.2 Delta Outflow-Abundance (Based on Nobriga and Rosenfield 2016)[8]

For Longfin Smelt, focus on estuarine flow has centered on the positive relationship found between winter/spring outflow and juvenile abundance during the fall (Rosenfield and Baxter 2007; Kimmerer et al. 2009). Specifically, as X2 (the position of the 2-ppt near-bottom salinity isohaline from the Golden Gate Bridge; see Jassby et al. [1995]) shifts downstream during the winter/spring, the abundance index of Longfin Smelt in the following FMWT survey increases (Kimmerer 2002; Kimmerer et al. 2009). The mechanisms underlying this relationship are poorly understood; however, the significant X2-abundance relationship suggests that higher outflow (lower X2) or conditions associated with wetter hydrological conditions produce conditions that enhance recruitment to juvenile life stages. Hypotheses about underlying mechanisms to this X2-abundance relationship include transport of larval Longfin Smelt out of the Delta to downstream rearing habitats (Moyle 2002; Rosenfield and Baxter 2007); increased extent of rearing habitat as X2 moves seaward (Kimmerer et al. 2009); retention of larvae in suitable rearing habitats (Kimmerer et al. 2009); increased food abundance under higher

[8] CDFW requested additional analyses using methods described in Kimmerer et al. 2009. These analyses are provided in Appendix F.

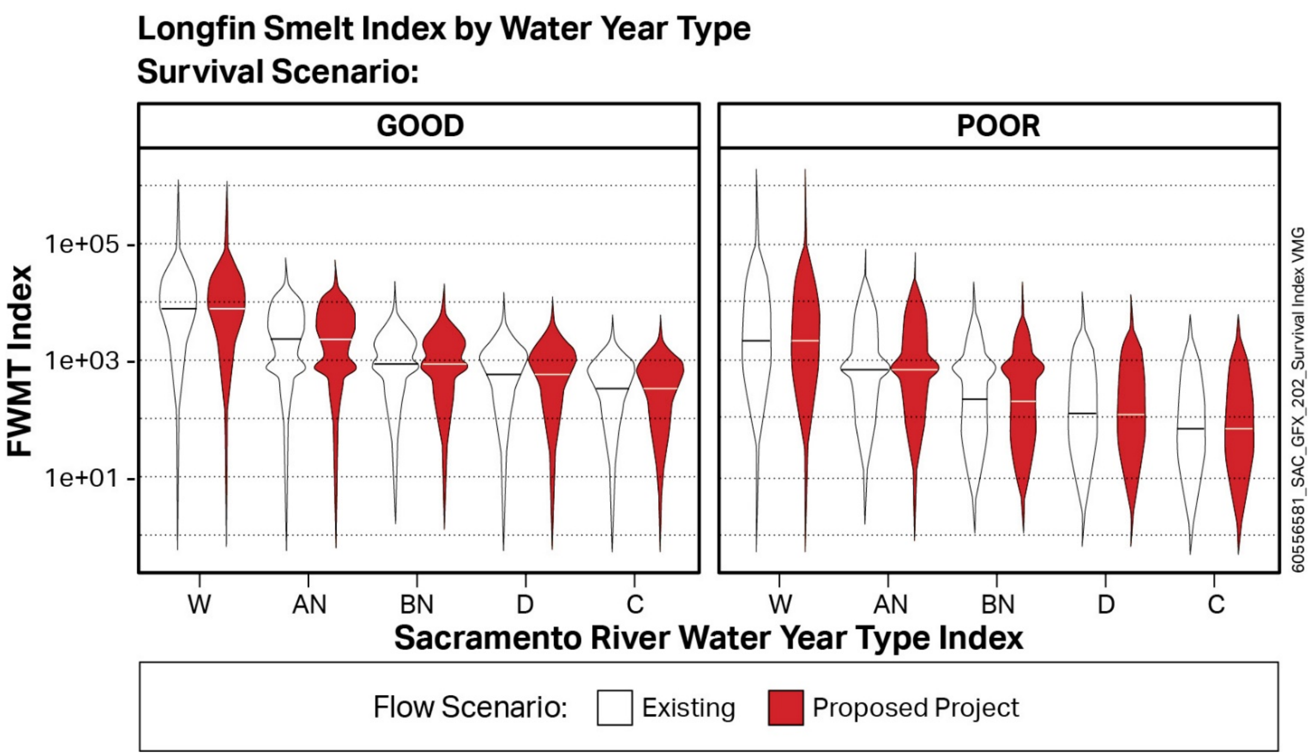
flows (DFG 2009b); and reduced clam grazing effects on primary and secondary production (DFG 2009b). With respect to habitat size for early life stages, new information indicates that the distribution of spawning and early life stages may be broader than previously thought, including areas with salinity ranging from 2–12 ppt (Grimaldo et al. 2017b). It has also been recognized that abundance of adults (spawners) is an important factor driving Longfin Smelt population dynamics (Baxter et al. 2010), with recent studies examining this link in detail (Maunder et al. 2015; Nobriga and Rosenfield 2016). A state-space modeling study by Maunder et al. (2015) found that multiple factors (flow, ammonium concentration, and water temperature) and density dependence influenced the survival of Longfin Smelt (represented by Bay Study abundance indices during 1980–2009). However, the flow terms included in their best models are not affected by the Proposed Project: Sacramento River October–July unimpaired runoff and Napa River runoff.

Aside from the Maunder et al. (2015) model, a recently published Longfin Smelt population dynamics modeling study is that of Nobriga and Rosenfield (2016), which examined various formulations of a Ricker (1954) stock-recruitment model to simulate fall midwater trawl indices through time. They found that December-May Delta outflow had a positive association with recruits per spawner and that juvenile recruitment from age 0 to age 2 was density-dependent (lower survival with greater numbers of juveniles), but cautioned that the density-dependence in the model may be too strong. It should also be noted that analyses relying on surveys such as the fall midwater trawl index do not fully encompass the range of Longfin Smelt and do not reflect potential changes in catchability over time because of factors such as increased water clarity and gear avoidance (Latour 2016), which are the subject of ongoing investigations. Nonetheless, the model may represent the best available option for assessing potential impacts of the Proposed Project. The model described by Nobriga and Rosenfield (2016) was used to compare the Proposed Project scenario to the Existing Conditions scenario, using Delta outflow outputs from CalSim; additional detail on the method is provided in Appendix D, Section D.3.3 (*based on Nobriga and Rosenfield 2016).)*[9].

The results of the Nobriga and Rosenfield (2016) model application suggested that differences in predicted fall midwater trawl abundance index between the Proposed Project and Existing Conditions scenarios would be very small, relative to the variability in the predicted values, which spans several orders of magnitude (Figure 4-54; Tables 4-9 and 4-10). Thus whereas the percentage difference in median index for the poor (post-1991) juvenile survival scenario, for example, ranges from 4% to 11% less under the Proposed Project scenario, there is only a 0% to 2% difference when accounting for the high signal to noise ratio (i.e., when divided by the Existing 95% confidence interval) (Table 4-10). Specifically, the simulation results showed that the variability in FMWT index predictions within each scenario was considerably greater than the differences between the scenarios. This variability reflects the uncertainty in parameter estimates, which results in uncertainty in the extent to which operations-related differences in Delta outflow could affect Longfin Smelt. Specifically, variability in Delta outflow associated with overall hydrological conditions (i.e., different water year types) is substantially larger than the minor differences in Delta outflow associated with changes in SWP operations. As described previously, Maunder et al. (2015) found that general hydrological conditions in the Sacramento River watershed and Napa River were a better explanation of population dynamics than Delta outflow. Note

[9] At the request of DFW, an additional analysis based on an X2-abundance relationship was undertaken (the so-called "Kimmerer regression"); this is presented in Appendix F.

that the outflow results from CalSim modeling do not reflect the proposed larval and juvenile Longfin Smelt entrainment protections, which may result in lower differences in spring outflow between the Existing Conditions and Proposed Project. In addition, as described in Section 3.3.16.1 *Adaptive Management Across Wetter and Drier Years*, adaptive management of spring outflow will be done by curtailing SWP south Delta exports, e.g., per the SWP portion of the San Joaquin River I:E ratio from the NMFS (2009) BiOp, which would reduce the difference in spring Delta outflow between Existing Conditions and the Proposed Project. Modeling including the additional spring Delta outflow[10] illustrates the reduction in the difference between PP including the additional spring Delta outflow and Existing scenarios, relative to the difference between PP (without additional spring Delta outflow) and Existing scenarios (Figure 4-55; Tables 4-11 and 4-12).



Note: Median is indicated by the horizontal line.
FMWT = Fall Midwater Trawl

Figure 4-54. Violin Plots of Predicted Longfin Smelt Fall Midwater Trawl Index by Water Year Type

[10] The scenario representing Proposed Project with additional spring Delta outflow represents the upper bound of the adaptive management of spring Delta outflow, i.e., with San Joaquin River I:E ratio implemented in all water year types, 44,500-cfs offramp, and dedication of instream flow, as described in Section 3.3.16.1 *Adaptive Management Across Wetter And Drier Years*.

Table 4-9. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Good (Pre-1991) Juvenile Survival

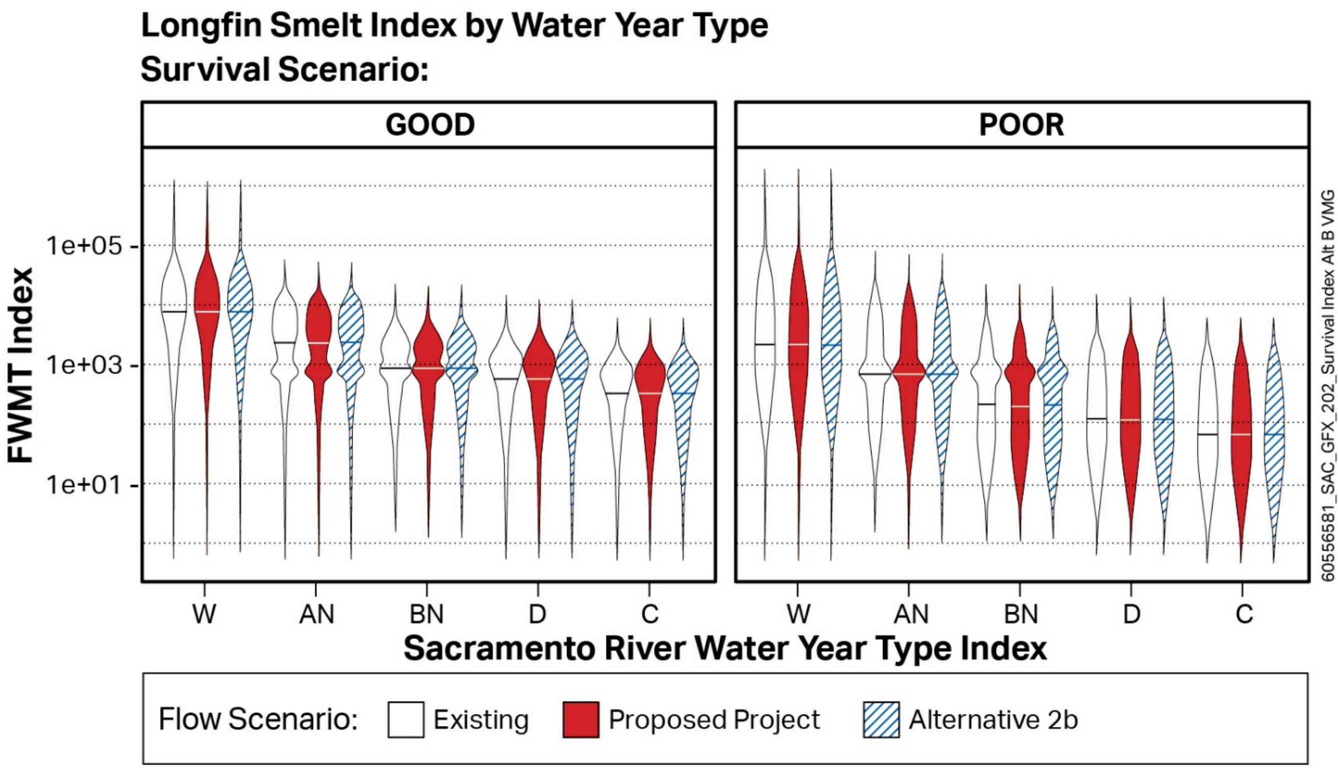
Water Year Type	Existing (95% Confidence Interval)	Proposed Project (95% Confidence Interval)	Proposed Project vs. Existing[1]	Proposed Project vs. Existing [2]
Wet	11,372 (271-46,328)	10,945 (268-44,593)	-428 (-4%)	-428 (-1%)
Above Normal	3,799 (92-11,441)	3,444 (83-10,530)	-355 (-10%)	-355 (-2%)
Below Normal	1,141 (25-4,204)	1,059 (23-3,962)	-81 (-8%)	-81 (-1%)
Dry	697 (17-2,508)	656 (16-2,395)	-40 (-6%)	-40 (-1%)
Critical	357 (9-1,634)	350 (9-1,593)	-7 (-2%)	-7 (0%)

Notes: [1] Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Table 4-10. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Poor (Post-1991) Juvenile Survival

Water Year Type	Existing (95% Confidence Interval)	Proposed Project (95% Confidence Interval)	Proposed Project vs. Existing[1]	Proposed Project vs. Existing [2]
Wet	2,916 (86-54,509)	2,729 (82-51,692)	-187 (-7%)	-187 (-1%)
Above Normal	948 (37-11,658)	851 (33-10,654)	-97 (-11%)	-97 (-1%)
Below Normal	197 (9-3,963)	179 (8-3,707)	-18 (-10%)	-18 (0%)
Dry	152 (6-2,333)	141 (6-2,215)	-11 (-8%)	-11 (0%)
Critical	83 (3-1,398)	80 (3-1,374)	-3 (-4%)	-3 (0%)

Notes: [1] Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.



Note: Median is indicated by the horizontal line.

Figure 4-55. Violin Plots of Predicted Longfin Smelt Fall Midwater Trawl Index by Water Year Type for Existing Conditions, Proposed Project, and Proposed Project Including Additional Spring Delta Outflow (Labeled as 'Alternative 2b').

Table 4-11. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Good (Pre-1991) Juvenile Survival for Existing Conditions and Proposed Project Including Additional Spring Delta Outflow.

Year	Existing (95% confidence Interval)	PP with Additional Spring Delta Outflow (95% Confidence Interval)	PP with Additional Spring Delta Outflow vs. Existing[1]	PP with Additional Spring Delta Outflow vs Existing [2]
Wet	11,372 (271–46,328)	11,006 (270–44,647)	-367 (-3%)	-367 (-1%)
Above Normal	3,799 (92–11,441)	3,668 (89–11,015)	-131 (-4%)	-131 (0%)
Below Normal	1,141 (25–4,204)	1,112 (24–4,099)	-29 (-3%)	-29 (0%)
Dry	697 (17–2,508)	679 (16–2,459)	-18 (-3%)	-18 (-1%)
Critical	357 (9–1,634)	352 (10–1,597)	-5 (-2%)	-5 (0%)

Notes: PP = Proposed Project

[1]Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.

[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project including additional spring Delta outflow and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Table 4-12. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Poor (Post-1991) Juvenile Survival for Existing Conditions and Proposed Project Including Additional Spring Delta Outflow.

	Existing (95% confidence interval)	PP with Additional Spring Delta Outflow (95% confidence interval)	PP with Additional Spring Delta Outflow vs. Existing[1]	PP with Additional Spring Delta Outflow vs Existing [2]
Wet	2,916 (86–54,509)	2,760 (83–52,037)	-156 (-6%)	-156 (0%)
Above Normal	948 (37–11,658)	907 (35–11,178)	-42 (-5%)	-42 (0%)
Below Normal	197 (9–3,963)	189 (9–3,849)	-8 (-4%)	-8 (0%)
Dry	152 (6–2,333)	146 (6–2,278)	-6 (-4%)	-6 (0%)
Critical	83 (3–1,398)	81 (3–1,376)	-3 (-3%)	-3 (0%)

Notes: PP = Proposed Project

[1]Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.

[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project including additional spring Delta outflow and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Investigations funded under the Longfin Smelt Science Program will continue to provide additional information regarding potential mechanisms behind the correlation between flow and Longfin Smelt abundance indices. These investigations will allow for a better understanding of Longfin Smelt distribution and abundance, which would be used to improve management actions. DWR proposes to undertake tidal habitat restoration to provide full mitigation for the take of Longfin Smelt because of reduction in Delta outflow under the Proposed Project relative to the Existing Conditions scenario (see Section 5.1.4 *New Tidal Habitat Restoration*).The results of the Longfin Smelt Science Program would be used to enhance the efficacy of these and other management actions.

The analysis based on the Nobriga and Rosenfield (2016) model application includes consideration of December–May Delta outflow, which depends on combined SWP and CVP operations. During this time period, the SWP is responsible for ~40% to 60% of Delta water operations, depending on month and water year type (Table 4-1).

4.2.2.3 Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited effects on Longfin Smelt, given that upstream migrating adults have very little entrainment during these months (Grimaldo et al. 2009).

4.2.2.4 Barker Slough Pumping Plant

Discussion of Barker Slough Pumping Plant effects is provided in the *Particle Tracking Modeling (Larval Entrainment)* section of Section 4.2.2.1 *Entrainment*.

4.2.2.5 South Delta Temporary Barriers

Installation of the South Delta Temporary Barriers Project's agricultural barriers in the South Delta would not differ between the Proposed Project and Existing Conditions scenarios, so potential effects would be expected to be limited to any currently occurring.

4.2.2.6 SUISUN MARSH OPERATIONS

As discussed for Delta Smelt, there are no operational changes proposed for the Suisun Marsh facilities, other than additional SMSCG operations that would occur during the period when Longfin Smelt would not be expected to be near the gates. Minimal take by entrainment of older Longfin Smelt is expected at the MIDS based on little observed entrainment during previous studies (2004-2006; Enos et al. 2007), and very little entrainment of larvae is expected based on PTM studies (Culberson et al. 2004). The screens on the RRDS intake minimize take of Longfin Smelt to entrainment of larvae or smaller juveniles (< 30 mm). As described for Delta Smelt, there are apparently no monitoring data from which to infer the level of take of larvae; the entrainment risk appears limited given that that DSM2-PTM modeling for the DFG (2009a) Longfin Smelt incidental take permit application did not observe any particles entering RRDS.

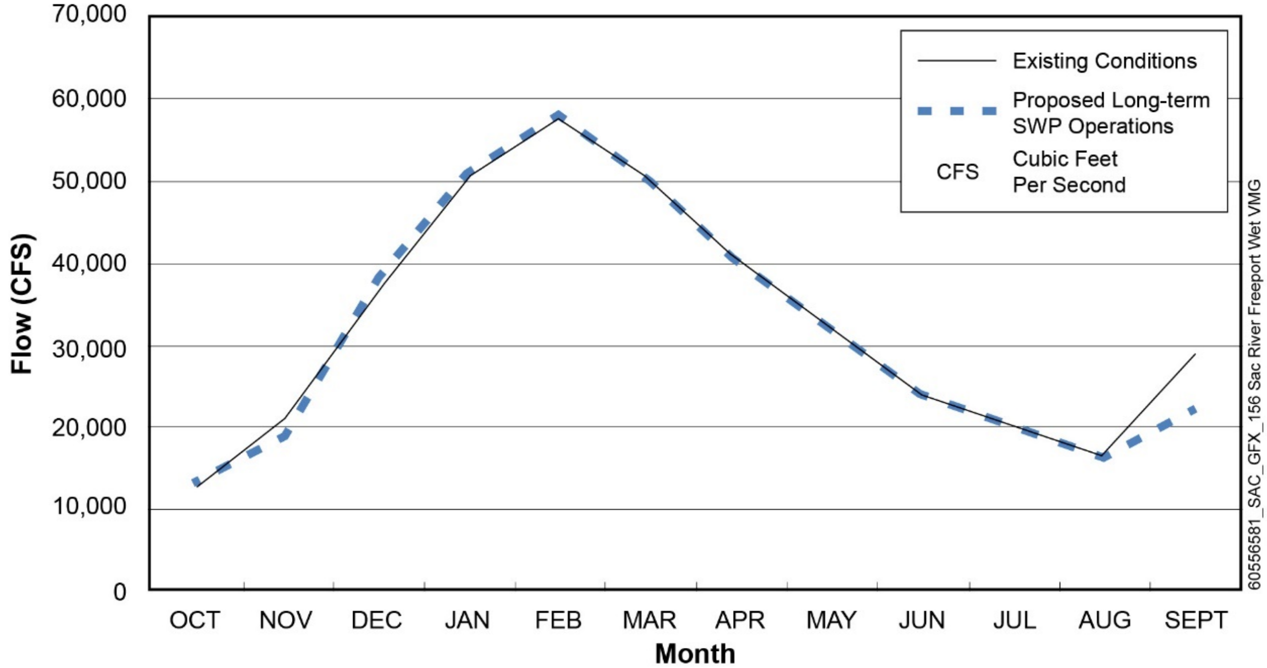
4.2.2.7 FOOD ENHANCEMENT SUMMER-FALL ACTIONS

The Food Enhancement Summer-Fall Actions as part of the Delta Smelt Summer-Fall Habitat Action would occur outside the window in which Longfin Smelt could be in the area of effect of the actions, so there would not be expected to be any effect.

4.2.3 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

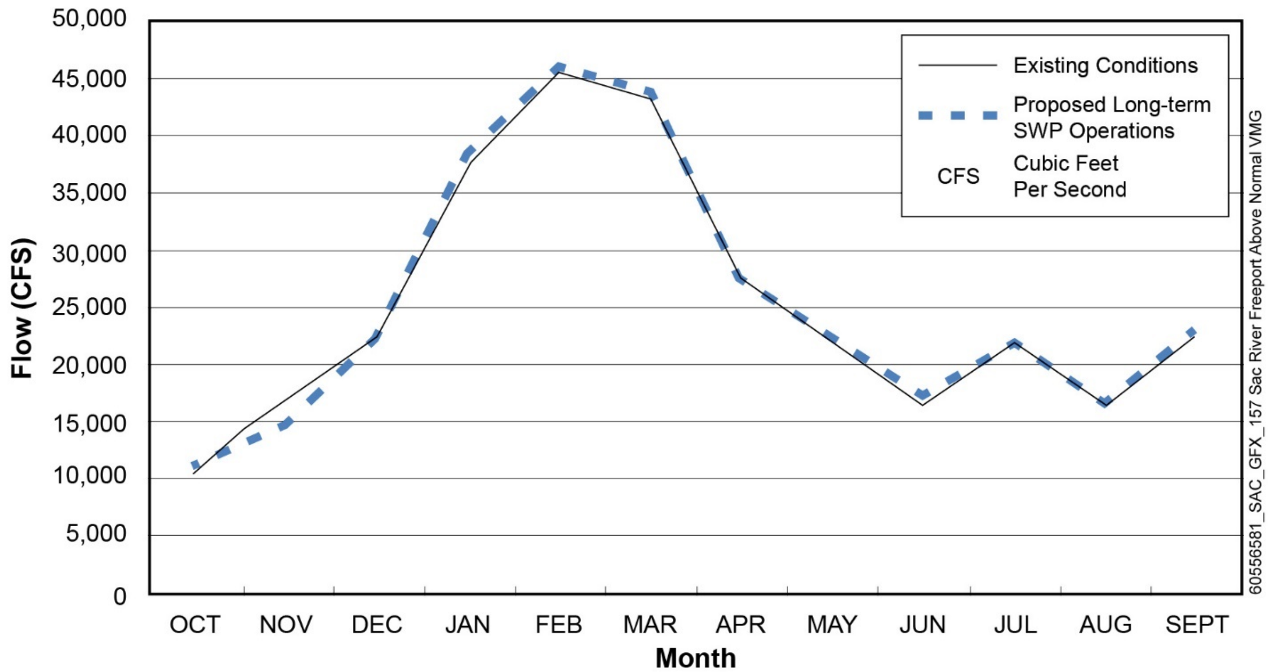
4.2.3.1 IMMIGRATING ADULTS

CalSim modeling suggests that there would be little difference between Existing Conditions and Proposed Project scenarios in flow entering the Delta in the Sacramento River at Freeport during the main winter period of upstream migration of adult Winter-run Chinook Salmon (Figures 4-56, 4-57, 4-58, 4-59, and 4-60). This suggests that there would be little potential for differences in rates of straying of adult Winter-run Chinook Salmon between the Existing Conditions and Proposed Project scenarios, because salmonids such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989), considerably greater than flow differences between the Existing Conditions and Proposed Project scenarios. Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Winter-run Chinook Salmon, potential impacts of the Proposed Project on immigrating adult Winter-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.



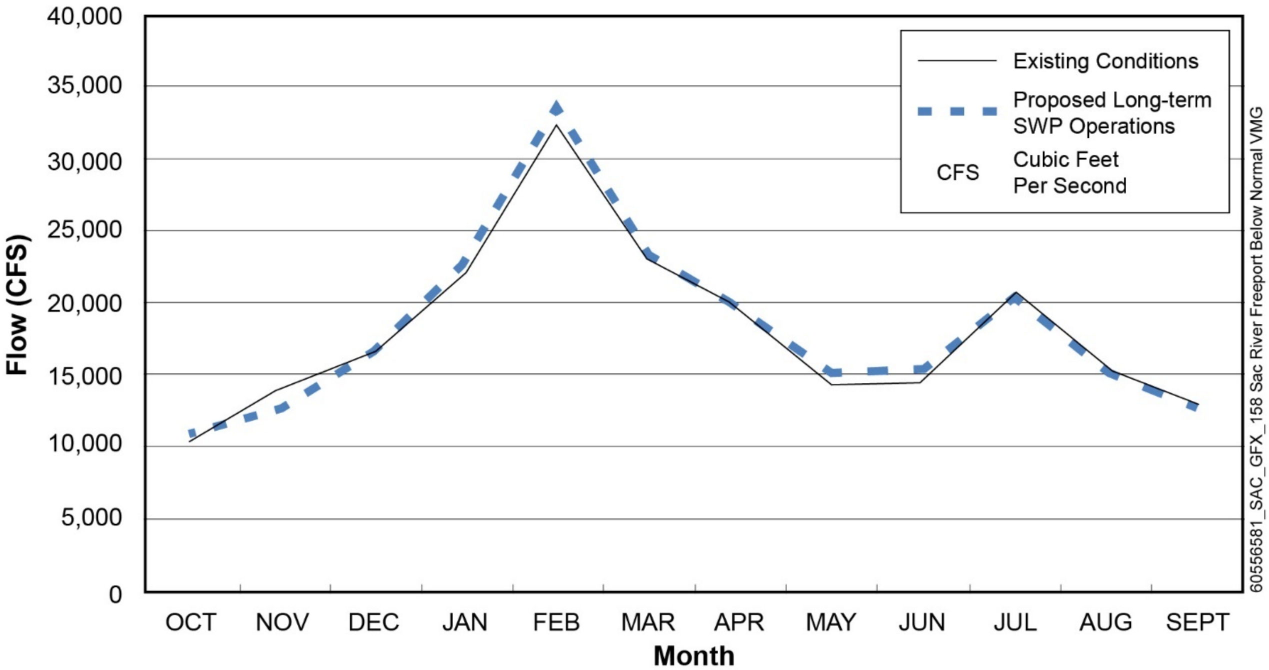
Source: DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm

Figure 4-56. CalSim-Modeled Mean Sacramento River Flow at Freeport By Month, Wet Years



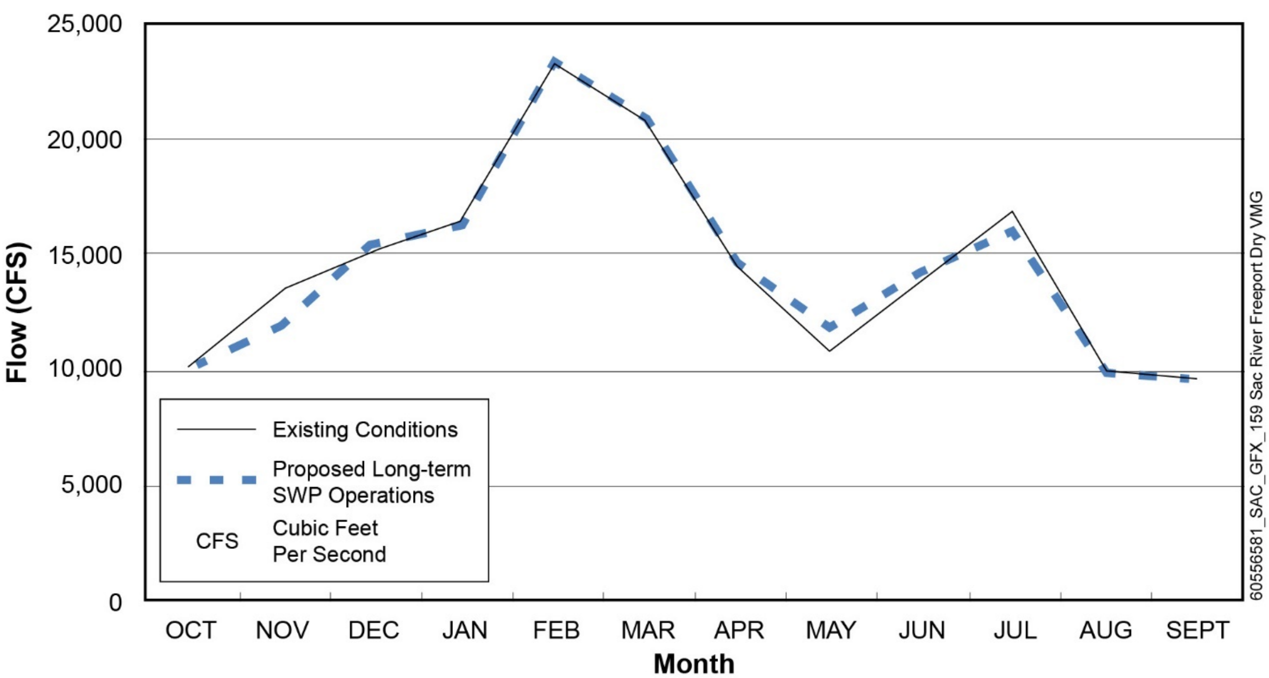
Source: DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm

Figure 4-57. CalSim-Modeled Mean Sacramento River Flow at Freeport By Month, Above Normal Years



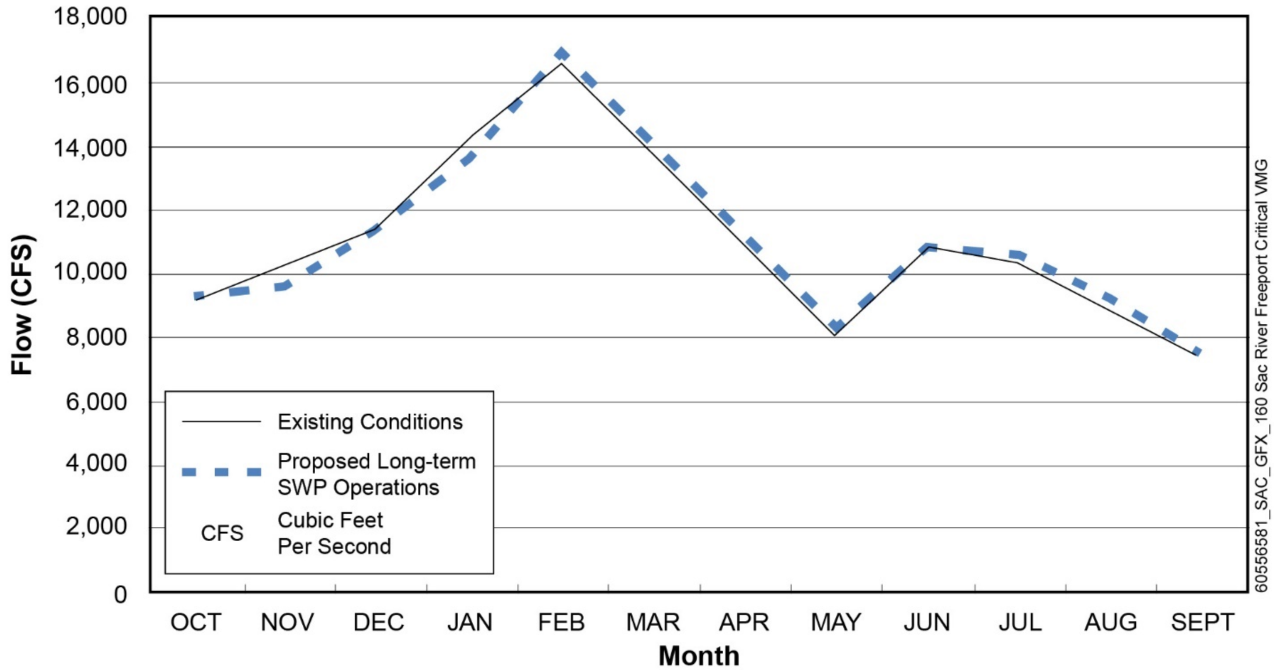
Source: DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm

Figure 4-58. CalSim-Modeled Mean Sacramento River Flow at Freeport By Month, Below Normal Years



Source: DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm

Figure 4-59. CalSim-Modeled Mean Sacramento River Flow at Freeport By Month, Dry Years



Source: DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm

Figure 4-60. CalSim-Modeled Mean Sacramento River Flow at Freeport By Month, Critical Years

4.2.3.2 OUTMIGRATING JUVENILES

Entrainment

Salvage-Density Method

To provide perspective on potential differences in entrainment loss of Winter-run Chinook Salmon juveniles between the Existing Conditions and Proposed Project scenarios, the salvage-density method was used (see Appendix D, Section D.4.1). Note that this method is based on length-at-date classification of Chinook Salmon race, and therefore reflects uncertainty in identification of the race; see additional discussion below.

The estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in South Delta exports between Existing Conditions and Proposed Project scenarios; the results are basically a description of differences in export flows weighted by historical monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but these data are more so a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected[11]. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of

[11] The loss density estimates reflect the regulatory accepted multipliers for estimating loss as a function of observed salvage; it is acknowledged herein that loss is likely to vary from the regulatory multipliers, for example as illustrated by historical and recent studies of prescreen loss in Clifton Court Forebay (Gingras 1997; Miranda 2019), but it is assumed that loss density provides a reasonable depiction of seasonal patterns in entrainment from which to weight modeled exports for comparison of the Existing and PP scenarios.

real-time adjustments to operations in order to minimize effects on listed fishes, so that differences between scenarios are likely to be less than suggested by the method. In addition, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which would reduce differences South Delta exports between the Proposed Project and Existing Conditions scenarios in spring months.

The salvage-density method suggested that entrainment loss of juvenile Winter-run Chinook Salmon at the SWP South Delta export facility would be similar between Existing Conditions and Proposed Project scenarios (Table 4-13). This is because most Winter-run Chinook Salmon entrainment largely occurs prior to the April–May period when the largest difference in South Delta exports is projected to occur between Existing Conditions and Proposed Project scenarios. As previously described, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to limit potential entrainment loss of Winter-run Chinook Salmon. This, together with the structured decision making and risk assessment-based approach for OMR flow management described in the project description, would be expected to limit entrainment loss for Winter-run Chinook Salmon juveniles to no more than the protective levels required by the NMFS (2019) ROC on LTO of the CVP and SWP Biological Opinion. These protective low levels would continue the low levels of entrainment, i.e., less than authorized take (i.e., ~1% of genetic Winter-run juveniles entering the Delta), that occurred as a result of the NMFS (2009) BiOp criteria implementation (see, for example, Islam et al. 2018).

Table 4-13. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4-11 a – Table 4-11 f

Table 4-13 a. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2,397	624	1,846	126	11	0	0	0	0	0	0	377
Proposed Project	2,284	639	1,594	323	29	0	0	0	0	0	0	379

Table 4-13 b. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4,613	1,710	1,076	25	0	0	0	0	0	0	0	760
Proposed Project	4,661	1,631	841	94	0	0	0	0	0	0	0	773

Table 4-13 c. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,272	1,209	1,447	0	0	0	0	0	0	0	0	68
Proposed Project	1,354	1,247	1,198	81	42	0	0	0	0	0	0	70

Table 4-13 d. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	531	990	2,039	44	0	0	0	0	0	0	0	354
Proposed Project	578	1,034	1,650	104	0	0	0	0	0	0	0	380

Table 4-13 e. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	386	697	436	39	7	0	0	0	0	0	0	243
Proposed Project	429	704	467	56	9	0	0	0	0	0	0	216

Table 4-13 f. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922–2003 – Totals

Totals per Scenario	Wet Year	Above Normal Year	Below Normal Year	Dry Year	Critical Year
Existing	5,381	8,184	4,031	3,958	1,809
Proposed Project	5,247	8,001	3,993	3,746	1,882
Proposed Project vs. Existing	-134 (-2%)	-183 (-2%)	-38 (-1%)	-212 (-5%)	73 (4%)

Salvage Analysis (Based on Zeug and Cavallo 2014)

Direct mortality of juvenile Winter-run Chinook Salmon occurs at the State Water Project South Delta pumping facility; both in the pre-screen space and at the facility itself (Gingras 1997, Clark et al. 2009). The Skinner Fish Facility salvages fish diverted along with water from the Delta and these fish are then released into the West Delta outside the influence of the facilities. The abundance of certain runs and species observed at the salvage facility are used in regulation of operations because it is assumed that salvage is directly proportional to mortality. Understanding the magnitude of direct mortality at the Skinner Fish Facility by analyzing raw salvage counts, or loss calculated from raw counts, is complicated by a lack of information on the size of the population from which salvage occurs and the race of the fish collected. Thus, it is difficult to determine if higher salvage occurs as a result of higher population productivity, increased susceptibility, or project operations.

Coded-wire-tagged Winter-run Chinook Salmon released from Livingston Stone hatchery are collected at the Skinner Fish Facility and provide a way to estimate the magnitude of salvage (and thus mortality) because the number of fish released, and the environmental conditions (e.g., river flow) they experienced, are known. Zeug and Cavallo (2014) analyzed salvage of coded wire tagged salmon including 178 release groups of Winter-run Chinook Salmon. A predictive model of Winter-run Chinook Salmon salvage was developed based on the Zeug and Cavallo (2014) study that included exports from SWP and Sacramento River discharge at Freeport as predictor variables. The response variable is the proportion of total juvenile Winter-run Chinook Salmon salvaged at the Skinner Fish Facility. The distribution of juvenile Winter-run Chinook Salmon entering the Delta was estimated using catch data from the Sacramento trawl between 1995 and 2009. Methods are described in more detail in Appendix D, Section D.4.2. A second model combined exports and salvage from both the SWP and CVP facilities, with results described in Section 6.3.1 *Cumulative Effects*.

The predictive salvage model was run for the Existing Conditions and Proposed Project scenarios using export and flow data from the DSM2 model. Results were compared between the two scenarios and summarized on an annual basis, and for each month juvenile Winter-run Chinook Salmon occur in the Delta by water year type.

Across the 82-year DSM2 simulation period, salvage of juvenile Winter-run Chinook Salmon was predicted to be less than 0.02% of the total juvenile population for both scenarios. Median salvage was slightly lower for the Proposed Project scenario relative to the Existing Conditions scenario over the entire modeling period (0.0119% and 0.0121%, respectively). Despite the trend of lower median salvage under the Proposed Project across all years, there was variation in which each scenario produced lower salvage in individual years (Figure 4-61).

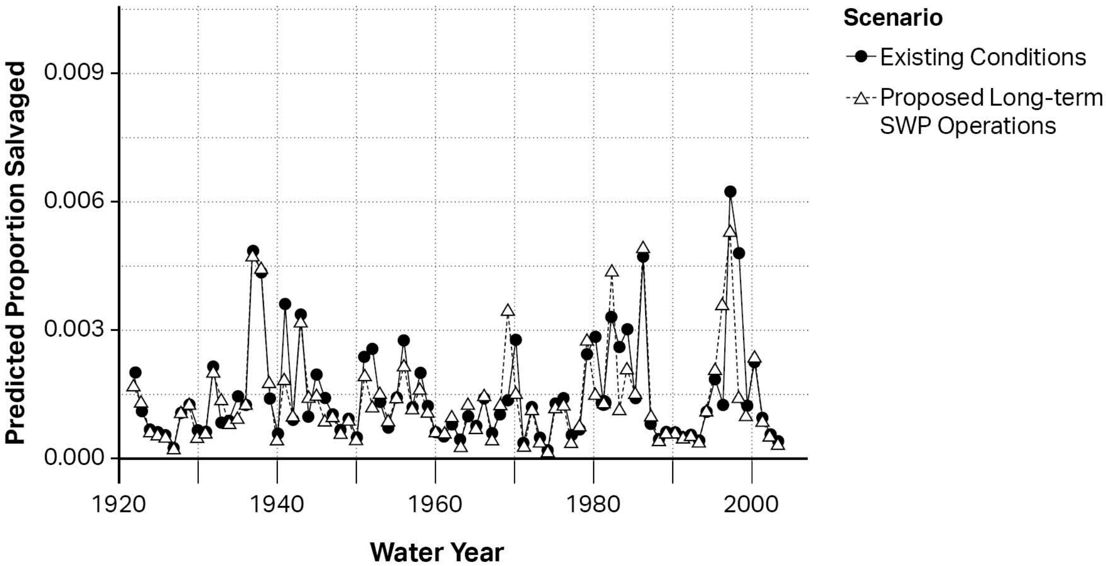
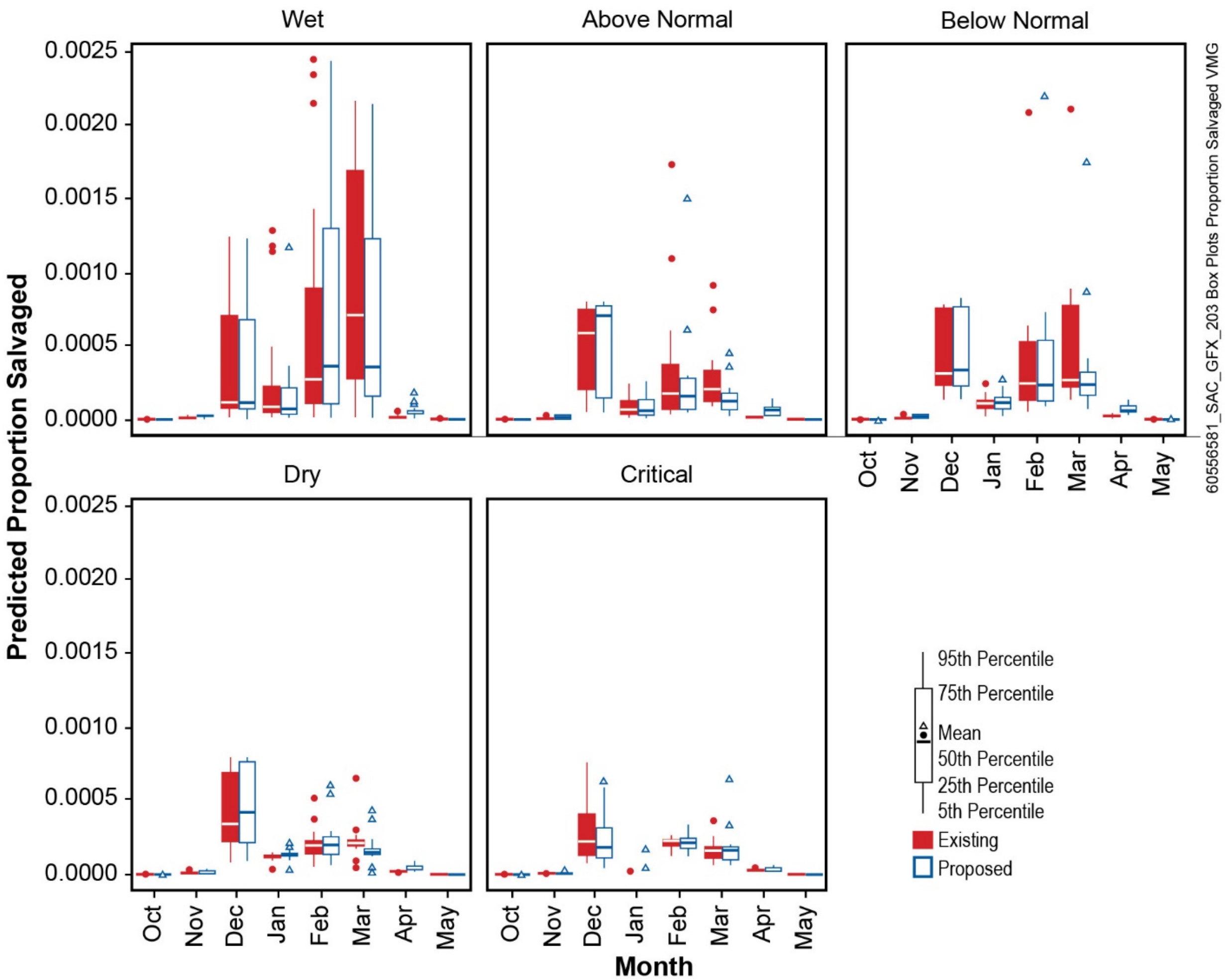


Figure 4-61. Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvage at the Skinner Delta Fish Protective Facility of the State Water Project under the Existing Conditions and Proposed Project scenarios across the 82-year DSM2 Simulation Period

The highest median salvage for both scenarios occurred in wet water years; however, salvage did not exceed 0.25% in any month (Figure 4-62). The lowest salvage for both scenarios occurred in critical water years. In all months, salvage was low and interquartile ranges overlapped considerably in the Proposed Project and the Existing Conditions scenarios (Figure 4-62). Overall, in most months, salvage of Winter-run Chinook Salmon is similar for the Proposed Project and Existing Conditions scenarios. However, notable differences in predicted salvage occur in some months of some water years. For example, in February and March of wet, above-normal, and below-normal water years, salvage was predicted to be lower under the Proposed Project scenario and in December of dry water years salvage was predicted to be higher under the Proposed Project scenario(Figure 4-62). Moreover, the underlying DSM2 modeling does not reflect real-time operational decision-making, modeling, and OMR management that would occur under the Proposed Project. These real-time operations and risk assessment-based OMR management, including cumulative and single-year loss thresholds, would be expected to limit entrainment (and thus, salvage) to protective levels. Also, as described in Section 3.3.16.1 *Adaptive Management Across Wetter and Drier Years*, adaptive management of spring outflow will be done by curtailing SWP south Delta exports, e.g., per the SWP portion of the San Joaquin River I:E ratio from the NMFS (2009) BiOp, which would reduce entrainment risk for the small proportion of Winter-run that could occur in April/May.



Note: The horizontal line is the median value, the box defines the interquartile range and vertical lines define the minimum and maximum values. Single points are outliers.

Figure 4-62. Box and Whisker Plots of Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvaged at the Skinner Delta Fish Protective Facility of the State Water Project as a Function of SWP Exports and Sacramento River Flow for Existing (EXG) and Proposed Project (PP) Scenarios (from analysis based on Zeug and Cavallo [2014])

Delta Hydrodynamic Assessment and Junction Routing Analysis

Velocity Assessment

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) "near-field" mortality associated with entrainment to the export facilities, and 2) "far-field" mortality resulting from altered hydrodynamics. Near-field or entrainment effects of proposed seasonal operations can be assessed by examining patterns of proportional population entrainment available from decades of coded wire tag studies (e.g., Zeug and Cavallo 2014), as discussed further above in *Salvage Analysis (Based on Zeug and Cavallo 2014)*. A foundation for assessing far-field effects has been provided by work of the Collaborative Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST 2017). The SST completed a thorough review of this subject and defined a driver-linkage-outcome (DLO) framework for specifying how water project operations (the "driver") can influence juvenile salmonid behavior (the “linkage”) and potentially cause changes in survival or routing (the “outcome”). The SST concluded altered “Channel Velocity” and altered “Flow Direction” were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta. Figure 4-63 provides a simplified conceptual model of the DLO defined by the CAMT SST.

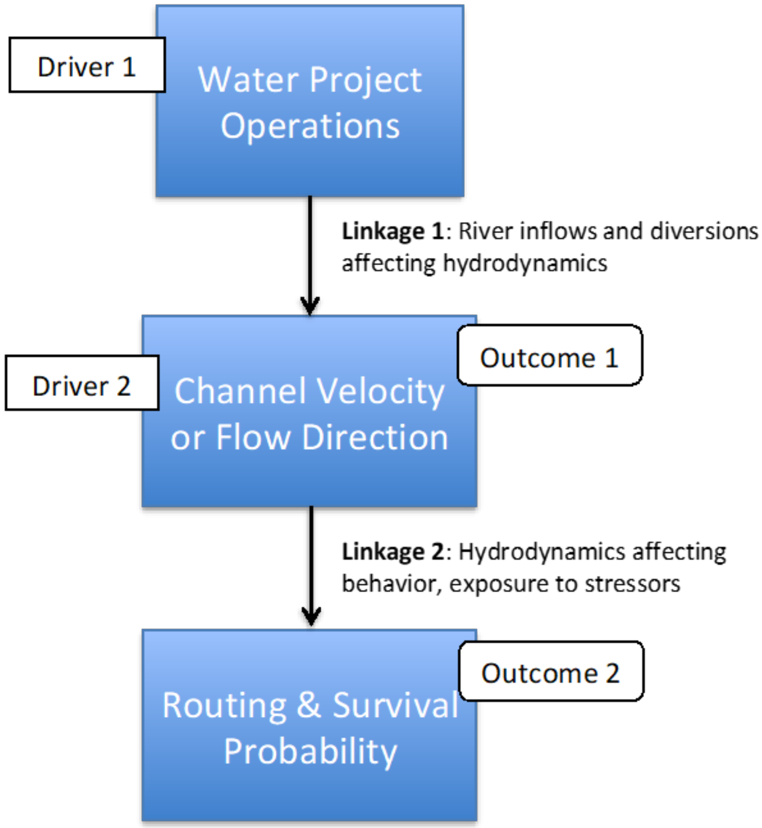
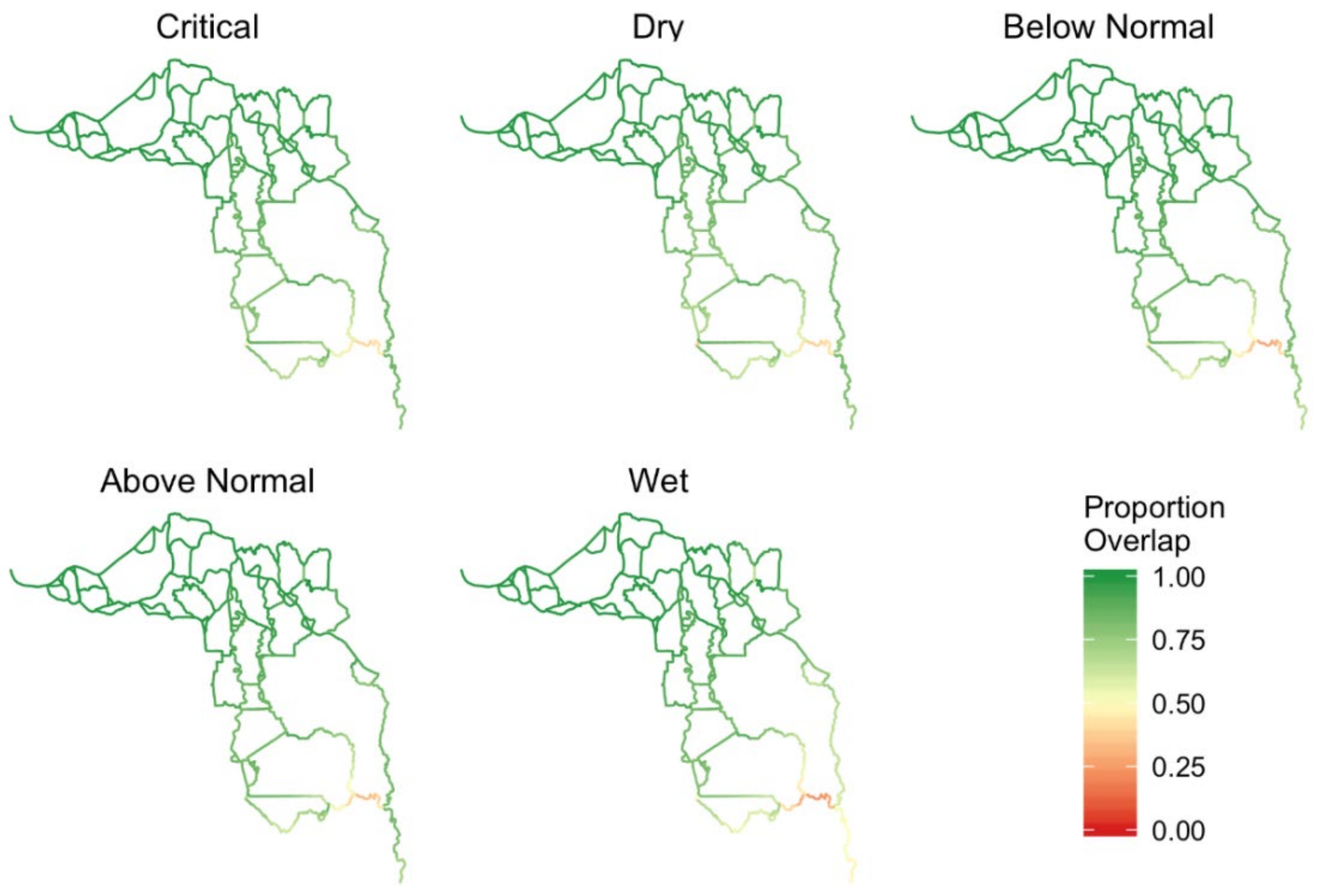


Figure 4-63. Conceptual Model for Far-Field Effects of Water Project Operations on Juvenile Salmonids in the Delta. This model is a simplified version of the information provided by the CAMT SST

To assess potential hydrodynamic effects, hourly DSM2-HYDRO outputs were used to identify Delta channels exhibiting velocity changes under the Proposed Project relative to the Existing Conditions scenario, as described in more detail in Appendix D, Section D.4.3.1. The analysis is stratified by water year type and by the three seasons when juvenile salmonids, including Winter-run Chinook Salmon, are present in the Delta (fall, winter, and spring). CalSim modeling indicates that inflows to the Delta from the Sacramento and San Joaquin rivers generally would not be appreciably different for the Proposed Project relative to the Existing Conditions scenario. As previously discussed, in the Delta, the largest hydrodynamic differences between the Proposed Project and Existing Conditions scenarios that may influence juvenile salmonids occur in the South Delta and result from changes to spring export rates and the Head of Old River Barrier (HORB).

Between September and November, velocities in the Central Delta (between Hwy 4 and north to the SJR mainstem) were largely similar between the Proposed Project and Existing Conditions scenarios (Figure 4-64). The largest velocity changes were apparent near the HOR. With the Proposed Project, there is no barrier in place at this location and therefore more water is flowing into eastern Old and

Middle rivers, increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibited few differences in critical, dry, below normal, and above normal water years. In wet water years, the absence of the HORB with the Proposed Project resulted in moderately increased velocities upstream and slightly decreased velocities downstream of HOR. Exports proposed for fall months (particularly November) lead to slight velocity changes in the South Delta near the export intake facilities. Flows in the South Delta are tidal (i.e. bi-directional), and so velocity changes in this region reflect both slightly stronger negative velocities and slightly weaker positive velocities.



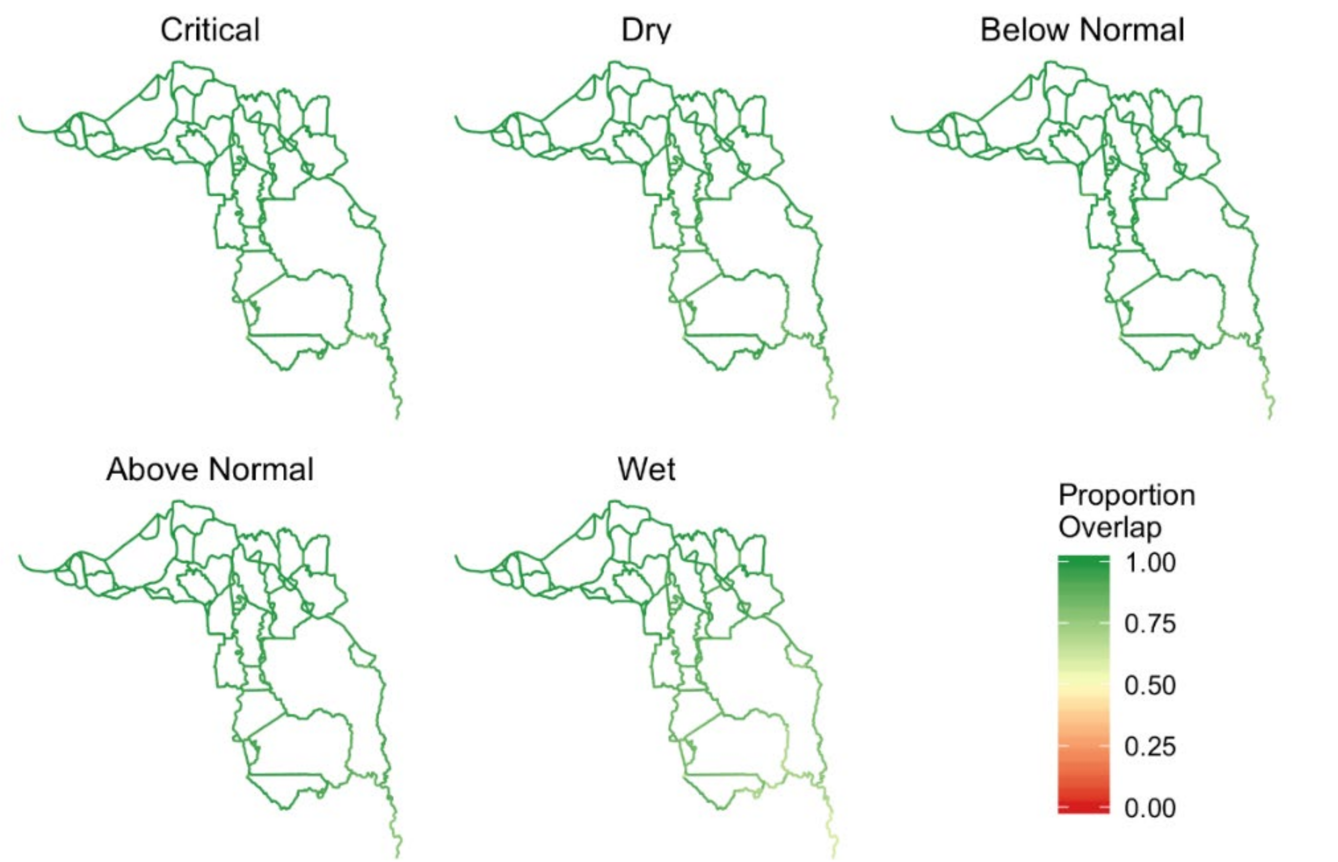
Note: Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/. The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 4-64. Overlap in Delta water velocity September–November between the Proposed Project and Existing Conditions Scenarios, from DSM2-HYDRO Modeling

Between December and February, exports would be similar between the Proposed Project and Existing Conditions scenarios, and the HORB would not be installed under either scenario. As a result, velocities throughout the South and Central Delta under the Proposed Project and Existing Conditions scenarios would be largely similar in winter months (Figure 4-65).

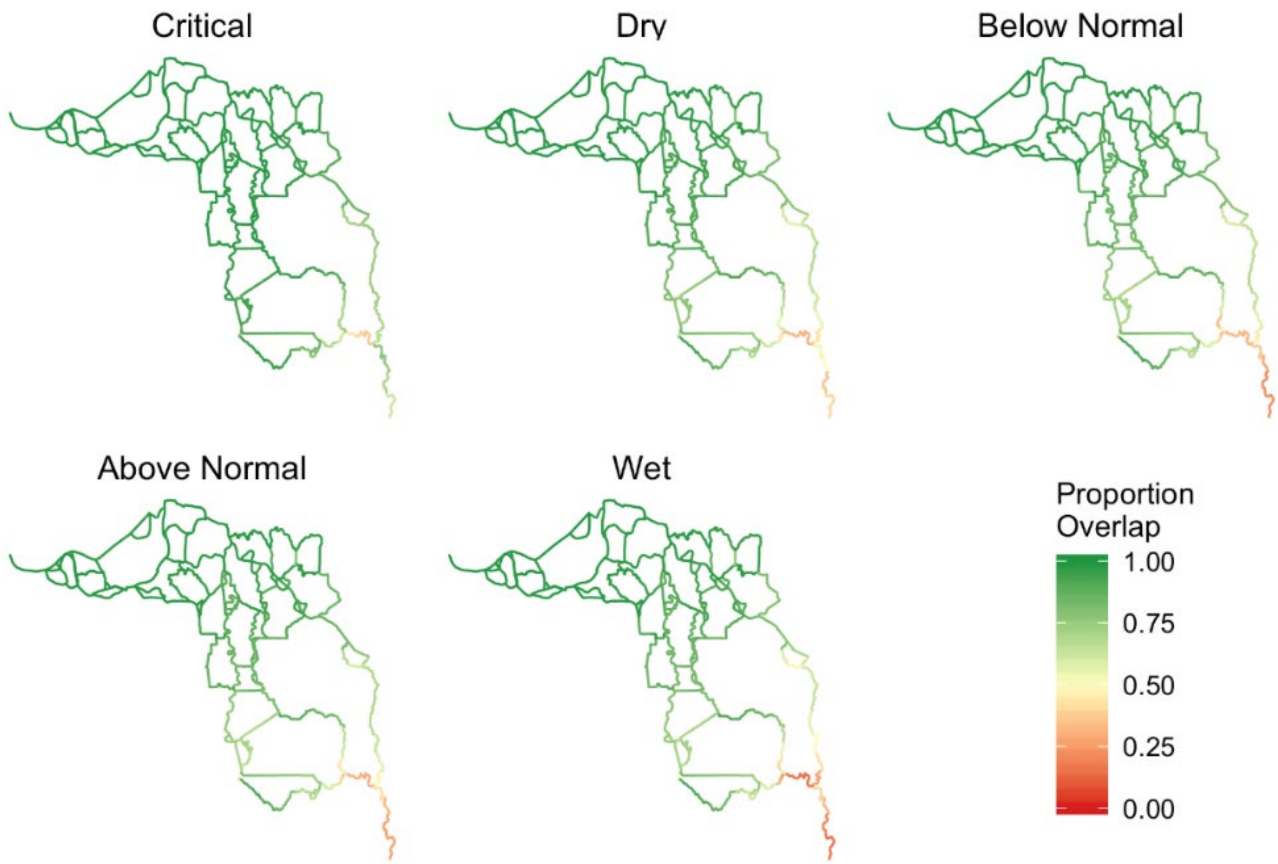
Between March and May, velocities in the Central Delta (between Hwy 4 and north to the SJR mainstem) would be largely similar between the Proposed Project and Existing Conditions scenarios

(Figure 4-66). The largest velocity changes apparent from the modeling would occur near the HOR. With the Proposed Project, there would be no barrier in place at this location and, therefore, more water would flow into the eastern Old and Middle rivers, thereby increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibit increasing differences with wetter water year types. These differences are due to the absence of the HORB under the Proposed Project. The lack of HORB causes moderate to large increases in velocities upstream of the HOR, and slight to moderately decreased velocities downstream of HOR. These effects occur because presence of the HORB creates hydraulic head that slows upstream velocities and this effect is stronger with higher San Joaquin River flows. Exports proposed for spring months (particularly April and May) lead to some velocity changes in the South Delta near the export intake facilities. Minimal differences were apparent in critically dry years, but slight to moderate velocity differences occurred in the Old and Middle Rivers immediately north of the export facilities during wetter water year types. Velocity changes associated with spring exports of the Proposed Project did not appear to extend into the Central Delta. Flows in the South and Central Delta are tidal (i.e., bi-directional), and so export related velocity changes observed in these regions reflect both slightly stronger negative velocities and slightly weaker positive velocities.



Note: Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/. The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 4-65. Overlap in Delta Water Velocity December–February between the Proposed Project and Existing Conditions Scenarios, from DSM2-HYDRO Modeling



Note: Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/. The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 4-66. Overlap in Delta Water Velocity March–May between Proposed Project and Existing Conditions Scenarios, from DSM2-HYDRO modeling

Coded wire tagging and acoustic tagging studies suggest few juvenile Chinook Salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the South Delta under the Proposed Project (e.g., less than 1% of coded-wire-tagged fish were found in salvage; Zeug and Cavallo 2014). Fish passing through the Delta Cross Channel or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. Velocity changes that could occur in the spring and fall are not likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are not generally present in the region in September and November. As previously noted, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which would reduce differences in South Delta exports and hydrodynamics between the Proposed Project and Existing Conditions scenarios relative to what was modeled.

Delta Passage Model

The Delta Passage Model (DPM) integrates operational effects of the Existing Conditions and Proposed Project scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts including Sacramento River Winter-run Chinook Salmon. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships and export-survival relationship. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis using Monte Carlo techniques. One hundred iterations of the model were run for each scenario where distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. These outputs are presented as mean values and 95% confidence intervals. A detailed description of the DPM is Appendix D, Section D.4.4.

Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project (28.4%, 95% CI 20.6-24.0) relative to the Existing Conditions scenario (28.3%, 95% CI 27.1-29.5). Survival was greater under the Existing Conditions scenario for 33 of the 82 years and greater under the Proposed Project scenario in 49 years (Figure 4-67). Differences in individual years were generally small (< 1%) and unlikely to be of biological significance. Confidence intervals for through-Delta survival overlapped between scenarios in all years.

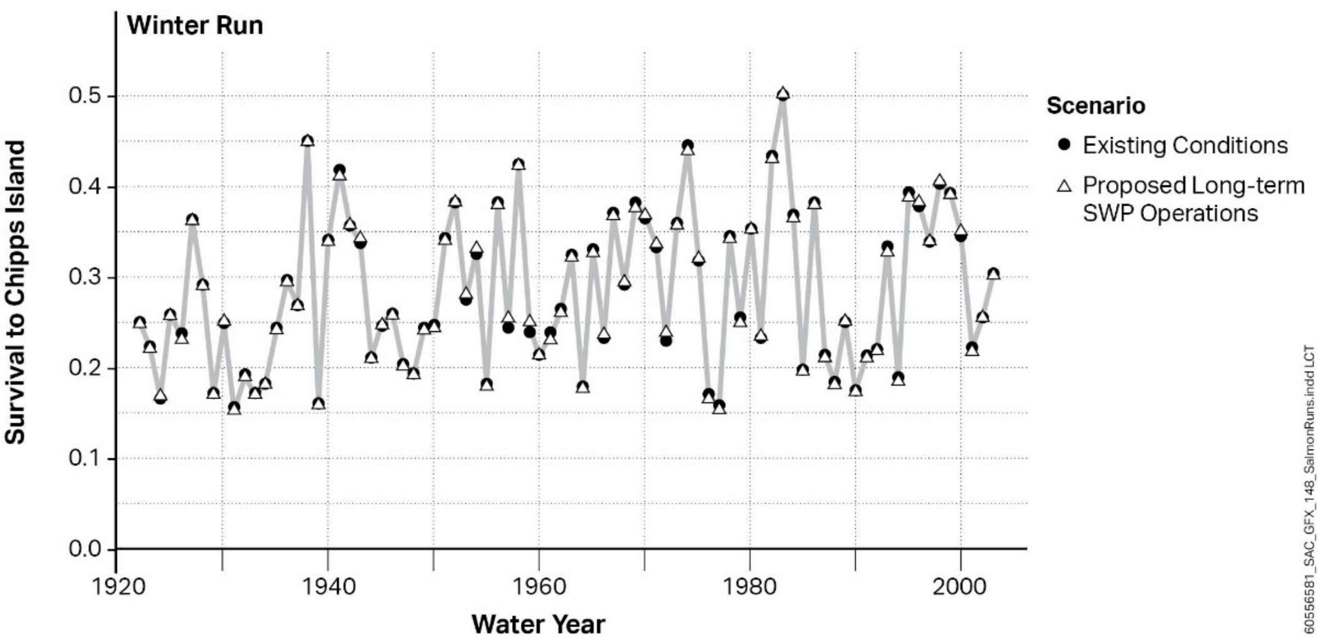


Figure 4-67. Delta Passage Model: Mean Estimates of Winter-run Chinook Salmon Through-Delta Survival with 95% Confidence Intervals for the Proposed Project and the Existing Conditions Scenarios in Each Simulation Year

For both scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 4-63). In each water year type, mean survival was slightly higher under the Proposed Project, relative to the Existing Conditions scenario. However, 95% confidence intervals overlapped substantially between survival estimates. The largest difference between scenarios occurred in below normal years when mean survival under the Proposed Project scenario was 0.22% higher than under the Existing Conditions scenario. The smallest difference occurred in critical water years when mean survival under the Proposed Project was 0.004% higher than under the Existing Conditions scenario (Figure 4-68).

Through-Delta survival effects as represented by the Delta Passage Model include the combined effects of the SWP and CVP; the SWP responsibility for Delta water operations during the winter-spring (~December through April) period of Winter-run Chinook Salmon entry into the Delta (Figure D.4-6 in Appendix D) is approximately 40-60% (Table 4-1).

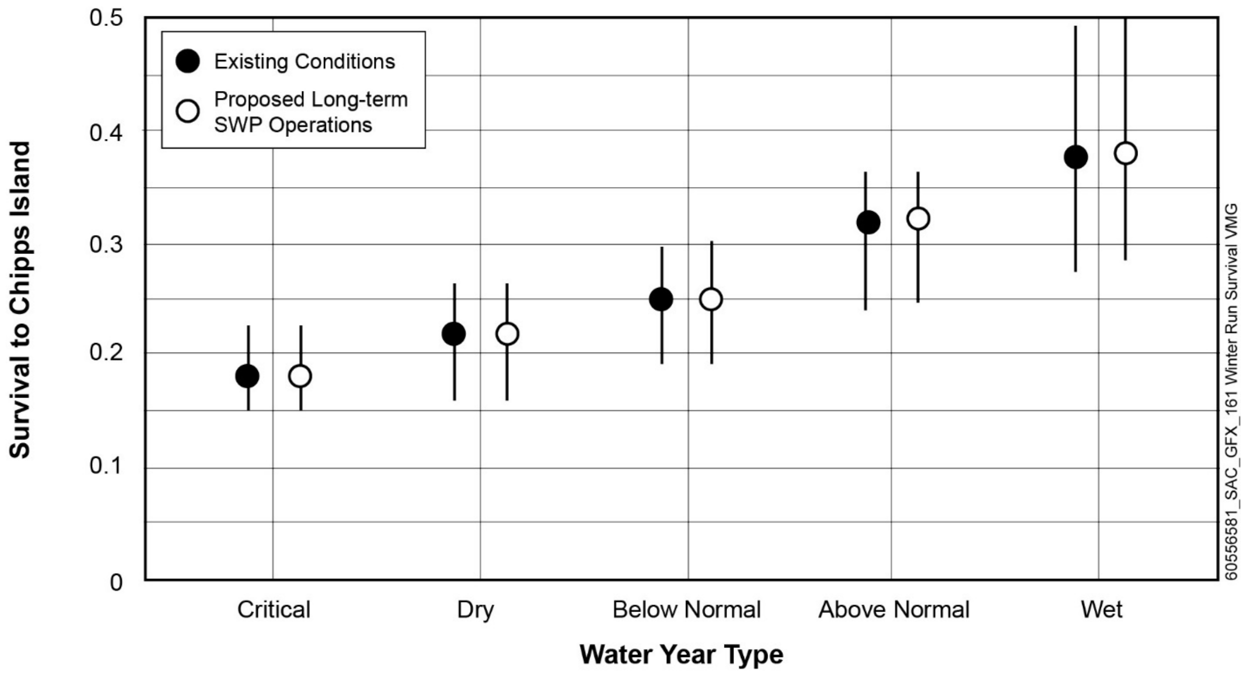


Figure 4-68. Delta Passage Model: Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Winter-run Chinook Salmon under the Proposed Project and the Existing Conditions Scenarios, by Water Year Type

Survival, Travel Time, and Routing Analysis (STARS, Based on Perry et al. 2018)

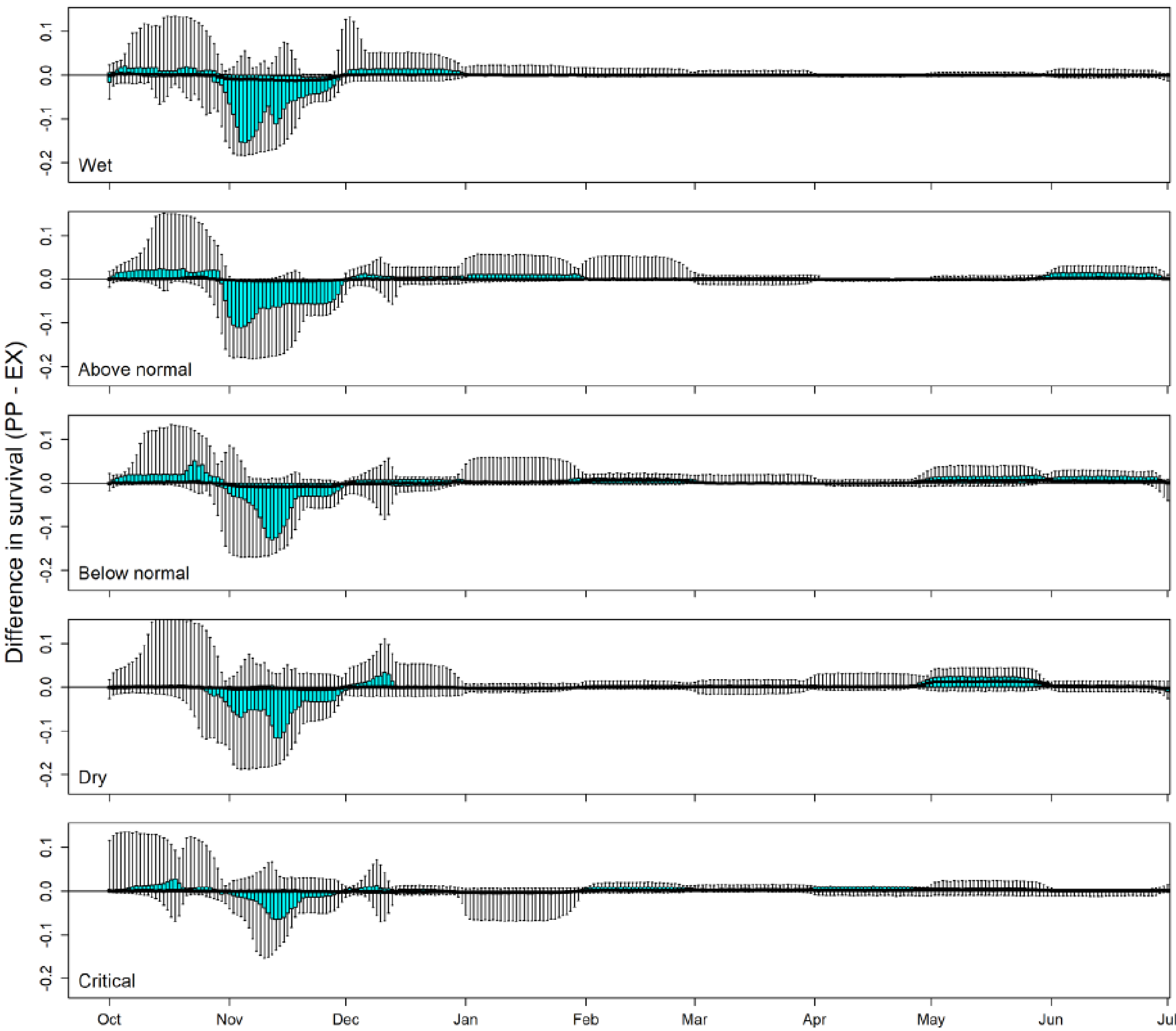
Through-Delta survival under the Existing Conditions and Proposed Project scenarios was simulated for juvenile Chinook Salmon using the STARS model (Survival, Travel time, And Routing Simulation model), a stochastic, individual based simulation model designed to predict survival of a cohort of fish that experience variable daily river flows as they migrate through the Delta from the Sacramento River. The parameters on which the STARS model is based were derived from a Bayesian mark-recapture model that jointly estimated reach-specific travel time, migration routing, and survival of juvenile Chinook Salmon. Perry et al. (2018) determined that the median travel time was related to inflow in all reaches of the Delta. In contrast, survival was strongly related to inflow in only three of eight reaches. In the three reaches that exhibited strong inflow-survival relationships, river flows transitioned from tidally influenced, bidirectional flow at low net inflow to unidirectional downstream flow as net inflows increased and tidal forcing was dampened. Thus, these three reaches caused route-specific survival through the Delta to increase with flow, yet fish that entered the interior Delta through Georgiana Slough or the DCC experienced lower route-specific survival than other migration routes. In addition, Perry et al. (2018) identified that the proportion of fish entering the interior Delta increased as 1) inflows decreased below about 25,000 cfs and 2) when the Delta Cross Channel gate was opened. These mechanisms increase the proportion of fish experiencing low-survival migration routes, thereby further reducing overall survival through the Delta. Because the STARS model incorporates the effect of river flow and DCC gate operation on juvenile Chinook Salmon survival, travel time, and migration routing, the analysis can be used to identify mechanisms by which operations affect overall survival through the Delta. One drawback, however, is that the statistical model of Perry et al. (2018) did not include South Delta exports. Thus, the modeling results presented herein are insensitive to any difference in exports between the scenarios being considered. Detailed methods and results for the STARS model are presented in Perry et al. (2019).

Although the STARS analysis considered survival, travel time, and routing, the discussion herein focuses on differences in survival because the survival calculations integrate flow-survival relationships, travel time, and routing of fish into different parts of the Delta with varying survival. The analyses were conducted for October–June and revealed that overall, there generally was little difference in predicted survival between Existing Conditions and Proposed Project scenarios (Figure 4-69). The exception generally was in November, for which survival under the Proposed Project was typically lower than under the Existing Conditions scenario, on the order of ≤1–2% (0.01–0.02) less under the Proposed Project for medians, with the interquartile range generally ≤10% less under the Proposed Project, and the range from nearly 20% less under the Proposed Project to over 5% greater under the Proposed Project. This likely reflected differences in inflow to the Delta based on the fact that the Proposed Project did not include the fall X2 action in November of wet and above-normal years that was included in the Existing Conditions scenario, resulting in lower Freeport flow and, therefore, greater frequency of opening of the DCC (assumed to be open at flow <25,000 cfs). Although the fall X2 action applies in wet and above-normal water year types, the difference between the Proposed Project and Existing Conditions scenarios in November survival was apparent in all water year types because November is part of the subsequent water year, for which the water year type would vary irrespective of the prior water year type.

From the perspective of Winter-run Chinook Salmon, the STARS model results suggest little potential for effects of the Proposed Project on through-Delta survival, except for juveniles migrating before December. Given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013) that may coincide with closure of the DCC, this may limit the potential for some of these Winter-run Chinook Salmon juveniles to find their way to the South Delta and potentially be taken by entrainment at the SWP export facility. As previously noted, a relatively low proportion of Winter-run Chinook Salmon juveniles are salvaged (Zeug and Cavallo 2014), and entrainment loss for Winter-run Chinook Salmon juveniles would be no more than the protective levels required by the NMFS ROC on LTO Biological Opinion

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Winter-run Chinook Salmon occurrence in the Delta, given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013). The potential for greater South Delta entrainment would exist for juvenile Winter-run Chinook Salmon occurring during the water transfer window, but this would be expected to be limited and any entrainment loss would count toward cumulative thresholds, which would protect the species throughout the entire winter/early spring entrainment risk period.



Source: Perry et al. (2019, p.26). Note: Each box plot represents the distribution of median survival differences among the 82 years for a given date. The point in each blue box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers (black lines) display the minimum and maximum. -, minus.

Figure 4-69. Daily Boxplots of Median Differences in Median Through-Delta Survival between the Proposed Project (PP) and Existing (EX) Scenarios by Water Year Type

Barker Slough Pumping Plant

Listed salmonids including Winter-run Chinook Salmon may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data are available at http://www.dfg.ca.gov/delta/data/nba/catchsummary.asp). Take from operations of the Barker Slough

Pumping Plant would be expected to be minimal because of infrequent presence of Winter-run Chinook Salmon in the nearby monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Plant fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. The change in the pumping limits based on Longfin Smelt presence in dry and critical years from 50 cfs under Existing Conditions to 60 cfs under the Proposed Project would not affect screen approach velocity at each operating pump and therefore would not be expected to result in different effects to Winter-Run Chinook Salmon under the Proposed Project compared to Existing.

4.2.3.3 South Delta Temporary Barriers

The potential for take of Winter-run Chinook Salmon associated with the South Delta temporary agricultural barriers would be expected to be zero or minimal because of the timing and location of the barrier installation, which occurs from April 15 to September 30 in the South Delta.

4.2.3.4 Suisun Marsh Operations

Operation of the SMSCG from October through May to meet salinity standards set by the State Water Resources Control Board and Suisun Marsh Preservation Agreement provides water quality benefits to Winter-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile Winter-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. The proportion of the total run utilizing this route is unknown. NMFS (2009:436–437) determined that operation of the SMSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators. Any take would be consistent between the Proposed Project and Existing Conditions scenarios. Winter-run Chinook Salmon would not be expected to occur during additional operations of the SMSCG for the Delta Smelt summer/fall habitat action.

As described by NMFS (2009: 437-438), the Roaring River Distribution System's (RRDS) water intakes (eight 60-inch-diameter culverts) are equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain a maximum average approach velocity of 0.2 ft/sec at the intake fish screens except during the period from September 14 through October 20, when RRDS diversion rates are controlled to maintain a maximum average approach velocity of 0.7 ft/sec for fall flood up operations, so that juvenile Winter-run Chinook Salmon would be excluded from entrainment. Any take would be consistent between the Proposed Project and Existing Conditions scenarios.

Goodyear Slough is not a migratory corridor for juvenile Winter-run Chinook Salmon, so there would be expected to be little if any take in association with operations of the Morrow Island Distribution System or the Goodyear Slough outfall (NMFS 2009:437–438). Any take would be consistent between the Proposed Project and Existing Conditions scenarios.

4.2.3.5 Food Enhancement Summer-Fall Actions

There would not be expected to be any effect on Winter-run Chinook Salmon from the Food Enhancement Summer-Fall Actions as part of the Delta Smelt Summer-Fall Habitat Action, which would occur during summer/fall, a period when Winter-run Chinook Salmon would not be expected to occur in the Delta.

4.2.4 Central Valley Spring-run Chinook Salmon

4.2.4.1 Immigrating Adults

CalSim modeling suggests that there would be little difference between the Existing Conditions and Proposed Project scenarios in flow entering the Delta in the Sacramento River at Freeport during the main spring period of upstream migration of adult Spring-run Chinook Salmon (Figures 4-55, 4-56, 4-57, 4-58, and 4-59). This suggests that there would be little potential for differences in rates of straying of adult Spring-run Chinook Salmon between the Existing Conditions and Proposed Project scenarios because, as noted for Winter-run Chinook Salmon, salmonids such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989), considerably greater than flow differences the Existing Conditions and Proposed Project scenarios. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during 1979-2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

4.2.4.2 Outmigrating Juveniles

Entrainment

To provide perspective on potential differences in entrainment loss of Spring-run Chinook Salmon juveniles between the Existing Conditions and Proposed Project scenarios, the salvage-density method was used (Appendix D, Section D.4.1), as described for Winter-run Chinook Salmon. The same caveats including those regarding length-at-date classification and the appropriate use of these results that are described for Winter-run Chinook Salmon also apply to Spring-run Chinook Salmon. In addition, as described for Winter-run Chinook Salmon, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Spring-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of Spring-run Chinook Salmon loss density. In addition, as previously noted, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which thereby decreases differences suggested by the salvage-density method.

The salvage-density method suggested that entrainment loss of juvenile Spring-run Chinook Salmon at the SWP South Delta export facility could be appreciably greater under the Proposed Project scenario compared to Existing (Table 4-14). This is because most juvenile Spring-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in South Delta exports is projected to occur between Existing Conditions and Proposed Project scenarios[12]. As described for

[12] Fish entrained during April-May would be expected to primarily be young-of-the-year; yearlings would tend to occur somewhat earlier in the winter, during a period when the Existing Conditions and Proposed Project scenarios would not be expected to differ greatly in exports, based on CalSim modeling.

Winter-run Chinook Salmon, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria; such errors are particularly pronounced in Spring-run, for which genetic studies have shown that the great majority of Spring-run-sized fish may actually be Fall Run (Harvey et al. 2014). Studies of coded-wire-tagged Spring-run Chinook Salmon suggest very few are salvaged at the South Delta export facilities (Zeug and Cavallo 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to assess and limit potential entrainment loss of Spring-run Chinook Salmon. During April-May, Spring-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management described in the project description that would be undertaken for other species, e.g., single year and cumulative loss thresholds for Winter-run Chinook Salmon and proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections. Also, as described in Section 3.3.16.1 *Adaptive Management Across Wetter and Drier Years*, adaptive management of spring outflow will be done by curtailing SWP south Delta exports, e.g., per the SWP portion of the San Joaquin River I:E ratio from the NMFS (2009) BiOp, which would reduce entrainment risk for Spring-run during April/May.

Table 4-14. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4-12 a – Table 4-12 f

Table 4-14 a. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	55	2,911	12,166	9,447	2,214	0	0	0	3	0	0
Proposed Project	2	56	2,514	31,196	25,239	2,187	0	0	0	3	0	0

Table 4-14 b. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	8	50	4,114	12,066	2,838	136	0	0	10	0	0	0
Proposed Project	8	48	3,216	45,615	11,693	135	0	0	9	0	0	0

Table 4-14 c. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	6	1,178	1,598	879	16	0	0	0	0	0	0
Proposed Project	2	6	974	5,987	3,090	16	0	0	0	0	0	0

Table 4-14 d. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	789	4,007	1,654	0	0	0	0	0	0	0
Proposed Project	0	0	638	9,429	3,511	0	0	0	0	0	0	0

Table 4-14 e. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	69	1,495	942	14	0	0	0	0	0	0
Proposed Project	0	2	74	2,155	1,160	14	0	0	0	0	0	0

Table 4-14 f. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet Year	Above Normal Year	Below Normal Year	Dry Year	Critical Year
Existing	26,798	19,221	3,679	6,449	2,521
Proposed Project	61,197	60,724	10,076	13,579	3,405
Proposed Project vs. Existing	34,399 (128%)	41,503 (216%)	6,397 (174%)	7,130 (111%)	884 (35%)

Delta Hydrodynamic Assessment and Junction Routing Analysis

Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April. Coded wire tagging and acoustic tagging studies suggest few juvenile Chinook Salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the South Delta under the Proposed Project scenario (e.g., Zeug and Cavallo 2014). Juvenile Spring-run entering the Delta from the Sacramento River and passing through the DCC or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of the Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment, primarily in April and May. Though the geographic footprint of velocity changes is relatively small, greater exports under the Proposed Project during April and May could affect a greater number of Spring-run Chinook Salmon juveniles than under the Existing Conditions scenario, with this season generally coinciding with the peak of juvenile Spring-run Chinook Salmon migration.

For Spring-run Chinook Salmon from the San Joaquin River basin, the absence of the HORB under the Proposed Project causes relatively large differences to velocities in the mainstem San Joaquin River between approximately Mossdale and Stockton. Velocities upstream of the HOR are higher under the Proposed Project (without HORB) and have the potential to be beneficial to juvenile Chinook Salmon by increasing their migration rate. This increase in velocity occurs when HORB is not installed because the presence of the HORB creates hydraulic head that slows upstream velocities and the impact is stronger with higher San Joaquin River flows. However, velocities downstream of the HOR under the Proposed Project are reduced and may offset the potential benefit of increased velocities upstream of HOR. The absence of HORB under the Proposed Project will allow more San Joaquin River origin juvenile salmonids to pass through Old River and the Grant Line Canal and approach the export facilities. While this routing increases entrainment risk for these fish, available coded-wire-tagging and acoustic-tagging studies indicate survival in this region is very poor generally and not adversely influenced by export rates (SST 2017). Entrainment at the CVP has been observed to yield higher through-Delta survival (via trucking) than volitional migration through the Delta by other routes, even with positive OMR conditions (Buchanan et al. 2018; SJRGA 2011, 2013). Though entrainment has the potential to increase during April and May due to increased exports under the Proposed Project in these months, through-Delta survival of juvenile Spring-run Chinook Salmon originating from the San Joaquin River basin may not be impaired by these operations, relative to the Existing Conditions scenario (see also the analysis below based on the San Joaquin River-origin Spring-run Chinook Salmon Structured Decision Model). As previously noted, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which would reduce differences in South Delta exports between Proposed Project and Existing Conditions scenarios.

The junction routing analysis for the HOR junction (see the method description provided in Appendix D, Section D.4.3.2, indicates the proportion of flow moving into the Old River route and toward the CVP and SWP export facilities and is relevant for juvenile Spring-run Chinook Salmon emigrating from the

San Joaquin River basin. Thus, lower flow proportion values indicate decreased flow toward the export facilities. Flow proportion into the Old River varied by month and water year type. Differences between the Proposed Project and Existing Conditions scenarios were apparent in November, April, and May (Figure 4-70). For these months, flow proportion into the Old River route is higher under the Proposed Project scenario in all water year types, but the differences were clearest and most substantial in below-normal and drier years. In dry years, flow proportion into the Old River route was 40% greater under the Proposed Project than under the Existing Conditions scenario. Results for April and May in wet, above normal, and below normal water years were highly variable for the Existing Conditions scenario because placement of the HORB was variable under wetter conditions (the barrier was assumed not to be installed at monthly average Vernalis flow >5,000 cfs). This change in flow proportion indicates juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route under the Proposed Project than under the Existing Conditions scenario.

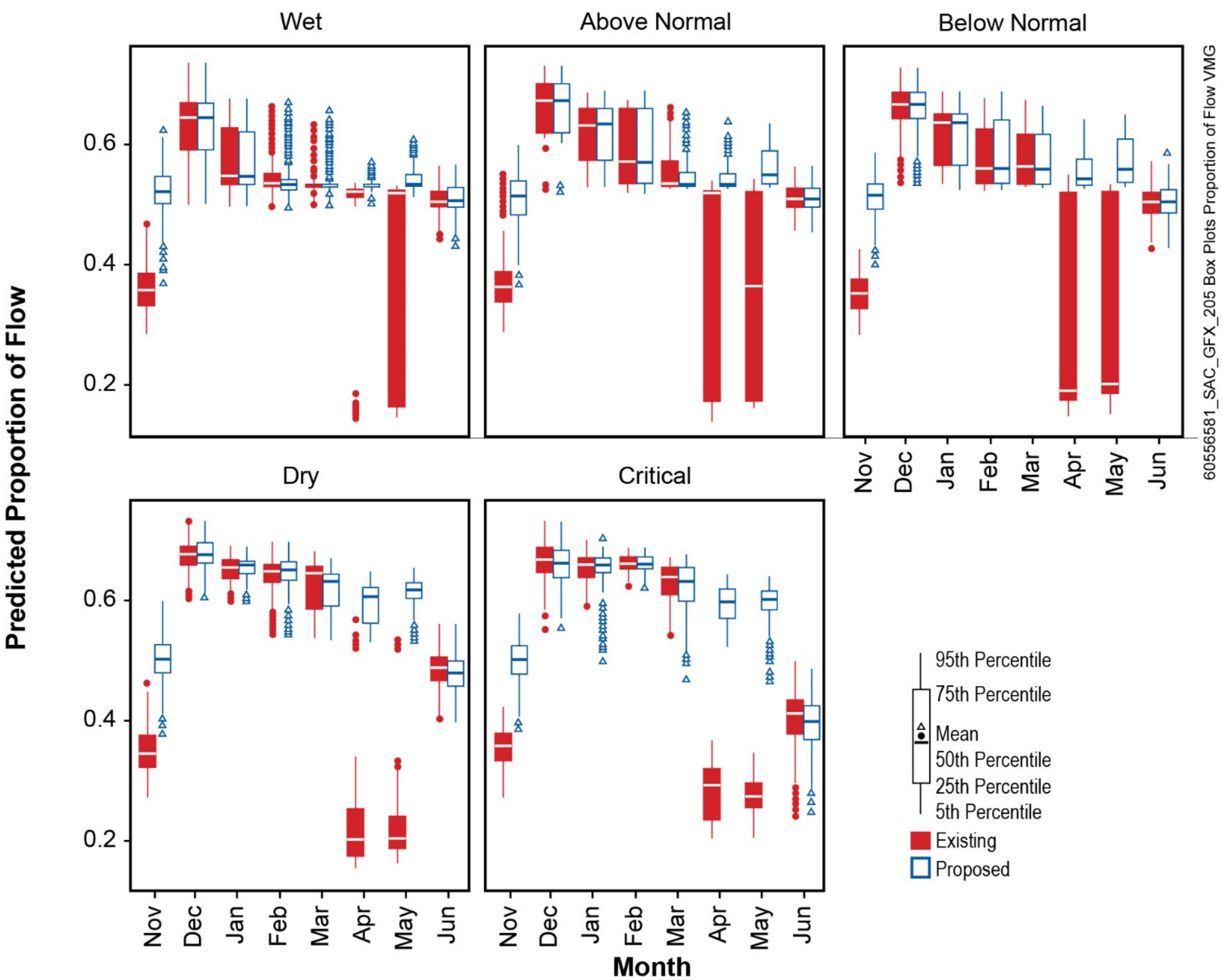


Figure 4-70. Boxplots of Proportion of Flow Entering the Head of Old River by Month and Water Year Type

Juvenile Spring-run Chinook Salmon originating from the Sacramento River basin would not encounter the HOR junction and would therefore not be affected by these differences. No juvenile Spring-run Chinook Salmon are expected to be emigrating from the San Joaquin River basin in November, so differences in this month do not have biological significance. All juvenile salmon emigrating from the San Joaquin River basin must pass through the HOR junction. Thus, the Proposed Project is expected to result in an increased proportion of juvenile salmon passing through the Old River route. However, recent acoustic tagging studies indicate no difference in survival for fish migrating through the Old River route relative to fish continuing through the San Joaquin River route (Buchanan et al. 2018). It is also important to note that although the Proposed Project does not include installation of the HORB, Spring-run Chinook Salmon juveniles may receive some ancillary protection during April and May from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be undertaken for other species. Specifically, single year and cumulative loss thresholds for Winter-run Chinook Salmon, and proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, could provide additional protection for Spring-run Chinook Salmon.

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the November through June period evaluated above is approximately 30% to 60%, depending on the month and water year type (Table 4-1).

Delta Passage Model

Background on the DPM was provided in the analysis of Winter-run Chinook Salmon, and additional detail of the model methods is provided in Appendix D, Section D.4.4. Across the 82-year simulation period, mean through-Delta survival was 0.6% greater for the Existing Conditions scenario (26.4%, 95% CI 24.7-28.1) relative to the Proposed Project scenario(25.8%, 95% CI 24.2-27.5). Survival was greater under the Existing Conditions scenario for 64 of the 82 years, and greater under the Proposed Project scenario in 18 years (Figure 4-71). Differences in individual years were generally small (< 1.5%). Confidence intervals for through-Delta survival overlapped between scenarios in all years.

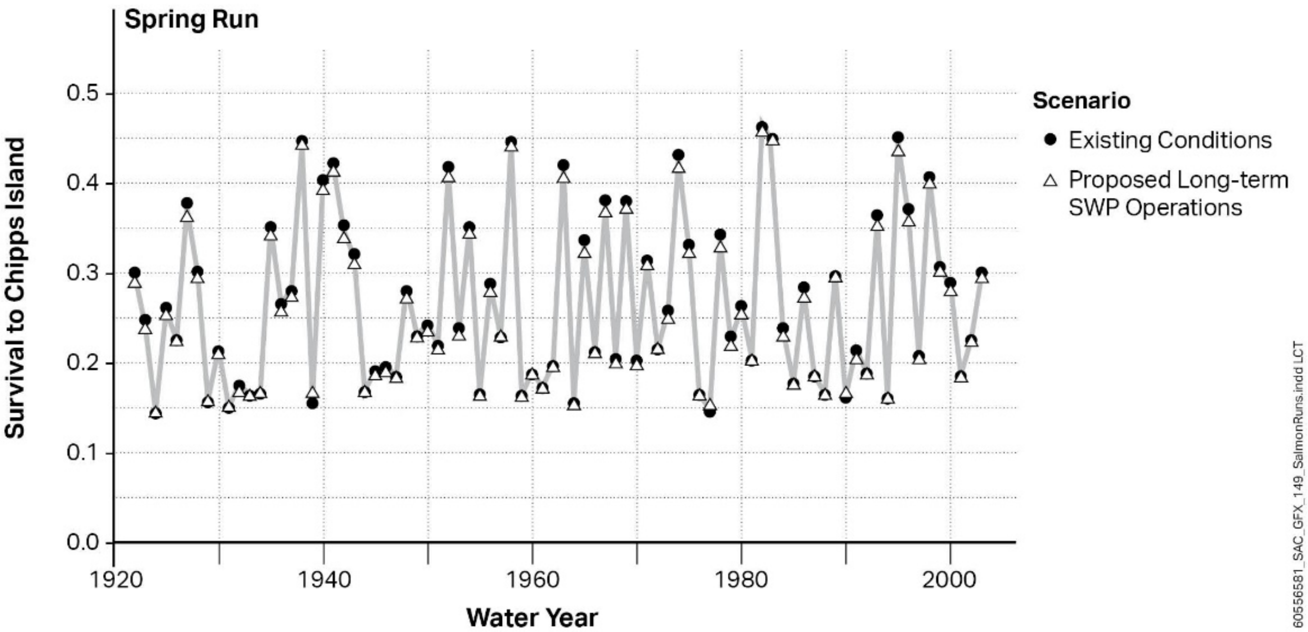


Figure 4-71. Delta Passage Model: Mean estimates of Spring-run Chinook Salmon through-Delta survival with 95% confidence intervals for the Proposed Project and the Existing Conditions scenarios in each simulation year

For both scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 4-72). Mean through-Delta survival was greater for the Existing relative to the Proposed Project in all but critical water year types (Figure 4-72). Although 95% confidence intervals for survival estimates overlapped between scenarios in each water year type, the largest difference occurred in wet years when mean survival for the Existing Conditions scenario was 0.9% higher than the Proposed Project scenario. The smallest difference occurred in dry years (0.06% higher for the Existing Conditions scenario), and survival was 0.07% higher in critical years under the Proposed Project (Figure 4-72). As previously noted, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which would reduce differences in South Delta exports between Proposed Project and Existing Conditions scenarios; this would be expected to reduce differences in through-Delta survival estimates suggested by the DPM results.

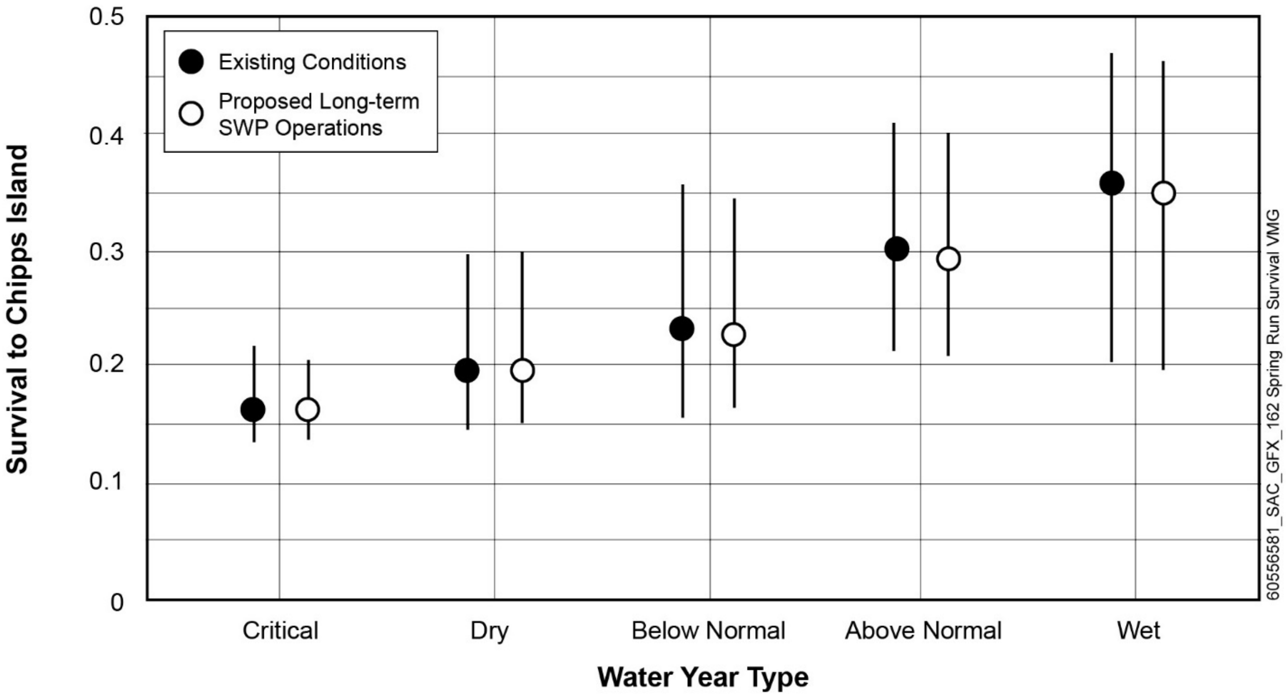


Figure 4-72. Delta Passage Model: Mean through-Delta survival with 95% confidence intervals for juvenile Spring-run Chinook Salmon under the Proposed Project and the Existing Conditions Scenarios. Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival effects as represented by the Delta Passage Model include the combined effects of the SWP and CVP; the SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta (see Figure D.4-6 in Appendix D) is approximately 40-60% (Table 4-1).

Survival, Travel Time, and Routing Analysis (STARS, Based on Perry et al. 2018)

As described for Winter-run Chinook Salmon, the STARS model provides an assessment of potential Proposed Project effects on juvenile Chinook Salmon emigrating from the Sacramento River through the Delta (Perry et al. 2019), albeit somewhat limited in considering only the effects of Freeport flows and DCC operations. STARS modeling results suggested little potential for difference in survival between the Proposed Project and Existing scenarios during the winter/spring juvenile Spring-run Chinook Salmon outmigration period (Figure 4-70). This is generally consistent with the results of the Delta Passage Model (see discussion above in the *Delta Passage Model* section), although the Delta Passage Model captures the relatively small potential negative effect of greater South Delta exports in wetter years (Figure 4-72), as also reflected in entrainment analyses such as the salvage-density method (Table 4-14).

San Joaquin River-Origin Spring-run Chinook Salmon Structured Decision Model

The Delta Structured Decision Model was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the impact of different management decisions on the survival and routing of juvenile Fall-run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin rivers and at the State and Federal export facilities. Only results from the San Joaquin River submodel are reported. The model and documentation has not been finalized and the code for the most recent version of the model that was used was accessed at https://github.com/FlowWest/chinookRoutingApp. Additional details of the model are provided in Appendix D, Section D.4.5.

Survival results from the SDM model were estimated for San Joaquin-origin Spring-run Chinook Salmon by weighting the daily proportion of Spring-run Chinook Salmon captured in the Sacramento trawl and reported as annual estimates and as aggregations by water year type. Sacramento River Spring-run Chinook Salmon timing was used because the reintroduced Spring-run Chinook Salmon population in the San Joaquin River has not existed long enough to generate a San Joaquin River-specific entry distribution.

Across the 82-year CalSim period, through-Delta survival was low (< 4%) for both the Proposed Project and Existing Conditions modeling scenarios (Figure 4-73). Survival was higher under the Proposed Project scenario for all years, although the magnitude of the difference between scenarios was variable.

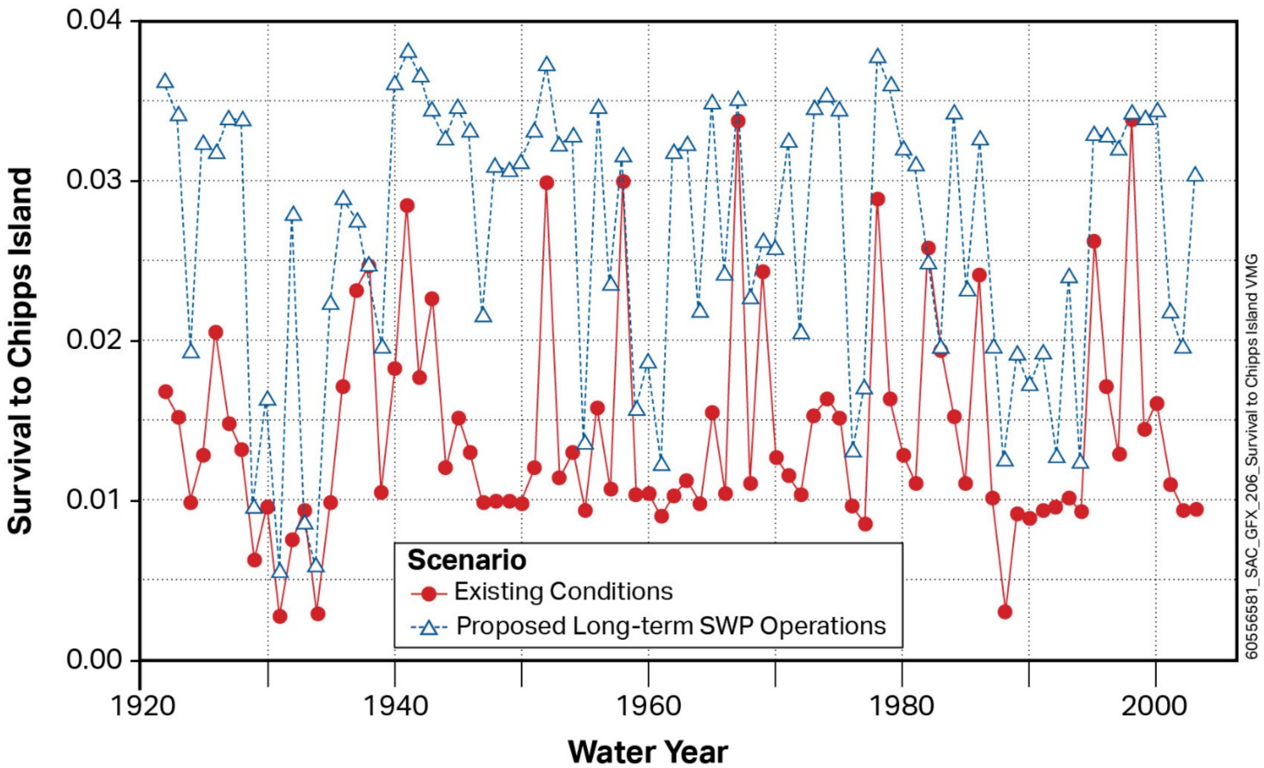


Figure 4-73. Mean Estimates of San Joaquin River Spring-run Chinook Salmon Through-Delta Survival for the Proposed Project (PP) and the Existing Conditions (EXG) in Each Simulation Year

Through Delta survival of Spring-run Chinook Salmon under the Proposed Project scenario tracked water year type with the highest values in wet and above-normal years and the lowest values in dry and critical years (Figure 4-74). Interquartile ranges of survival under the Existing Conditions and

Proposed Project scenarios overlapped only in critical years. However, in all water year types, interquartile ranges of survival were greater under the Proposed Project scenario. As previously noted, the modeling of operations effects does not account for the inclusion of proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections, which would reduce differences in in South Delta exports between the Proposed Project and Existing Conditions scenarios. would reduce differences in South Delta exports between the Proposed Project and Existing Conditions scenarios. This would be expected to reduce the differences in predicted survival suggested by the San Joaquin River Structured Decision Model, because it is a model wherein survival through salvage is positively related to export pumping (see the description in Appendix D, Section D.4.5).

Through-Delta survival impacts as represented by the San Joaquin River Structured Decision Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March through May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40% to 60% (Table 4-1).

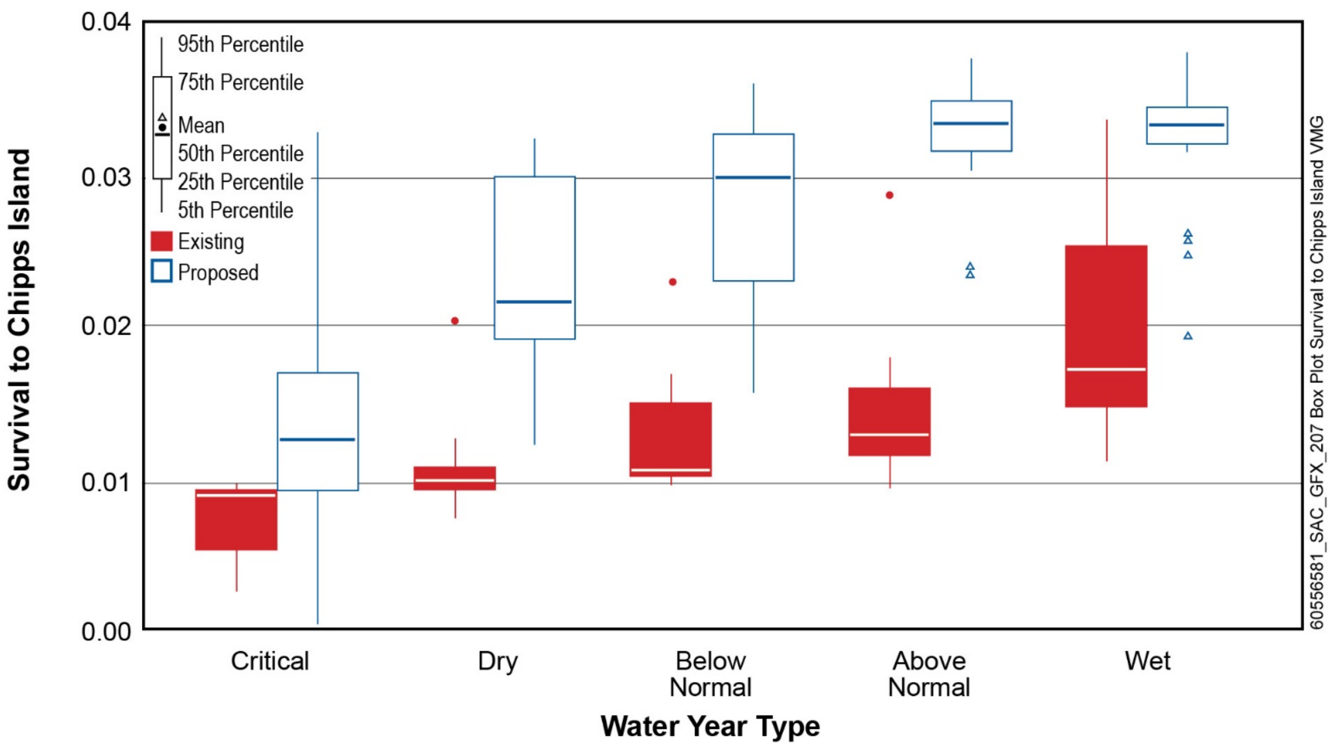


Figure 4-74. Median Through-Delta Survival (Horizontal Line) with Interquartile Ranges (Boxes), Minimum and Maximum Values (Vertical Lines) for Juvenile San Joaquin River-origin Spring-run Chinook Salmon under the Proposed Project (PP) and the Existing Conditions (EXG) Scenarios. Values were summarized by water year-type over the 82-year CalSim period

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Spring-run Chinook Salmon occurrence in the Delta. Yearlings generally may migrate in winter (as indicated by monitoring of Late Fall-run surrogate fish for entrainment management) and young-of-the-year Spring-run Chinook Salmon migrate through the Delta in spring, so potential for take would be limited.

Barker Slough Pumping Plant

As noted for Winter-run Chinook Salmon, listed salmonids including Spring-run Chinook Salmon may be present in the waterways adjacent to the Barker Slough Pumping Plant (monitoring data is available at http://www.dfg.ca.gov/delta/data/nba/catchsummary.asp). Take from operations of the Barker Slough Pumping Plant would be expected to be minimal because of infrequent presence of Spring-run Chinook Salmon in the nearby monitoring surveys indicating a low risk of entrainment. Further, Barker Slough Pumping Plant fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. The change in the pumping limits based on Longfin Smelt presence in dry and critical years from 50 cfs under Existing Conditions to 60 cfs under the Proposed Project would not affect screen approach velocity at each operating pump and therefore would not be expected to result in different effects to Spring-Run Chinook Salmon under the Proposed Project compared to Existing.

4.2.4.3 South Delta Temporary Barriers

The agricultural barriers that are part of the South Delta Temporary Barriers program at Middle River and Old River near Tracy can begin operating as early as April 15 but the tide gates are tied open from May 16 to May 31. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

The proportion of juvenile Spring-run Chinook Salmon exposed to the agricultural barriers depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the temporary barriers. The peak relative abundance of juvenile Spring-run Chinook Salmon in the Delta is March and April. If the agricultural barriers are operating as early as April 15 then they have the potential to expose a large proportion of the juvenile Spring-run Chinook Salmon migrating down the San Joaquin River. When the Head of Old River barrier is not in place, acoustically tagged juvenile Chinook Salmon have demonstrated a high probability of selecting the Old River route (Buchanan et al. 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barrier has been observed compared to when the barrier is not present (DWR 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barrier was improved (DWR 2018). Flap gates tied up on agricultural barriers from May 16 to May 31 would help to reduce the negative effect of the barriers during this period. However, juveniles migrating before or after this period could be exposed to the agricultural barriers with flaps down which apparently decreases passage success and survival (DWR 2018).

4.2.4.4 Suisun Marsh Operations

As noted for Winter-run Chinook Salmon, operation of the SMSCG from October through May to meet salinity standards set by the State Water Resources Control Board and Suisun Marsh Preservation

Agreement provides water quality benefits to Spring-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile Spring-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. The proportion of the total run utilizing this route is unknown. As described by NMFS (2009), adult Spring-run Chinook Salmon typically migrate through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. Spring-run generally utilize high stream flow conditions during the spring snowmelt to assist their upstream migration. Rapid upstream movement may be needed to take advantage of a short duration high stream flow event, particularly in dry years when high flow events may be uncommon. If the destination of a pre-spawning adult salmon is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows. However, NMFS (2009:436–437) determined that operation of the SMSCG is unlikely to impede migration of salmonids or produce conditions that support unusually high numbers of predators, and any take would be consistent between the Proposed Project and Existing Conditions scenarios. Spring-run Chinook Salmon would not be expected to occur during additional operations of the SMSCG for the Delta Smelt summer/fall habitat action.

As described by NMFS (2009: 437-438), the Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain a maximum average approach velocity of 0.2 ft/sec at the intake fish screens except during the period from September 14 through October 20, when RRDS diversion rates are controlled to maintain a maximum average approach velocity of 0.7 ft/sec for fall flood up operations so that juvenile Spring-run Chinook Salmon would be excluded from entrainment. Any take from RRDS operation would be consistent between the Proposed Project and Existing Conditions scenarios.

Goodyear Slough is not a migratory corridor for juvenile Spring-run Chinook Salmon, so there would be expected to be little if any take in association with operations of the Morrow Island Distribution System or the Goodyear Slough outfall (NMFS 2009, p.437-438). Any take would be consistent between Proposed Project and Existing.

4.2.4.5 Food Enhancement Summer-Fall Actions

There would not be expected to be any effect on Spring-run Chinook Salmon from the Food Enhancement Summer-Fall Actions as part of the Delta Smelt Summer-Fall Habitat Action, which would occur during summer/fall, a period when Spring-run Chinook Salmon would not be expected to occur in the Delta.

4.3 MAINTENANCE EFFECTS

4.3.1 Delta Smelt

Of the various maintenance activities detailed in Section 3 *Project Description*, there are several with the potential to take Delta Smelt. Fish screen cleaning would result in greater potential for entrainment at the Suisun Marsh Facilities during screen cleaning (generally in August–October), if diversion is occurring. Repair of exterior levees at the Suisun Marsh facilities could result in disturbance of Delta Smelt if occurring near work areas. Sediment removal by suction dredge at the Barker Slough Pumping Plant would have the potential to entrain Delta Smelt, although the numbers would be expected to be limited given low numbers of Delta Smelt expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks at the Barker Slough Pumping Plant would be expected to have little effect on Delta Smelt given that the species does not occur in vegetation (Ferrari et al. 2014) and as previously noted, abundance would be expected to be low in the vicinity. Screen and louver cleaning at the Skinner Fish Facility would increase entrainment loss of Delta Smelt that otherwise could have been salvaged during cleaning operations, although increased take would be limited because few Delta Smelt would not be expected to be near louvers and screens as a result of Old and Middle River flow management and observed low survival in CCF. Maintenance of CCF for embankment repairs would occur within in-water work windows and therefore would be expected to avoid take of Delta Smelt.

For control of aquatic weeds (predominantly *Egeria densa*) in Clifton Court Forebay, the Proposed Project includes application of herbicides after water temperatures within Clifton Court Forebay are above 25°C or after June 28 and prior to the activation of Delta Smelt and salmonid protective measures following the first flush rainfall event in fall/winter, and mechanical harvesting as needed. Given the timing of the action, individual adult Delta Smelt would not be exposed to any toxic effects of the herbicides, as adult Delta Smelt would not be in Clifton Court Forebay after water temperatures are above 25°C or after June 28 and before activation of Delta Smelt protection measures. Treatment with herbicides prior to June 28 or after August 31 would occur only with concurrence of fishery agencies and therefore also would be expected to result in limited effects. Mechanical removal of aquatic weeds in Clifton Court Forebay would occur on an as needed basis and therefore could coincide with occurrence of migrating adult Delta Smelt. Delta Smelt generally would not be expected to found near aquatic weeds (Ferrari et al. 2014), but could occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the Clifton Court Forebay. Any potential adverse effects on individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Fish Facility because of reduced smothering by weeds. Juvenile Delta Smelt may have more potential for exposure to aquatic weed control with herbicides, but take would be expected to be limited given that herbicide application would only begin late in spring or early summer. As noted for adult Delta Smelt, there may be the potential for injury during mechanical removal, but take would be expected to be limited given expected low numbers of juvenile Delta Smelt in Clifton Court Forebay as a result of Old and Middle River flow management.

4.3.2 Longfin Smelt

As described for Delta Smelt, there is potential for take of Longfin Smelt from the various activities described in Section 3 *Project Description*. However, as noted for Delta Smelt, take would be expected to be limited, even more so for Longfin Smelt given that the species generally occurs farther downstream from proposed maintenance activities than Delta Smelt.

4.3.3 Sacramento River Winter-run Chinook Salmon

As described for Delta Smelt, there is potential for take of juvenile Winter-run Chinook Salmon from the various activities described in Section 3 *Project Description*. However, as noted for Delta Smelt, take would be expected to be limited.

4.3.4 Central Valley Spring-run Chinook Salmon

As described for Delta Smelt, there is potential for take of juvenile Spring-run Chinook Salmon from the various activities described in Section 3 *Project Description*. However, as noted for Delta Smelt and the other covered species, take would be expected to be limited.

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5 TAKE AND EFFECT MINIMIZATION AND MITIGATION MEASURES

5.1 INTRODUCTION

Take minimization measures, together with mitigation measures, for the Proposed Project are required to:

- Minimize and fully mitigate the impacts of take from the covered activities
- Be roughly proportional in extent to the impact of take
- Meet DWR's objectives for operation of the SWP to the greatest extent possible
- Be capable of successful implementation

Minimization and mitigation measures are discussed in turn for each of the covered fish species. A summary of the main take and effect mechanisms and minimization and mitigation measures is provided in Tables 5-1 and 5-2. Note that while some measures may not be originally intended for a given species, they still are likely to provide a minimization/mitigation function for other species because of seasonal and spatial overlap.

Table 5-1. Principal Take and Effect Mechanisms, by Species – Tables 5-1a through 5-1d

Table 5-1a. Principal Take and Effect Mechanisms – Delta Smelt

Mechanism	Take	SWP Operations Responsibility[13]
South Delta entrainment (adults) (see Section 4.2.1.1 *Entrainment*)	X	~40–60%
South Delta entrainment (larvae/early juveniles) (see Section 4.2.1.1 *Entrainment*)	X	~30–60%
Barker Slough Pumping Plant entrainment (larvae) (see Section 4.2.1.1 *Entrainment*)	X	100%
South Delta Temporary Barriers operations	X	—
Maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)	X	—
Eurytemora affinis Delta outflow effect (see Section 4.2.1.2 *Food Availability*)		~40–60%
Pseudodiaptomus forbesi food subsidy (see Section 4.2.1.2 *Food Availability*)		~23–28%
Size and location of low salinity zone (see Section 4.2.1.5 *Size and Location of the Low Salinity Zone (Summer-Fall Delta Smelt Habitat Actions)*		~30–40% (Jun.); ~20–40% (Jul./Aug.); ~20–50% (Sep.); ~40–50% (Oct.)

[13] As estimated from analyses in Section 4 *Analysis of Take and Effects*, generally with reference to Table 4-1 for operations effects.

Table 5-1b. Principal Take and Effect Mechanisms – Longfin Smelt

Mechanism	Take	SWP Operations Responsibility[14]
South Delta entrainment (adults) (see Section 4.2.2.1 *Entrainment*)	X	~40–60%
South Delta entrainment (larvae) (see Section 4.2.2.1 *Entrainment*)	X	~40–60%
South Delta entrainment (juveniles) (see Section 4.2.2.1 *Entrainment*)	X	~40–50%
Barker Slough Pumping Plant entrainment (larvae) (see Section 4.2.2.1 *Entrainment*)	X	100%
Winter-spring Delta outflow-abundance (see Section 4.2.2.2 *Delta Outflow-Abundance (Based on Nobriga and Rosenfield (2016)*)	X	~40–60%
South Delta Temporary Barriers operations	X	—
Maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)	X	—

Table 5-1c. Principal Take and Effect Mechanisms – Winter-run Chinook Salmon

Mechanism	Take	SWP Operations Responsibility[15]
South Delta entrainment/Through-Delta Survival (see Section 4.2.3.2 *Outmigrating Juveniles*)	X	~40–60%
South Delta Temporary Barriers operations	X	—
Maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)	X	—

Table 5-1d. Principal Take and Effect Mechanisms – Spring-run Chinook Salmon

Mechanism	Take	SWP Operations Responsibility[16]
South Delta entrainment/Through-Delta Survival (see Section 4.2.4.2 *Outmigrating Juveniles*)	X	~40–60%
South Delta Temporary Barriers operations	X	—
Maintenance (fish screen cleaning at Skinner Fish facility, Suisun Marsh facilities, and Barker Slough Pumping Plant; exterior levee repair at Suisun Marsh facilities and embankment repairs at Clifton Court Forebay; sediment and aquatic weed removal at Barker Slough pumping plant; aquatic weed treatment in Clifton Court Forebay)	X	—

[14] As estimated from analyses in Section 4 *Analysis of Take and Effects*, generally with reference to Table 4-1 for operations effects.

[15] As estimated from analyses in Section 4 *Analysis of Take and Effects*, generally with reference to Table 4-1 for operations effects.

[16] As estimated from analyses in Section 4 *Analysis of Take and Effects*, generally with reference to Table 4-1 for operations effects.

Table 5-2. Applicable Minimization and Mitigation Measures, by Species

Species	Applicable Minimization/Mitigation Measures

Delta Smelt	• Proposed entrainment protections:
	  ○ Adult Old and Middle River flow management (first flush and turbidity bridge avoidance)
	  ○ Larval and juvenile Old and Middle River flow management
	  ○ Barker Slough minimization
	• Adaptive Management for Delta outflow actions
	  ○ Export reduction for spring Delta outflow
	  ○ 100 TAF block of summer/fall water
	• Summer/fall Delta Smelt habitat actions
	• Other:
	  ○ Rio Vista Field Station
	  ○ Cultured Smelt studies
	  ○ Four-year reviews
	  ○ Skinner Fish Facility Improvements
	  ○ Adaptive Management
	  ○ Clifton Court Predator Management Study
	  ○ Clifton Court Aquatic Weed Control Program
	• Habitat restoration
	  ○ Remaining portion of the 8,000 acres required under 2008 BiOp
	  ○ Remaining portion of the 800 acres required under 2009 Longfin Smelt ITP
	  ○ Yolo Bypass
	  ○ New tidal habitat restoration
	• Federal BiOp (Delta)
	  ○ Delta Smelt BiOp ITS take limits for Barker Slough, RRDS and MIDS
	  ○ Delta Smelt BiOp RPM 1: Skinner Fish Facility, Turbidity Bridge Avoidance
	  ○ Delta Smelt BiOp RPM 2: Summer-fall habitat action
	  ○ Delta Smelt BiOp RPM 4: Barker Slough Intake O&M

Longfin Smelt	• Proposed entrainment protections:
	  ○ Adult Old and Middle River flow management
	  ○ Larval and juvenile Old and Middle River flow management
	  ○ Barker Slough 60-cfs pumping restriction based on presence during dry and critical water years
	• Adaptive management of export reduction for spring Delta outflow
	• Other:
	  ○ Longfin Smelt Science Program
	  ○ Longfin Smelt Life-Cycle Model
	  ○ Rio Vista Field Station
	  ○ Cultured Smelt studies
	  ○ Four-year reviews
	  ○ Skinner Fish Facility Improvements
	  ○ Adaptive Management
	  ○ Expanded Monitoring
	  ○ Clifton Court Predator Management Study
	  ○ Clifton Court Aquatic Weed Control Program
	• Habitat restoration
	  ○ Remaining portion of the 8,000 acres required under 2008 BiOp
	  ○ Remaining portion of the 800 acres required under 2009 Longfin Smelt ITP
	  ○ Yolo Bypass
	  ○ New tidal habitat restoration
	• Federal BiOp (Delta)

Species	Applicable Minimization/Mitigation Measures
	○ Delta Smelt BiOp ITS take limits for Barker Slough, RRDS and MIDS ○ Delta Smelt BiOp RPM 1: Skinner Fish Facility, Turbidity Bridge Avoidance ○ Delta Smelt BiOp RPM 4: Barker Slough Intake O&M
Winter-run Chinook Salmon	• Proposed entrainment protections: ○ Old and Middle River flow management ○ -5,000-cfs Old and Middle River flow limit ○ Single Year Loss Protections ○ Cumulative Loss Protections • Adaptive management of export reduction for spring Delta outflow • Other: ○ Rio Vista Field Station ○ Clifton Court Predator Management Study ○ Clifton Court Aquatic Weed Control Program ○ Four-year reviews ○ Skinner Fish Facility Improvements • Habitat restoration ○ Remaining portion of the 8,000 acres required under 2008 BiOp ○ Remaining portion of the 800 acres required under 2009 Longfin Smelt ITP ○ Yolo Bypass ○ New tidal habitat restoration • Federal BiOp (Delta) ○ NMFS BiOp Winter Run ITLs for Banks and Jones PP ○ NMFS BiOp Winter-run ITL for Barker Slough, SMSCG, Temporary Ag Barriers ○ NMFS BiOp RPM 5: predator hot spot management, Skinner and Tracy FF improvements, Barker Slough O&M, Temporary Ag Barriers
Spring-run Chinook Salmon	• Proposed entrainment protections: ○ Old and Middle River flow management ○ -5,000-cfs Old and Middle River flow limit ○ Single Year Loss Protections for Winter-run Chinook Salmon ○ Cumulative Loss Protections for Winter-run Chinook Salmon • Adaptive management of export reduction for spring Delta outflow • Other: ○ Rio Vista Field Station ○ Clifton Court Predator Management Study ○ Clifton Court Aquatic Weed Control Program ○ Four-year reviews ○ Skinner Fish Facility Improvements • Habitat restoration ○ Remaining portion of the 8,000 acres required under 2008 BiOp ○ Remaining portion of the 800 acres required under 2009 Longfin Smelt ITP ○ Yolo Bypass ○ New tidal habitat restoration • Federal BiOp (Delta) ○ NMFS BiOp CV Spring-run Chinook Salmon – yearlings ITL for Banks and Jones Pumping Plant ○ NMFS BiOp CV Spring-run ITL for Barker Slough, SMSCG, Temporary Ag Barriers ○ NMFS BiOp RPM 5: predator hot spot management, Skinner and Tracy FF improvements, Barker Slough O&M, Temporary Ag Barriers ○ NMFS BiOp RPM 10: Delta Performance Objective for YoY CV spring-run Chinook salmon

Among the minimization/mitigation measures described in Table 5-2 is new tidal habitat restoration.

In combination with other measures such as OMR management and adaptive management of spring Delta outflow (Table 5-2), DWR proposes to achieve full mitigation of the Proposed Project for Longfin Smelt with this new tidal habitat restoration, similar to the approach taken in the DFG (2009) ITP. For full mitigation of Existing Conditions operations, DFG (2009) required two main components: flow measures and tidal habitat restoration. DFG (2009:9) stated that the flow measures minimized take and provided partial mitigation for the remaining take by (1) minimizing entrainment, (2) improving estuarine processes and flow; (3) improving downstream transport of Longfin Smelt larvae; and (4) providing more water that is used as habitat (increased habitat quality and quantity)[17]. The flow measures consisted of (a) meeting OMR criteria in December–February to protect Longfin Smelt adults, (b) meeting OMR criteria in January through June in consideration of survey data to protect larval and juvenile Longfin Smelt distribution, and (c) restricting Barker Slough Pumping Plant diversions between January 15 and March 31 of dry and critically dry years to protect larval Longfin Smelt if distributed near the Barker Slough Pumping Plant. To contribute to full mitigation, DFG (2009:14) determined that permanent protection of inter-tidal and associated sub-tidal habitat wetland habitat to enhance Longfin Smelt water habitat was necessary and required under CESA to fully mitigate the impacts of the taking under Existing Conditions. DFG (2009) required acquisition, initial enhancement, restoration, long-term management, and long-term monitoring of 800 acres of inter-tidal and associated sub-tidal wetland habitat in a mesohaline part of the estuary. DFG (2009:14) stated that the restoration, together with the flow measures, “will enhance the estuarine processes and open water habitat beneficial for Longfin Smelt and provide some additional habitat for Longfin Smelt in deeper areas.”

Completion of the Tule Red Restoration Project and Winter Island Tidal Habitat Restoration Project in 2019, once credited, will provide the required 800 acres of restoration under the DFG (2009) ITP. A total of 1,153.7 acres of mesohalinie tidal habitat has been completed and is expected to be credited for Longfin Smelt. Full mitigation for the Proposed Project will be provided by new tidal habitat restoration in addition to the mesohaline habitat restoration already completed. The required acreage was calculated with the same method used for the 8,000/800 acres (Kratville 2010) under the USFWS (2008) SWP/CVP BiOp and the DFG (2009) ITP. The final acreage was based on the acreage calculated from the anticipated February–June export to inflow (E:I) ratio for the Proposed Project (i.e., 0.21) and the SWP percentage of operations during February–June (i.e., 44%), which was 750 acres, minus the additional mesohaline acreage above the 800 acres required under the DFG (2009) ITP, i.e., 353.7 acres. Thus, the total acreage of new tidal habitat restoration as mitigation for the Proposed Project would be 396.3 acres. The proposed habitat restoration is a conservative estimate (i.e., provides a greater amount of habitat restoration) because it does not account for additional curtailment of exports during spring, which is proposed as part of the Adaptive Management Planning process.

[17] It is uncertain to what extent these mechanisms may actually be important, but they are as hypothesized by DFG (2009).

Table 5-3. Habitat Restoration Acreages for Longfin Smelt

Restoration Habitat	Acres	Comments
Mesohaline Tidal Habitat Completed (to be credited as of December 2019)	1,153.7	Based on Tule Red (610 acres) plus Winter Island (543.7 acres)
Mesohaline Tidal Habitat Required by 2009 ITP	800	
Excess Mesohaline Tidal Habitat Completed Above 2009 ITP Requirements	353.7	Calculated based on 1,153.7 – 800
Mesohaline Habitat Mitigation Requirement Calculated for Proposed Project	750	Based on February–June export to inflow (E:I) ratio for the Proposed Project (i.e., 0.21) and the SWP percentage of operations during February–June (i.e., 44%),
Additional New Mesohaline Tidal Habitat Restoration for Proposed Project	396.3	Calculated based on 750-353.7

The USFWS BiOp (2008) required 8,000 acres of habitat restoration to mitigate for project effects. The estimated creditable acreages, status, and completion dates of these projects is described in Table 5-4. Additionally, construction of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is anticipated to be completed by December 2022.

Table 5-4. Estimated Creditable Acreages, Status, and Completion Dates of Restoration Projects.

Project	Estimated Creditable Acres	Estimated Construction Start	Estimated Construction Completion	Conditional Credit[1]
Arnold Slough	137	Jul-22	Oct-23	-
Bradmoor Island	522	Jul-22	Oct-23	-
Chipps Island (DWR)	807	Jul-21	Nov-21	-
Decker Island	114	Jul-18	Oct-18 (complete)	NMFS, USFWS
Lookout Slough	3,000	Spring 2020	Fall 2021	-
Lower Yolo Ranch	1,680	Aug-20	Oct-20	NMFS, USFWS
Prospect Island	1,360	Apr-21	Oct-23	-
Tule Red	610	Sep-16	Oct-19 (complete)	USFWS
Yolo Flyway Farms	294	Aug-18	Oct-18 (complete)	NMFS, USFWS
Wings Landing	190	Sep-20	Dec-22	-
Winter Island	553	Aug-19	Nov-19 (complete)	USFWS
TOTAL	9,267	-	-	-

1. NMFS provides credit for Winter-run Chinook Salmon and Spring-run Chinook Salmon restoration. USFWS provides credit for Delta Smelt restoration.

"-" indicates blank cell

5.2 DELTA SMELT

Applicable minimization and mitigation measures for the Proposed Project's potential take and effects on Delta Smelt include entrainment protection, adaptively managed Delta outflow actions, habitat restoration, other measures such as cultured smelt studies and the Rio Vista Estuarine Research Station, and take limits and measures from the USFWS (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation (ROC on LTO) of the CVP and SWP Biological Opinion (Table 5-2). Additional description of some of these aspects is generally provided in Section 3, "Project Description." The following are among the applicable minimization and mitigation measures:

- Old and Middle River (OMR) Flow Management (see Section 3.3.1): specific entrainment minimization criteria for Delta Smelt (see Section 3.3.1.1), plus ancillary protection that may occur as a result of criteria for other species;
- Delta Smelt Summer/Fall habitat actions (see Section 3.3.4): operation of the SMSCG (see Sections 3.1.3.5, 3.3.4), X2 requirements (see Section 3.3.4), and food enhancement summer/fall actions (3.3.4.1), which would manage habitat and increase food availability to Delta Smelt, in accordance with biological and environmental objectives;
- Clifton Court Forebay (see Section 3.3.12): use of appropriate collection gear for predatory fish (i.e., larger mesh nets to limit potential for incidental capture of Delta Smelt; herbicide control of aquatic weeds within a window aimed to minimize overlap with Delta Smelt (Table 3-4, see Section 3.3.12.2).
- Any low salinity (~5–6) portions of new tidal habitat restoration focused on Longfin Smelt mitigation (see Section 5.1.4 *New Tidal Habitat Restoration*) would benefit Delta Smelt, in addition to other habitat restoration (remainder of the 8,000 acres and 800 acres required under the USFWS [2008] SWP/CVP BiOp and DFG (2009) ITP, as well as Yolo Bypass restoration).
- The proposed work on cultured Delta Smelt (see Sections 3.3.15 and 3.3.16) includes the development of tools that may improve the efficacy and monitoring of different management actions. For example, recently developed cage methods should improve the ability to assess the effects of different operations, as well as other actions such as habitat restoration.
- The Rio Vista Estuarine Research Station (RVERS) is a proposed state and federal facility to consolidate and improve the current Bay-Delta science enterprise. The project is proposed in conjunction with the USFWS Fish Technology Center, a research facility for cultured fish and a future home for Delta Smelt refuge populations. The facility has the potential to greatly improve science support for the Bay-Delta, which in turn should create opportunities to better optimize Delta Smelt management. A limiting factor for RVERS construction is that the full federal cost share has not been secured. DWR proposes to provide funding beyond the current 50% level of state commitment, thereby facilitating faster construction of the project. Note that the RVERS and FTC have already been permitted through a separate state and federal environmental review process.

Delta outflow actions described above would provide positive effects on Delta Smelt. Additional spring Delta outflow would reduce South Delta exports, thereby reducing risk of larval/early juvenile take by entrainment (see Section 4.2.1.1 *Entrainment*), and also would reduce the potential for albeit uncertain Delta outflow-associated negative effects on food availability (*E. affinis* density in the low salinity zone). Additional summer outflow provided by the 100 TAF block of water would increase outflow relative to Existing Conditions if applied during August as described in Section 5.1.2, potentially providing positive effects such as increased *P. forbesi* subsidy to the low salinity zone, although this is uncertain (see Section 4.2.1.2 *Food Availability*).

5.3 LONGFIN SMELT

Applicable minimization and mitigation measures for the Proposed Project's potential take and effects on Longfin Smelt include entrainment protection, export reduction for spring Delta outflow, other measures such as cultured smelt studies and the Rio Vista Estuarine Research Station, habitat restoration, and take limits and measures from the USFWS (2019) ROC on LTO of the CVP and SWP Biological Opinion (Table 5-2). Additional description of some of these aspects is generally provided in Section 3 *Project Description*. The following are among the applicable minimization and mitigation measures:

- Old and Middle River Flow Management (see Section 3.3.1): specific entrainment minimization criteria for Longfin Smelt (see Section 3.3.1.1), plus ancillary protection that may occur as a result of criteria for other species;
- Barker Slough Pumping Plant (see Section 3.3.11): real-time restriction of diversions to 60 cfs from January 15 to March 31 during dry or critical water years when Longfin Smelt are found in Barker Slough;
- Clifton Court Forebay: use of appropriate collection gear for predatory fish (i.e., larger mesh nets to limit potential for incidental capture of Longfin Smelt; herbicide control of aquatic weeds within a window aimed to minimize overlap with Delta Smelt, which would also be protective of Longfin Smelt (see Table 3-4, Section 3.3.12.2).
- Habitat restoration: This includes the remainder of the 8,000 acres and 800 acres required under the USFWS (2008) SWP/CVP BiOp and the DFG (2009) ITP, Yolo Bypass restoration, and 396.3 acres of new tidal habitat restoration (see Section 5.1 *Introduction*)

Adaptively managed additional spring Delta outflow may reduce the potential for take of Longfin Smelt, as described in Section 4.2.2.2 *Delta Outflow-Abundance (Based on Nobriga and Rosenfield 2016)*.

5.4 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

Applicable minimization and mitigation measures for the Proposed Project's potential take and effects on Winter-run Chinook Salmon include entrainment protection, export reduction for spring Delta outflow, other measures such as Skinner Fish Facility Improvements and the Rio Vista Estuarine Research Station, habitat restoration, and take limits and measures from the NMFS (2019) ROC on LTO of the CVP and SWP Biological Opinion (Table 5-2). Additional description of some of these aspects is generally provided in Section 3 *Project Description*. The following are among the applicable minimization and mitigation measures:

- Old and Middle River Flow Management (see Section 3.3.1): various specific entrainment protection for Winter-run (see Section 3.3.1.1);
- Clifton Court Forebay (see Section 3.3.12): use of appropriate collection gear for predatory fish (i.e., larger mesh nets to limit potential for incidental capture of Winter-run Chinook Salmon; herbicide

control of aquatic weeds within a window aimed to minimize overlap with Delta Smelt, thereby also protecting Winter-run Chinook Salmon (see Table 3-4, Section 3.3.12.2);

- Habitat restoration: This includes the remainder of the 8,000 acres and 800 acres required under the USFWS (2008) SWP/CVP Biological Opinion and the DFG (2009) ITP, Yolo Bypass restoration, and new tidal habitat restoration (see Section 5.1 *Introduction*);
- As noted above, the Rio Vista Estuarine Research Station (RVERS) is a proposed state and federal facility to consolidate and improve the current Bay-Delta science enterprise. The project is proposed in conjunction with the USFWS Fish Technology Center, a research facility for cultured fish. The facility has the potential to greatly improve science support for the Bay-Delta, which in turn should create opportunities to optimize salmon management.

The adaptively managed additional spring Delta outflow measure would be achieved South Delta export reductions, which would reduce South Delta entrainment risk for any juvenile Winter-run Chinook Salmon occurring in the South Delta relative to the Proposed Project without the measure; as previously described, the seasonality and distribution of the species suggests that entrainment risk is low during the spring (see Section 4.2.3.2 *Outmigrating Juveniles*).

5.5 CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

Applicable minimization and mitigation measures for the Proposed Project's potential take and effects on Spring-run Chinook Salmon include entrainment protection, export reduction for spring Delta outflow, other measures such as Skinner Fish Facility Improvements and the Rio Vista Estuarine Research Station, habitat restoration, and take limits and measures from the NMFS (2019) ROC on LTO of the CVP and SWP Biological Opinion (Table 5-2). Additional description of some of these aspects is generally provided in Section 3, "Project Description." The following are among the applicable minimization and mitigation measures:

- Old and Middle River Flow Management (see Section 3.3.1): ancillary protection that may occur as a result of criteria for other species (see Section 3.3.1.1), plus incidental take would be required to be within protective criteria required by the NMFS (2019) BiOp on Long-term Operation of the Central Valley Project and the State Water Project;
- Export reduction for spring Delta outflow under adaptive management: operation to the SWP portion of the San Joaquin River I:E ratio would reduce South Delta exports and therefore entrainment risk for Spring-run Chinook Salmon;
- Clifton Court Forebay: use of appropriate collection gear for predatory fish (i.e., larger mesh nets to limit potential for incidental capture of Spring-run Chinook Salmon; herbicide control of aquatic weeds within a window aimed to minimize overlap with Delta Smelt, thereby also protecting Spring-run Chinook Salmon);
- Habitat restoration: This includes the remainder of the 8,000 acres and 800 acres required under the USFWS (2008) SWP/CVP BiOp and the DFG (2009) ITP, Yolo Bypass restoration, and new tidal habitat restoration, as described above in Section 5.1 *Introduction*.

- As noted above, the Rio Vista Estuarine Research Station (RVERS) is a proposed state and federal facility to consolidate and improve the current Bay-Delta science enterprise. The project is proposed in conjunction with the USFWS Fish Technology Center, a research facility for cultured fish. The facility has the potential to greatly improve science support for the Bay-Delta, which in turn should create opportunities to optimize salmon management.

6 ANALYSIS OF POTENTIAL FOR JEOPARDY

Permit regulations require an analysis of whether the activities covered by an incidental take permit (ITP) would jeopardize the continued existence of the species (14 CCR 783.2(a)(7)). A jeopardy analysis is provided for each species; this analysis evaluates the species' capability to survive and reproduce, and any adverse impacts of the taking on those capabilities in light of the following.

- Known population trends (described in Section 2, "*Covered Species*")
- Known threats to the species (described in Section 2, "*Covered Species*")
- Reasonably foreseeable impacts on the species from other related projects and activities.

This section describes the potential for take before implementation of minimization measures, the ways in which minimization measures will reduce the potential for take, and the reasons that issuance of the ITP is not expected to jeopardize the continued existence of each species. A discussion of cumulative effects is also included, thereby addressing reasonably foreseeable impacts on the species from other related projects and activities.

6.1 DELTA SMELT

The cumulative effects and potential to jeopardize the continued existence of Delta Smelt are presented below.

6.1.1 CUMULATIVE EFFECTS

6.1.1.1 SPECIFIC PROJECTS AND PROGRAMS

Continued operation of the CVP is the project with the greatest potential to affect Delta Smelt. The analyses described in Section 4.2.1 *Delta Smelt* consider the combined, cumulative effects of the SWP and CVP. Analyses specific to SWP facilities included particle tracking modeling for larval/early juvenile Delta Smelt entrainment. Similar to the results for entrainment into Clifton Court Forebay, results from this modeling suggested the potential for appreciable increases in entrainment into Jones Pumping Plant under the Proposed Project relative to the Existing Conditions scenario (Table 6-1). DSM2-PTM does not include real-time operational decision-making, modeling, and OMR management, which would be used by Reclamation and DWR to minimize entrainment at the CVP and SWP facilities, as required by the USFWS (2019) biological opinion (BiOp) for the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project. This would be expected to reduce the relative difference between scenarios suggested by DSM2-PTM because species-specific measures would be in place to minimize potential effects. In addition, the modeling of operations effects does not account for the inclusion of additional Delta outflow as minimization for effects of the Proposed Project in spring through SWP export curtailments by operating to the SWP proportional share of the SJR I:E ratio during April 1–May 31 (see Section 5.1.1 *Additional Spring Delta Outflow*), which would increase Delta outflow relative to the Proposed Project's results presented herein and would reduce the differences in South Delta exports suggested by the modeling of the Proposed Project and Existing Conditions scenarios; inclusion of this in DSM2-PTM modeling would be expected to reduce the suggested differences between Proposed Project and Existing Conditions scenarios in predicted entrainment. Actual management of larval/early juvenile Delta Smelt entrainment during implementation of the USFWS (2008) BiOp—i.e., what the Existing Conditions scenario essentially represents—limited entrainment well below authorized protective take limits. Whereas there may be greater take under the Proposed Project scenario than under the Existing Conditions scenario, entrainment would be kept to protective levels, consistent with the management required by the USFWS (2019) Biological Opinion.

Table 6-1. Percentage of Particles Entrained Over 30 Days into the Central Valley Project Jones Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	2.20	1.83	-0.37 (-17%)
March	Above Normal	3.57	3.01	-0.55 (-16%)
March	Below Normal	7.56	6.45	-1.11 (-15%)
March	Dry	11.94	10.01	-1.93 (-16%)
March	Critical	9.43	10.54	1.11 (12%)
April	Wet	0.79	1.63	0.84 (107%)
April	Above Normal	1.85	2.87	1.03 (56%)
April	Below Normal	4.21	5.41	1.20 (28%)
April	Dry	5.49	5.23	-0.26 (-5%)
April	Critical	4.84	4.31	-0.53 (-11%)
May	Wet	1.82	3.69	1.87 (103%)
May	Above Normal	3.19	7.96	4.77 (150%)
May	Below Normal	3.15	8.37	5.22 (166%)
May	Dry	5.82	8.30	2.48 (43%)
May	Critical	8.99	7.70	-1.29 (-14%)
June	Wet	9.56	9.67	0.11 (1%)
June	Above Normal	13.20	13.00	-0.20 (-2%)
June	Below Normal	16.01	16.07	0.06 (0%)
June	Dry	17.49	17.15	-0.35 (-2%)
June	Critical	12.12	11.04	-1.07 (-9%)

Other factors that may influence the cumulative effects of the combined SWP and CVP operations previously described in this section include:

- South Delta entrainment as a function of Old and Middle River flows (Section 4.2.1.1 *Entrainment*, subsection *Consideration of Old and Middle River Flows*);
- Food availability in spring (*E. affinis*) and summer/fall (*P. forbesi*) (Section 4.2.1.2 *Food Availability*, subsections discussing *Eggs and Larvae to Juveniles (March–June)* and *Juveniles to Subadults (June–September)*;
- Size and location of the low salinity zone (Section 4.2.1.5 *Size and Location of the Low Salinity Zone (Summer-Fall Delta Smelt Habitat Actions)*)

The proposed action described in the USFWS (2019) BiOp on Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project includes a number of components that have the potential to affect Delta Smelt, as described by USFWS (2019:29–

58); asterisks below indicate components that are also part of the Proposed Project, including components that are part of the Proposed Project including as minimization/mitigation measures):

- CVP- And SWP-Wide: Divert and Store Water Consistent With Obligations Under Water Rights and Decisions by the State Water Resources Control Board*
- Seasonal Operations*
- Minimum Export Rate*
- Delta Cross Channel Operations
- Agricultural Barriers*
- Contra Costa Water District Rock Slough Operations
- North Bay Aqueduct*
- Suisun Marsh Salinity Control Gates*
- Roaring River Distribution System*
- Morrow Island Distribution System*
- Water Transfers*
- Clifton Court Aquatic Weed Removal*
- OMR Management*
- Tracy Fish Collection Facility
- Skinner Fish Facility*
- Delta Cross Channel Gate Improvements
- Delta Smelt Summer-Fall Habitat Action*
- Clifton Court Predator Management*
- Sediment Supplementation Feasibility Study
- Sacramento Deepwater Ship Channel Food Study
- North Delta Food Subsidies/Colusa Basin Drain Study*
- Suisun Marsh and Roaring River Distribution System Food Subsidies Study*
- Intertidal and Associated Subtidal Habitat Restoration (Complete 8,000 acres from USFWS 2008 Biological Opinion)*
- Predator Hot Spot Removal
- Reintroduction Efforts for Delta Smelt
- Delta Fish Species Conservation Hatchery

Other water supply and water management projects could also affect Delta conditions and therefore affect Delta Smelt, including long-term and short-term water transfers and the Sites Reservoir Project and the Shasta Dam Raise and enlargement Project. Each of these would be subject to project-specific permitting analyses and, if necessary, full mitigation to meet CESA requirements. A number of habitat restoration projects beyond those described in Section 5, including projects under the California EcoRestore program, have the potential to positively affect Delta Smelt through increased food production. Minor negative effects from construction may also occur but would be minimized by implementation of construction best management practices.

Voluntary Agreements have the potential to benefit Delta Smelt through a combination of flow and non-flow projects. Voluntary Agreements would implement a combination of flow and non-flow projects. The largest change in outflow due to the Proposed Project would occur in April and May of most years and occasionally in November following wet and above-normal years. Voluntary Agreements would augment Delta outflow, particularly in spring, which, cumulatively with the proposed long-term SWP operations, may result in Delta outflow similar to or greater than baseline conditions in April and May of most water year types except wet water year types. The cumulative effects of the Voluntary Agreements have the potential to have positive effects on *E. affinis*, although as noted previously, there is uncertainty in the relationship of *E. affinis* with Delta outflow (X2) (Section 4.2.1.2 *Food Availability*, subsection discussing *Eggs and Larvae to Juveniles (March–June)*).

The proposed inclusion of additional Delta outflow beyond the levels included in the Proposed Project would minimize potential negative effects on Delta Smelt in spring. Delta outflow would be provided through SWP export curtailments by operating to the SWP proportional share of the SJR I:E ratio during April 1–May 31. The result would be to increase Delta outflow relative to the Proposed Project results presented in Section 4, "Analysis of Take and Effects."

6.1.1.2 Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain and kill many life stages of aquatic species, including Delta Smelt. However, the vast majority of private unscreened diversions in the Delta are small pipes in large channels that do not operate every day of the year. As a result, even where they do regularly co-occur with these diversions, Delta Smelt appear to have low vulnerability to entrainment (Nobriga et al. 2004). Most of the 370 water diversions operating in Suisun Marsh are likewise unscreened (Herren and Kawasaki 2001). However the two major Suisun Marsh distribution systems, both part of the SWP, divert most of the water into the marsh that is subsequently redistributed further by the many smaller diversions. Of the two SWP distribution systems, Roaring River is screened while Morrow Island is not. Delta Smelt entrainment into the Morrow Island Distribution system is very low due to high salinity in western Suisun Marsh (Enos et al. 2007); the effects of these systems on Delta Smelt was analyzed in Section 4.2.1.9 *Suisun Marsh Operations.*

New municipal water diversions in the Delta are routinely screened per biological opinions. Private irrigation diversions in the Delta are mostly unscreened but the total amount of water diverted onto Delta farms has remained very stable for decades (Culberson et al. 2008) so the cumulative impact should remain similar to baseline. Ongoing diversions of water within the project area (e.g., municipal and industrial uses, as well as diversions through intakes serving numerous small, private agricultural lands) are not likely to entrain very many Delta Smelt based on the results of a study by Nobriga et al. (2004). Nobriga et al. reasoned that the littoral location and low-flow operational characteristics of these diversions reduced their risk of entraining Delta Smelt. A study of the Morrow Island Distribution System by DWR produced similar results, with one demersal species and one species that associates with structural environmental features, together accounting for 97% to 98% percent of entrainment; only one Delta Smelt was observed to be entrained during the 2 years of the study (Enos et al. 2007).

6.1.1.3 Agricultural Practices

Farming occurs throughout the Delta adjacent to waterways used by Delta Smelt. Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman et al. 2014); however, wastewater treatment provides the bulk of ammonium loading, for example (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 and Moon 2004; Scholz et al. 2012). Discharges occurring outside the Delta that flow into the project area also contribute to cumulative effects of contaminant exposure.

6.1.1.4 Increased Urbanization

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 6-2 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 6-2. 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 6-3 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 6-3. Delta Communities Population, 2000 and 2010 – Tables 6-3a through 6-3e

Table 6-3a. Delta Communities Population, 2000 and 2010 – Contra Costa CountyCommunity	2000	2010	Average Annual Growth Rate 2000–2010
Antioch[1]	90,532	102,372	1.3%
Brentwood[1]	23,302	51,481	12.1%
Oakley[1]	25,619	35,432	3.8%
Pittsburg[1]	56,769	63,264	1.1%
Bay Point[2]	21,415	21,349	-0.0%
Bethel Island[2]	2,252	2,137	-0.5%
Byron[2]	884	1,277	4.5%
Discovery Bay[2]	8,847	13,352	5.1%
Knightsen[2]	861	1,568	8.2%

Table 6-3b. Delta Communities Population, 2000 and 2010 – Sacramento County

Community	2000	2010	Average Annual Growth Rate 2000–2010
Isleton[1]	828	804	-0.3%
Sacramento[1]	407,018	466,488	1.5%
Courtland[2]	632	355	-4.4%
Freeport and Hood[2]	467	309[3]	-3.4%
Locke[2]	1,003	Not available	—
Walnut Grove[2]	646	1,542	13.9%

Table 6-3c. Delta Communities Population, 2000 and 2010 – San Joaquin County

Community	2000	2010	Average Annual Growth Rate 2000–2010
Lathrop[1]	10,445	18,023	7.3%
Stockton[1]	243,771	291,707	2.0%
Tracy[1]	56,929	82,922	4.6%
Terminous[2]	1,576	381	-7.6%

Table 6-3d. Delta Communities Population, 2000 and 2010 – Solano County

Community	2000	2010	Average Annual Growth Rate 2000–2010
Rio Vista[1]	4,571	7,360	6.1%

Table 6-3e. Delta Communities Population, 2000 and 2010 – Yolo County

Community	2000	2010	Average Annual Growth Rate 2000–2010
West Sacramento[1]	31,615	48,744	5.4%
Clarksburg[2]	681	418	-3.9%

[1] Incorporated Cities and Towns
[2] Small or Unincorporated Communities
[3] Freeport had a population of 38; Hood had a population of 271.
Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth has the potential to place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Negative effects on Delta Smelt and their habitat may result from urbanization-induced point and non-point source chemical contaminant discharges. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Increased urbanization may also result in increased recreational activities in the region.

6.1.1.5 Waste Water Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of the magnitude of their discharge of ammonia. The Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L total ammonia nitrogen) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day. A study by Werner et al. (2008) concluded that ammonia concentrations present in the Sacramento River below the SRWTP are not acutely toxic to 55-day-old Delta Smelt. However, based on information provided by U.S. Environmental Protection Agency (1999) and other related studies, it is possible that concentrations below the SRWTP may be chronically toxic to Delta Smelt and other sensitive fish species (Werner et al. 2010). In 2010 the same group conducted three exposure experiments to measure the effect concentration of SRWTP effluent. No significant effects of effluent on the survival of larval Delta Smelt or Rainbow Trout was found. More recent studies (which used concentrations of ammonia higher than typically experienced by Delta Smelt) have shown that Delta Smelt that are exposed to ammonia exhibit membrane destabilizations. This results in increased membrane permeability and increased susceptibility to synergistic effects of multi-contaminant exposures (Connon et al. 2009; Hasenbein et al. 2014). Results are unclear at this time as to what the effect of ammonia exposure is on Delta Smelt, and research is ongoing. EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Studies are ongoing to further determine the effect of ammonia on Delta Smelt and other fish populations. The Freeport location of the SRCSD discharge places it upstream of the confluence of Cache Slough and the mainstem Sacramento River, a location just upstream of where Delta Smelt have been observed to congregate in recent years during the spawning season. The potential for exposure of a substantial fraction of Delta Smelt spawners to elevated ammonia levels has heightened the importance of this investigation.

In addition to concerns about direct toxicity of ammonia to Delta Smelt, another important concern is that ammonium inputs have suppressed diatom blooms in the Delta and Suisun Bay, thereby reducing productivity in the Delta Smelt food web. The IEP MAST Team (2015: 71) provided the following summary: “Dugdale et al. (2007) and Wilkerson et al. (2006) found that high ammonium concentrations prevented the formation of diatom blooms but stimulated flagellate blooms in the lower estuary. They propose that this occurs because diatoms preferentially utilize ammonium in their physiological processes even though it is used less efficiently and at high concentrations ammonium can prevent uptake of nitrate (Dugdale et al. 2007). Thus, diatom populations must consume available ammonium before nitrate, which supports higher growth rates, can be utilized or concentrations of ammonium need to be diluted. A recent independent review panel (Reed et al. 2014) found that there is good evidence for preferential uptake of ammonium and sequential uptake of first ammonium and then nitrate, but that a large amount of uncertainty remains regarding the growth rates on ammonium relative to nitrate and the role of ammonium in suppressing spring blooms.”

The IEP MAST Team (2015: 71-72) further discussed this issue as follows: “Glibert (2012) analyzed long-term data (from 1975 or 1979 to 2006 depending on the variable considered) from the Delta and Suisun Bay and related changing forms and ratios of nutrients, particularly changes in ammonium, to declines in diatoms and increases in flagellates and cyanobacteria. Similar shifts in species composition were noted by Brown (2009), with loss of diatom species, such as *Thalassiosira* sp., an important food for calanoid copepods, including *Eurytemora affinis* and *Sinocalanus doerri* (Orsi 1995). More recently, Parker *et al.* (2012) found that the region where blooms are suppressed extends upstream into the Sacramento River to the SRWTP, the source of the majority of the ammonium in the river (Jassby 2008). Parker *et al.* (2012) found that at high ambient ammonium concentrations, river phytoplankton cannot efficiently take up any form of nitrogen including ammonium, leading to often extremely low biomass in the river. A study using multiple stable isotope tracers (Lehman *et al.* 2014) found that the cyanobacteria *M. aeruginosa* utilized ammonium, not nitrate, as the primary source of nitrogen in the central and western Delta. In 2009, the ammonia concentration in effluent from SRWTP was reduced by approximately 10%, due to changes in operation (K. Ohlinger, Sacramento Regional County

Sanitation District, personal communication cited in ICF International 2016). In spring 2010 unusually strong spring diatom blooms were observed in Suisun Bay that co-occurred with low ammonia concentrations (Dugdale et al. 2013)." It has been suggested, based on consideration of ammonium loading into Suisun Bay, that with reduced discharge of ammonium as a result of the upgrades to the SRWTP, the food web could respond positively (Dugdale et al. 2013), which could provide a benefit to Delta Smelt.

Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the Estuary frequented by Delta Smelt and its recent upgrades suggest any potential effects would be limited.

6.1.1.6 Other Activities

Other future actions within the project area that are likely to occur and have the potential to negatively affect Delta Smelt and their 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; federal, state, or local levee maintenance, and maintenance of shipping channels with dredging that may also destroy or negatively affect habitat and interfere with natural, long-term habitat-maintaining processes.

6.1.1.7 Climate Change

Climate change and associated sea level rise have considerable potential to negatively affect Delta Smelt. These drivers may affect water temperature, and also the location and extent of the low salinity zone, which constitutes much of the rearing habitat for juvenile Delta Smelt. Effects on water temperature are relatively independent of water operations, and are mainly driven by climate (USFWS 2017:274). Location of the low salinity zone, however, is also dependent on water operations (e.g., see discussion in the *Qualitative Analysis* subsection of Section 4.2.1.5 *Size and Location of the Low Salinity Zone (Summer-Fall Delta Smelt Habitat Actions)*).

An analysis of plausible temperature change scenarios by Brown et al. (2016) found that over the time scale of the Proposed Project operations (i.e., up to 2029), there would be some changes in temperature-related habitat availability during time periods of importance for Delta Smelt, with the extent of these changes varying depending on the climate change scenario analyzed. Brown et al.'s (2016) analysis included a number of locations, the results for which are summarized in their Tables S1, S2, S3, S4, S5, and S6 of the supplemental material to their study. They reported the decadal (2010-2019, 2020-2029, 2030-2039, etc.) annual median, minimum, and maximum values for a number of important variables, including the number of days per year when mean daily water temperature is ≥ 27°C, the chronic lethal temperature for juveniles; the number of days per year when mean daily water temperature is ≥ 24°C, the temperature for onset of physiological thermal stress for juveniles; the duration (days per year) of the spawning window (15-20°C); the Julian date of the beginning of the spawning window (15-20°C); the Julian date of the beginning of the maturation window (last day of 24°C to beginning of spawning window); and the duration of the maturation window (number of days from last day of 24°C to beginning of spawning window). Given the timeline for operations of the

Proposed Project (2020–2029), of most relevance to consideration of the cumulative effects are the first three decades of the analysis by Brown et al. (2016), i.e., 2010-2019, 2020-2029, and 2030-2039.

Based on the existing distribution of Delta Smelt, perhaps the most representative locations for consideration from the analysis of Brown et al. (2016) are in the lower San Joaquin River (Prisoners Point, Jersey Point, and Antioch), the Sacramento River (Hood, Rio Vista, and Decker Island), the North Delta (upper Cache Slough, Miner Slough, Liberty Island, and the Sacramento Deep Water Ship Channel), the Sacramento-San Joaquin River confluence (Mallard Island), and Suisun Bay (Martinez), as shown in Tables 6-4 to 6-9 (see also Figure 1 of Brown et al. [2016]). The main trends in these projections are as follows, based on a comparison of the current decade (2010-2019) to the decade including operations of the Proposed Project (2020-2029):

- Number of days per year with chronic lethal maximum temperature (≥ 27°C) for juveniles (June-December) (Table 6-4)
  - There is generally little difference to no difference between 2010-2019 and 2020-2029, except at Jersey Point, Antioch (most warming scenario), and Liberty Island, where maxima tend to increase.
- Number of days per year with onset of physiological thermal stress (≥ 24°C) for juveniles (June-December) (Table 6-5)
  - There is generally greater frequency in 2020-2039 than in 2010-2019, throughout much of the range.
  - However, this is not the case for the confluence and Suisun Bay in the least warming scenario (no difference).
  - For the most warming scenario, the median number of stressful days increases in some important existing portions of the species' range, e.g., from around 40 days to 47 to 48 days at Rio Vista/Decker Island and from 18 days to 35 days at Mallard Island.
- Number of days per year within the spawning window (15-20°C) for adults (Table 6-6):
  - For the least warming scenario, there generally is little difference between 2010–2019 and 2020–2029.
  - For the most warming scenario, the minimum number of days decreases at all locations, whereas the maximum number of days generally is similar or different by a few days, except for the Deepwater Ship Channel (16 days less); however, the median number of days has limited difference at all locations.
- Julian date of the beginning of the spawning window for adults (Table 6-7):
  - There is generally little difference between 2010-2019 and 2020-2029.

Table 6-4. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 27°C (chronic lethal maximum temperature), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-4a and 6-4b

Table 6-4a. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 27°C (chronic lethal maximum temperature), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the least-warming (PCM-B1) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	0	0	8	0	0	0	0	0	11
San Joaquin River	Jersey Point	0	0	0	0	0	3	0	0	12
San Joaquin River	Antioch	0	0	16	0	0	6	0	0	17
Sacramento River	Hood	0	0	0	0	0	0	0	0	0
Sacramento River	Rio Vista	0	0	5	0	0	0	0	0	5
Sacramento River	Decker Island	0	0	0	0	0	0	0	0	0
North Delta	Upper Cache Slough	0	0	0	0	0	0	0	0	0
North Delta	Miner Slough	0	0	0	0	0	0	0	0	0
North Delta	Liberty Island	0	0	0	0	0	5	0	0	15
North Delta	Deepwater Ship Channel	0	0	0	0	0	0	0	0	0
Confluence	Mallard Island	0	0	0	0	0	0	0	0	0
Suisun Bay	Martinez	0	0	0	0	0	0	0	0	0

Table 6-4b. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 27°C (chronic lethal maximum temperature), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the most-warming (GFDL-A2) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	0	0	7	0	0	7	4.5	0	12
San Joaquin River	Jersey Point	0	0	5	0	0	16	0	0	12
San Joaquin River	Antioch	0	0	11	0	0	21	7.5	0	14
Sacramento River	Hood	0	0	0	0	0	0	0	0	5
Sacramento River	Rio Vista	0	0	3	0	0	3	0	0	7

Sacramento River	Decker Island	0	0	0	0	0	0	0	0	5
North Delta	Upper Cache Slough	0	0	0	0	0	0	0	0	0
North Delta	Miner Slough	0	0	0	0	0	0	0	0	0
North Delta	Liberty Island	0.5	0	10	0	0	12	5	0	15
North Delta	Deepwater Ship Channel	0	0	3	0	0	2	0	0	5
Confluence	Mallard Island	0	0	0	0	0	0	0	0	1
Suisun Bay	Martinez	0	0	0	0	0	0	0	0	0

Table 6-5. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 24°C (onset of physiological thermal stress), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-5a and 6-5b

Table 6-5a. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 24°C (onset of physiological thermal stress), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the least-warming (PCM-B1) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	36.5	8	69	44.5	20	69	51	34	86
San Joaquin River	Jersey Point	61.5	13	79	56.5	36	83	69	54	91
San Joaquin River	Antioch	29.5	0	65	37.5	7	57	35.5	13	69
Sacramento River	Hood	7.5	0	55	10	0	41	6.5	0	43
Sacramento River	Rio Vista	14	0	58	22.5	1	47	18.5	0	50
Sacramento River	Decker Island	29	0	63	42	6	63	41.5	23	71
North Delta	Upper Cache Slough	0	0	13	0	0	29	0	0	37
North Delta	Miner Slough	2.5	0	24	4	0	37	2.5	0	39
North Delta	Liberty Island	28	0	46	37	8	56	37.5	13	68
North Delta	Deepwater Ship Channel	11.5	0	32	17	0	44	14.5	0	46
Confluence	Mallard Island	0	0	36	0	0	29	0	0	34
Suisun Bay	Martinez	0	0	9	0	0	0	0	0	7

Table 6-5b. Median, minimum, and maximum values for the number of days each year when mean daily water temperature is ≥ 24°C (onset of physiological thermal stress), during each decade from 2010-2039, for the juvenile life stage of Delta Smelt (June-December) for the most-warming (GFDL-A2) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	66.5	35	98	68	63	104	82.5	57	93
San Joaquin River	Jersey Point	69.5	23	104	70.5	57	113	79.5	60	98
San Joaquin River	Antioch	57	21	93	63.5	55	100	74.5	49	88
Sacramento River	Hood	26.5	2	56	43	18	86	45.5	27	76
Sacramento River	Rio Vista	40.5	18	62	48.5	33	90	55.5	38	82
Sacramento River	Decker Island	42	5	67	46.5	18	94	64	39	83
North Delta	Upper Cache Slough	9	0	22	8.5	0	62	17.5	0	43
North Delta	Miner Slough	13.5	0	28	17	0	66	24	3	57
North Delta	Liberty Island	36	8	61	42.5	25	88	54	37	78
North Delta	Deepwater Ship Channel	18.5	0	50	27	4	76	33	19	70
Confluence	Mallard Island	17.5	0	48	35	9	82	29.5	16	71
Suisun Bay	Martinez	0	0	13	0	0	40	10	0	23

Table 6-6. Median, minimum, and maximum values for the duration (number of days each year) of the spawning window (15-20°C), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-6a and 6-6b.

Table 6-6a. Median, minimum, and maximum values for the duration (number of days each year) of the spawning window (15-20°C), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	53.5	41	74	51.0	43	68	38.0	32	64
San Joaquin River	Jersey Point	56.5	36	65	52.0	36	70	50.5	30	88
San Joaquin River	Antioch	57.5	42	72	55.5	42	70	44.5	31	65
Sacramento River	Hood	57.0	21	64	47.0	35	70	50.5	25	87
Sacramento River	Rio Vista	57.0	21	64	47.0	35	70	52.0	29	87
Sacramento River	Decker Island	57.5	25	66	51.5	36	72	63.0	31	88

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
North Delta	Upper Cache Slough	55.0	26	64	58.5	33	73	48.0	32	68
North Delta	Miner Slough	57.0	34	65	53.5	34	72	51.0	30	68
North Delta	Liberty Island	57.5	27	65	53.5	34	72	48.5	29	67
North Delta	Deepwater Ship Channel	57.0	40	65	57.0	38	71	46.0	31	65
Confluence	Mallard Island	58.5	40	66	58.5	36	74	63.0	31	89
Suisun Bay	Martinez	59.5	26	72	60.5	38	79	72.0	34	90

Table 6-6b. Median, minimum, and maximum values for the duration (number of days each year) of the spawning window (15-20°C), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the most-warming ((GFDL-A2) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	54.0	33	79	52.5	19	82	50.0	25	58
San Joaquin River	Jersey Point	47.5	28	72	46.0	23	66	46.5	15	58
San Joaquin River	Antioch	53.5	29	80	54.0	22	87	50.0	21	58
Sacramento River	Hood	42.0	28	68	44.5	23	67	39.5	20	59
Sacramento River	Rio Vista	42.5	28	70	45.0	22	66	39.5	20	58
Sacramento River	Decker Island	48.0	33	70	51.5	22	71	41.0	20	80
North Delta	Upper Cache Slough	50.0	27	72	45.5	22	72	42.0	17	58
North Delta	Miner Slough	42.5	28	71	47.5	22	69	45.0	18	58
North Delta	Liberty Island	43.0	27	71	46.5	23	67	44.0	11	65
North Delta	Deepwater Ship Channel	52.0	27	82	46.5	16	66	44.0	18	58
Confluence	Mallard Island	51.5	32	73	54.0	23	71	46.5	21	83
Suisun Bay	Martinez	59.0	38	90	63.0	24	80	51.5	22	94

Table 6-7. Median, minimum, and maximum values for the julian date of the beginning of the spawning window (15-20°C) each year, during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-7a and 6-7b

Table 6-7a. Median, minimum, and maximum values for the julian date of the beginning of the spawning window (15-20°C) each year, during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	86.0	82	97	90.0	81	111	89.0	69	94
San Joaquin River	Jersey Point	100.0	86	109	98.0	92	116	97.0	80	108
San Joaquin River	Antioch	93.0	83	104	93.5	84	113	94.5	69	106
Sacramento River	Hood	101.5	88	126	100.5	93	118	101.0	82	111
Sacramento River	Rio Vista	101.5	88	126	100.5	93	117	100.5	82	109
Sacramento River	Decker Island	102.5	89	127	105.0	93	119	101.5	82	112
North Delta	Upper Cache Slough	100.5	83	117	96.0	84	118	94.0	68	103
North Delta	Miner Slough	100.5	84	110	97.5	91	117	95.0	80	108
North Delta	Liberty Island	101.0	85	117	100.0	92	118	97.5	81	109
North Delta	Deepwater Ship Channel	97.0	83	106	95.5	84	113	94.0	68	102
Confluence	Mallard Island	101.0	86	110	100.0	92	117	97.5	81	109
Suisun Bay	Martinez	101.5	88	127	100.5	93	119	101.0	81	111

Table 6-7b. Median, minimum, and maximum values for the julian date of the beginning of the spawning window (15-20°C) each year, during each decade from 2010-2039, for the adult life stage of Delta Smelt for the most-warming (GFDL-A2) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	82.5	75	99	84.5	70	105	86.5	81	96
San Joaquin River	Jersey Point	93.0	79	112	96.5	78	109	98.5	85	119
San Joaquin River	Antioch	89.5	77	105	86.0	72	108	91.0	82	103
Sacramento River	Hood	98.0	82	113	101.0	92	110	103.0	88	120
Sacramento River	Rio Vista	97.0	81	113	100.5	92	110	103.0	88	120
Sacramento River	Decker Island	99.0	82	114	101.5	92	111	104.5	89	124

North Delta	Upper Cache Slough	94.5	76	112	96.5	67	109	95.0	84	119
North Delta	Miner Slough	95.5	78	112	98.0	70	109	95.0	85	119
North Delta	Liberty Island	96.5	79	113	100.5	78	109	99.0	86	120
North Delta	Deepwater Ship Channel	90.5	76	112	95.5	67	108	92.5	84	119
Confluence	Mallard Island	95.5	79	113	98.5	78	110	99.5	86	120
Suisun Bay	Martinez	97.0	80	113	101.0	79	110	103.5	88	124

Table 6-8. Median, minimum, and maximum values for the julian date of the beginning of the maturation window (last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-8a and 6-8b.

Table 6-8a. Median, minimum, and maximum values for the julian date of the beginning of the maturation window (last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) climate change scenarios examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	247.5	205	269	251.0	227	274	253.5	237	270
San Joaquin River	Jersey Point	255.0	204	275	259	236	277	259.5	252	292
San Joaquin River	Antioch	246.0	200	269	251.5	227	275	256.0	236	291
Sacramento River	Hood	223.0	210	235	223.0	212	249	230.0	216	267
Sacramento River	Rio Vista	233.5	196	250	248.5	225	273	246.0	223	269
Sacramento River	Decker Island	236.0	217	252	247.5	222	273	250.0	224	277
North Delta	Upper Cache Slough	206.0	205	227	214.5	200	233	227.0	202	264
North Delta	Miner Slough	218.0	197	230	212.5	198	236	212.0	198	250
North Delta	Liberty Island	235.0	213	256	246.5	224	274	250.0	226	291
North Delta	Deepwater Ship Channel	221.5	199	234	219.0	211	237	222.0	204	265
Confluence	Mallard Island	220.5	199	234	220.0	210	237	219.0	199	266
Suisun Bay	Martinez	205.0	199	211	228.5	226	231	224.0	224	224

Table 6-8b. Median, minimum, and maximum values for the julian date of the beginning of the maturation window (last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the most-warming (GFDL-A2) climate change scenario examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	260.5	224	280	256.5	236	278	251.5	234	265
San Joaquin River	Jersey Point	264.0	217	278	264.0	251	285	260.5	240	279
San Joaquin River	Antioch	261.0	217	282	257.0	236	279	251.5	234	277
Sacramento River	Hood	232.5	207	262	249.5	216	276	236.0	216	251
Sacramento River	Rio Vista	252.5	215	280	251.0	226	277	248.0	231	263
Sacramento River	Decker Island	246.5	215	270	253.0	235	281	251.5	235	265
North Delta	Upper Cache Slough	215.0	207	260	222.5	207	276	227.0	198	248
North Delta	Miner Slough	216.0	210	260	222.0	214	259	227.0	199	249
North Delta	Liberty Island	252.5	208	273	253.0	217	281	249.5	228	264
North Delta	Deepwater Ship Channel	221.0	212	261	241.0	215	276	230.5	214	250
Confluence	Mallard Island	226.0	216	262	235.5	215	276	229.0	213	251
Suisun Bay	Martinez	211.5	198	236	210.5	187	258	224.0	197	227

Table 6-9. Median, minimum, and maximum values for the duration of the maturation window (number of days from last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) and most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016) – Tables 6-9a and 6-9b.

Table 6-9a. Median, minimum, and maximum values for the duration of the maturation window (number of days from last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the least-warming (PCM-B1) climate change scenarios examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	202.0	185	243	208.5	188	243	194.0	173	213
San Joaquin River	Jersey Point	211.0	178	262	206.5	182	226	192.5	165	218
San Joaquin River	Antioch	203.0	188	255	212.0	194	245	188.0	168	228
Sacramento River	Hood	245.0	231	268	241.0	211	258	243.5	189	258
Sacramento River	Rio Vista	234.0	202	267	225.5	206	255	207.0	187	248
Sacramento River	Decker Island	235.5	218	243	233.5	203	261	214.5	179	246
North Delta	Upper Cache Slough	264.0	236	276	243.0	226	264	230.5	189	265
North Delta	Miner Slough	249.0	230	276	249.5	226	272	244.5	208	265
North Delta	Liberty Island	223.5	218	268	219.5	190	255	215.5	154	233
North Delta	Deepwater Ship Channel	235.0	228	264	239.0	222	264	226.0	188	262
Confluence	Mallard Island	249.0	234	262	244.0	222	268	247.0	193	266
Suisun Bay	Martinez	255.0	255	255	238.0	229	247	221.0	221	221

Table 6-9b. Median, minimum, and maximum values for the duration of the maturation window (number of days from last day of 24°C to beginning of spawning window), during each decade from 2010-2039, for the adult life stage of Delta Smelt for the most-warming (GFDL-A2) climate change scenarios examined by Brown et al. (2016)

Area	Location	2010-2019 Median	2010-2019 Minimum	2010-2019 Maximum	2020-2029 Median	2020-2029 Minimum	2020-2029 Maximum	2030-2039 Median	2030-2039 Minimum	2030-2039 Maximum
San Joaquin River	Prisoners Point	188.0	174	223	185.5	166	208	198.5	192	220
San Joaquin River	Jersey Point	193.0	176	259	195.5	180	207	198.5	174	220
San Joaquin River	Antioch	194.0	173	232	189.0	168	209	203.5	175	221
Sacramento River	Hood	237.0	198	260	222.0	192	250	229.5	210	256
Sacramento River	Rio Vista	225.0	185	237	209.0	188	237	219.0	205	232

Sacramento River	Decker Island	216.0	187	263	209.5	185	229	213.5	201	239
North Delta	Upper Cache Slough	239.0	201	269	227.5	194	253	236.0	210	260
North Delta	Miner Slough	240.0	202	266	230.0	195	256	232.0	210	253
North Delta	Liberty Island	215.0	178	263	213.5	189	233	212.5	201	233
North Delta	Deepwater Ship Channel	225.5	200	264	218.5	193	231	221.0	205	249
Confluence	Mallard Island	231.5	195	261	221.5	191	252	231.5	210	255
Suisun Bay	Martinez	257.0	223	267	253.0	200	281	246.5	233	271

- Julian date of the beginning of the maturation window (last day of 24°C to beginning of spawning window) for adults (Table 6-8):
  - This generally occurs later in the year, although is variable by location.
- Duration of the maturation window (number of days from last day of 24°C to beginning of spawning window) for adults (Table 6-9):
  - The results vary by location in the comparison between 2010-2019 and 2030-2039, with some locations having little difference (e.g., Decker Island under a least warming scenario, comparing medians), with others having greater difference (e.g., 10 fewer days at Mallard Island under the most warming scenario).

Overall, the results from Brown et al. (2016) suggest that there is the potential for increased thermal stress on juvenile and adult Delta Smelt from climate change effects within the 2020–2029 period of Proposed Project operations. This could negatively affect the Delta Smelt population through habitat compression for juveniles, as juveniles move away from stressful conditions; and reduced fecundity for adults, as fecundity is positively related to fish length, which may be lessened by the shorter maturation period (i.e., less time for growth). This concern is a key rationale for some of the previously-described habitat measures (e.g., Summer-Fall Flow Action) to maximize the distribution of Smelt, thereby spreading risk across different geographic locations.

6.1.2 Potential to Jeopardize the Species

The issuance of the ITP will not jeopardize the continued existence of Delta Smelt for the following reasons.

6.1.2.1 Level of Take

As described in Section 4, "Analysis of Take and Effects," the overall potential for take of Delta Smelt individuals by the Proposed Project is high, but the potential take would be limited to a low proportion of the population. Covered activities have a high likelihood of mortality of individuals. The principal means of potential take is by direct entrainment at the SWP intakes (CCF and Barker Slough Pumping Plant), with additional smaller levels of take potentially occurring in association with activities such as maintenance (Table 5-2). Entrainment would be the primary mechanism for take. Therefore, take would be expected to be low, i.e., in the low single-digit percentage of the population (e.g., for adult Delta Smelt, <5% of the population, as discussed in Section 4.2.1.1 *Entrainment*).

6.1.2.2 Minimization and Mitigation Measures

Minimization and mitigation measures applicable to Delta Smelt were discussed in Section 5.2 *Delta Smelt* (see also Table 5-2). Among the main measures are proposed entrainment protections, adaptively managed Delta outflow actions, summer-fall Delta Smelt habitat actions, habitat restoration, and items related to the USFWS (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley and State Water Project Biological Opinion (Table 5-2).

6.1.2.3 Conclusion

Considering the level of take, the minimization and mitigation measures outlined in Section 5, "Take and Effect Minimization and Mitigation Measures, together with known population trends and threats to the species (see Section 2.1 *Delta Smelt*), and reasonably foreseeable impacts on the species from other related projects and activities (see Section 6.1.1 *Cumulative Effects*), the issuance of the ITP for the covered activities will not jeopardize the continued existence of Delta Smelt.

6.2 LONGFIN SMELT

6.2.1 Cumulative Effects

The CVP has the potential to cumulatively affect Longfin Smelt together with the SWP. A number of analyses previously described in Section 4.2.2 *Longfin Smelt* reflected the combined, cumulative effects of the SWP and CVP. Analyses specific to SWP facilities included particle tracking modeling for larval Longfin Smelt entrainment. Similar to results for entrainment into CCF, the PTM modeling suggested that there would be limited differences between the Existing Conditions and Proposed Project scenarios in terms of entrainment to the CVP's Jones Pumping Plant (Tables 6-10 and 6-11), with the same general pattern being evident when focusing only on the seven stations analyzed by DFG (2009a); see Appendix D, Section D.3.1.4.

Table 6-10. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into the Central Valley Project Jones Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.54	0.51	-0.04 (-7%)
January	Above Normal	1.01	1.06	0.05 (4%)
January	Below Normal	1.64	1.68	0.04 (2%)
January	Dry	2.47	2.57	0.10 (4%)
January	Critical	2.80	2.76	-0.04 (-2%)
February	Wet	0.29	0.26	-0.03 (-11%)
February	Above Normal	0.64	0.62	-0.02 (-3%)
February	Below Normal	0.94	0.98	0.03 (4%)
February	Dry	1.63	1.70	0.08 (5%)
February	Critical	2.33	2.35	0.02 (1%)
March	Wet	0.23	0.16	-0.06 (-27%)
March	Above Normal	0.41	0.28	-0.13 (-32%)
March	Below Normal	0.77	0.53	-0.24 (-31%)
March	Dry	1.21	0.88	-0.33 (-27%)
March	Critical	1.23	1.37	0.14 (11%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table 6-11. Percentage of Surface-Oriented Particles Entrained Over 45 Days into the Central Valley Project Jones Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.06	2.84	-0.21 (-7%)
January	Above Normal	6.18	6.08	-0.10 (-2%)
January	Below Normal	9.40	9.15	-0.25 (-3%)
January	Dry	12.40	12.34	-0.06 (0%)
January	Critical	13.84	12.81	-1.03 (-7%)
February	Wet	1.63	1.41	-0.22 (-14%)
February	Above Normal	4.05	3.76	-0.30 (-7%)
February	Below Normal	6.05	5.74	-0.30 (-5%)
February	Dry	9.85	9.55	-0.30 (-3%)
February	Critical	11.53	11.87	0.34 (3%)
March	Wet	1.37	1.37	0.00 (0%)
March	Above Normal	2.35	2.00	-0.35 (-15%)
March	Below Normal	5.08	4.59	-0.50 (-10%)
March	Dry	7.93	6.85	-1.08 (-14%)
March	Critical	8.05	8.35	0.30 (4%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat

Other potential cumulative factors reflecting combined SWP and CVP operations previously described in this section include:

- Juvenile South Delta entrainment as a function of Old and Middle River flows (Subsection on *Juvenile Salvage-Old and Middle River Flow Analysis (Based on Grimaldo et al. 2009)*);
- Delta outflow-abundance (Section 4.2.2.2 Delta Outflow-Abundance (Based on Nobriga and Rosenfield 2016))

As described for Delta Smelt, a number of other water supply and water management projects potentially could affect Delta conditions and therefore Longfin Smelt, including long-term and short-term water transfers and the Sites Reservoir Project and Shasta Dam Enlargement Project. Each of these would be subject to their own permitting analyses and to meet CESA requirements, including full mitigation. A number of habitat restoration projects beyond those described in Section 5, including projects under the California EcoRestore program, have the potential to positively affect Longfin Smelt, depending on location in relation to typical Longfin Smelt distribution, by increasing food availability, for example.

As described for Delta Smelt, Voluntary Agreements are proposed to increase Delta outflow, including in the spring, which may have the potential to benefit Longfin Smelt given the correlation between juvenile survival and Delta outflow (Nobriga and Rosenfield 2016), although there is appreciable uncertainty in the predictive nature of the relationship given the variability (low signal to noise; see Figure 4-54 and Table 4-9).

Other cumulative effects discussed for Delta Smelt in Section 4.6.1.1 *Cumulative Effects* also are relevant to Longfin Smelt. These include effects from water diversions, agricultural practices, increased urbanization, waste water treatment plants, and various other activities, such as dumping of garbage and oil and gas development and production. In addition, Longfin Smelt are known to be taken by commercial Bay Shrimp fisheries, although the take appears to be limited to approximately a few percent of the population (ICF International 2016:4-294).

In contrast to Delta Smelt, there have been no quantitative projections of potential climatic effects on Longfin Smelt at the broad, estuary-wide scale. However, there has been examination of climate variability effects on fluctuations in fish communities in the San Francisco Estuary, with Longfin Smelt among the key species differentiating climatic regimes propagating from both the land (outflow) and the ocean (North Pacific Gyre Oscillation, NPGO) (Feyrer et al. 2015). Age-0 and age-1 Longfin Smelt were found in higher abundance during the high outflow regime, so that future conditions with decreased precipitation and outflow could potentially negatively affect Longfin Smelt (Feyrer et al. 2015). Age-0 Longfin Smelt abundance was greater during the warm NPGO regime, so that cooler conditions (positive NPGO values) could negatively affect populations of Longfin Smelt (Feyrer et al. 2015); however, expected changes to the North Pacific Ocean are uncertain and may include increased temperature (Furtado et al. 2011, as cited by Feyrer et al. 2015:3618). Thus climate change could produce mixed effects on Longfin Smelt, particularly with respect to rising sea level potentially changing the distribution of the species within the Bay-Delta, and associated effects on outflow from shifts in the timing of precipitation (more rain compared snowmelt). Within the Bay-Delta, increasing water temperature because of climate change could reduce the amount of habitat available for larvae and small juveniles, which are rarely found in water warmer than 22°C (DFG 2009b). Jeffries et al. (2016) examined physiological performance in larval/young juvenile Longfin Smelt and Delta Smelt in relation to water temperature in a laboratory study. They found that Longfin Smelt exhibited a pronounced cellular stress response, with an upregulation of heat shock proteins, after exposure to 20°C water; such a response was not observed in Delta Smelt. They also detected an increase in metabolic rate in Delta Smelt at 20°C and increased expression of genes involved in metabolic processes and protein synthesis, with such patterns not observed in Longfin Smelt. Jeffries et al. (2016) concluded that Longfin Smelt may be more susceptible than Delta Smelt to increases in temperature, and therefore that Longfin Smelt may have little tolerance for future warming in California under climate change.

6.2.2 Potential to Jeopardize the Species

The issuance of the ITP will not jeopardize the continued existence of Longfin Smelt for the following reasons.

6.2.2.1 Level of Take

As described in Section 4, "Analysis of Take and Effects," the overall potential for take of individual Longfin Smelt by the Proposed Project is high, but take would be limited to a low proportion of the population. Covered activities have a high likelihood of mortality of individuals. The principal means of potential take is by direct entrainment at the SWP intakes (the CCF and Barker Slough Pumping Plant). As illustrated by the analyses in this Section 4, take would be expected to be relatively low, i.e., in the low single digit percentage of the population or lower, and would be managed with OMR flow criteria for Longfin Smelt (Section 4.2.2.1 *Entrainment*).

6.2.2.2 Minimization and Mitigation Measures

Minimization and mitigation measures applicable to Longfin Smelt are discussed in Section 5.3 *Longfin Smelt* (see also Table 5-2). Among the main measures are proposed entrainment protections, additional spring Delta outflow, habitat restoration, expanded monitoring, and the Longfin Smelt science program (Table 5-2).

6.2.2.3 Conclusion

Considering the level of take, the minimization and mitigation measures outlined in Section 5"Take and Effect Minimization and Mitigation Measures,", together with known population trends and threats to the species (see Section 2.2 *Longfin Smelt*), and reasonably foreseeable impacts on the species from other related projects and activities (see Section 6.2.1 *Cumulative Effects*), the issuance of the ITP for the covered activities will not jeopardize the continued existence of Longfin Smelt.

6.3 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

6.3.1 Cumulative Effects

The CVP has the potential to cumulatively affect Winter-run Chinook Salmon in addition to the SWP. With respect to entrainment from the CVP South Delta export facility, the salvage-density method suggested that entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between the Existing Conditions and Proposed Project scenarios (Table 6-12). As noted for the SWP analysis discussed in the *Salvage-Density Method* section of Section 4.2.3.2 *Outmigrating Juveniles*, this is because most Winter-run Chinook Salmon entrainment largely occurs prior to the April–May period when the largest difference in South Delta exports is projected to occur between the Existing Conditions and Proposed Project scenarios. As previously emphasized, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to limit potential entrainment loss of juvenile Winter-run Chinook Salmon. This, together with the risk assessment-based approach for OMR flow management described in the project description in this Application and the consistent approach presented in Reclamation's (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project biological assessment's proposed action, would be expected to limit entrainment loss for Winter-run Chinook Salmon juveniles to no more than the protective levels required by the NMFS (2019) BiOp. As previously described in the *Salvage-Density Method* section of Section 4.2.3.2 *Outmigrating Juveniles*, these protective low levels would continue the low levels of entrainment, i.e., less than authorized take (i.e., ~1% of genetic Winter-run juveniles entering the Delta), that occurred as a result of the NMFS (2009) BiOp criteria implementation.

Table 6-12. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 6-12a – Table 6-12 f

Table 6-12 g. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	232	97	187	31	1	0	0	0	0	0	0	57
Proposed Project	220	88	179	68	2	0	0	0	0	0	0	56

Table 6-12 h. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	659	184	212	19	9	2	0	0	0	0	0	137
Proposed Project	663	183	198	55	30	2	0	0	0	0	0	136

Table 6-12 i. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	273	255	288	14	0	0	0	0	0	0	0	14
Proposed Project	271	254	238	35	0	0	0	0	0	0	0	14

Table 6-12 j. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	238	331	497	25	0	0	0	0	0	0	0	41
Proposed Project	235	337	416	45	0	0	0	0	0	0	0	40

Table 6-12 k. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	294	529	403	37	0	0	0	0	0	0	0	26
Proposed Project	271	521	411	48	0	0	0	0	0	0	0	26

Table 6-12 l. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet Year	Above Normal Year	Below Normal Year	Dry Year	Critical Year
Existing	604	1,222	845	1,132	1,289
Proposed Project	613	1,266	811	1,073	1,278
Proposed Project vs. Existing	10 (2%)	44 (4%)	-34 (-4%)	-58 (-5%)	-11 (-1%)

The salvage analysis method based on Zeug and Cavallo (2014) was used to assess potential cumulative effects of combined SWP and CVP South Delta operations of juvenile Winter-run Chinook Salmon (see Appendix D, Section D.4.2). Across the 82-year DSM2 simulation period, salvage of juvenile Winter Run Chinook Salmon was predicted to be less than 0.04% of the total juvenile population for both facilities combined. Predicted salvage at both facilities combined was slightly lower for the Proposed Project (0.353%) relative to Existing (0.380%) over the entire modeling period. Despite the trend of lower salvage under the Proposed Project across all years, there was variation in which scenario produced lower salvage in individual years (Figure 6-1).

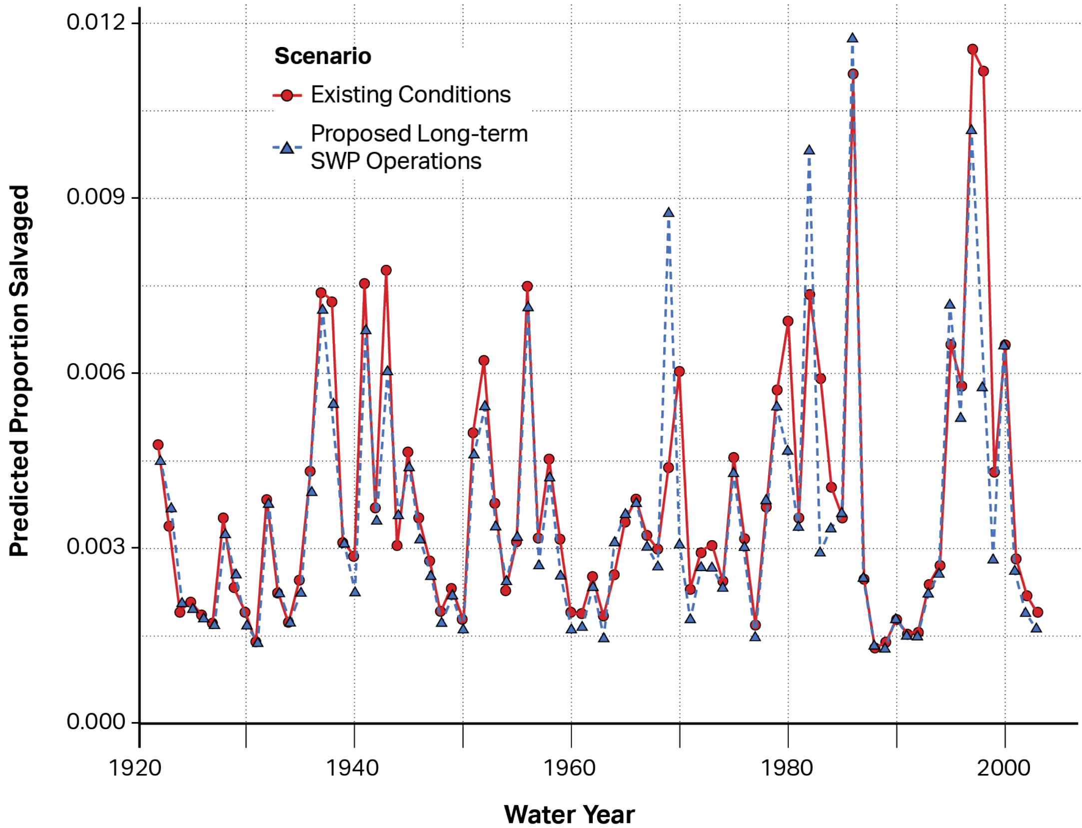
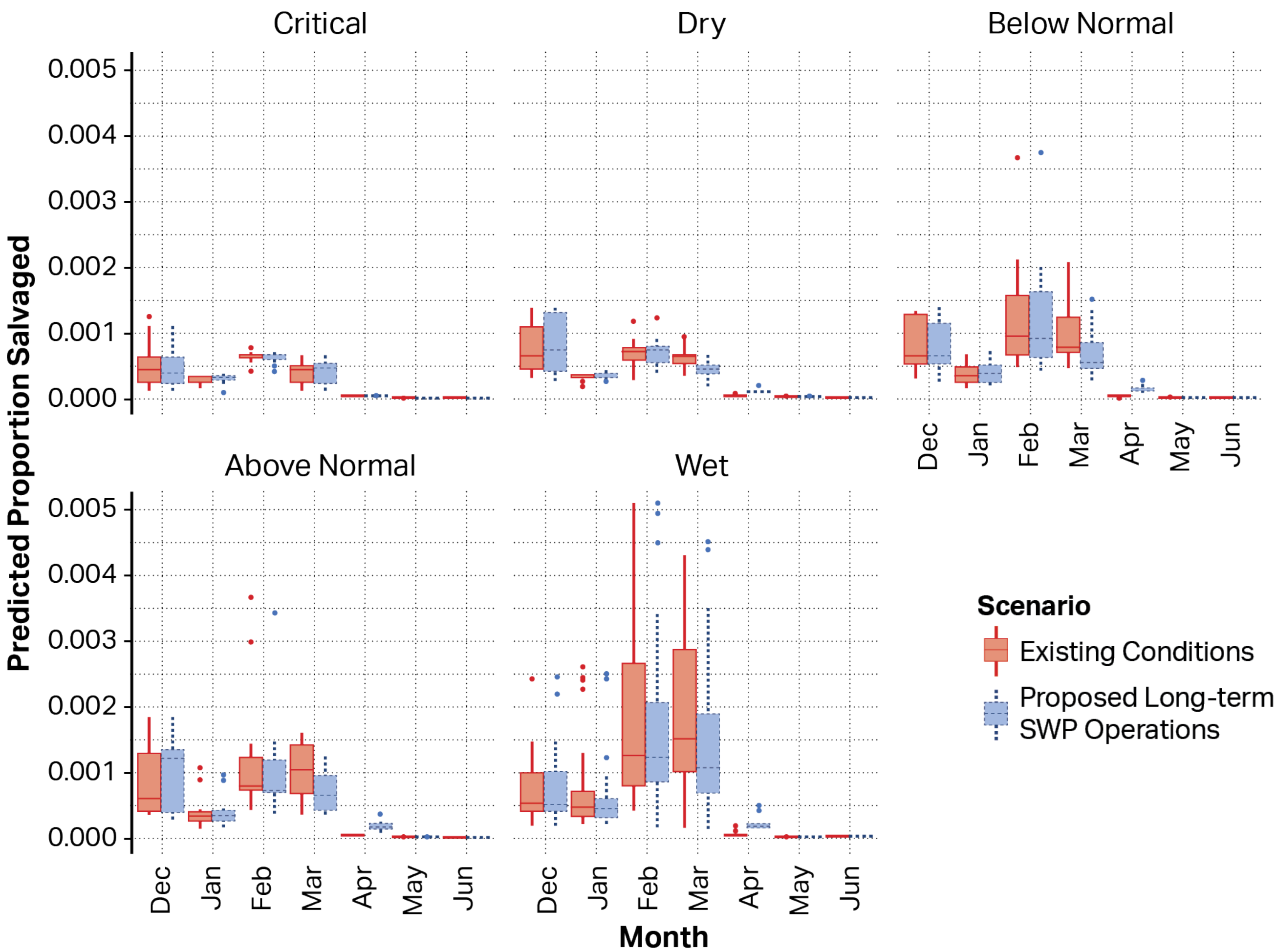


Figure 6-1. Predicted proportion of Juvenile Winter-run Chinook Salmon salvage at the Skinner Delta Fish Protective Facility of the State Water Project and the Central Valley Project Tracy Fish Collection Facility under the Existing Conditions and Proposed Project scenarios across the 82-year DSM2 simulation period

The highest median salvage for the combined facilities occurred in wet water years; however, salvage did not exceed 0.625% in any month (Figure 6-2). Within wet water years, the interquartile range of salvage at the combined facilities for both scenarios overlapped considerably in all months except February and March, which were the months with the highest salvage. In February, 75th percentile values of combined salvage were greater under the Existing Conditions scenario than under the Proposed Project. In March, 25th, median, and 75th percentile values of salvage were greater under Existing (Figure 6-2). In above normal years salvage at the combined facilities was greatest in December for both scenarios though values were below 0.2% of all juveniles, and interquartile ranges were similar between the two scenarios. In March, all interquartile values were greater for the existing condition (Figure 6-2). The interquartile range of combined salvage was higher for the Proposed Project in April but the total value of salvage in this month was low. In below normal years, salvage at the combined facilities was similar between scenarios in all months except March when interquartile values the Existing Conditions scenario were greater than the Proposed Project scenario (Figure 6-2). In dry years, salvage was greatest in December, and median and 75th percentile values were greater for the Proposed Project in that month. In March of dry years, predicted combined salvage was lower under the Proposed Project than under the Existing Conditions scenario. In all other months of dry years, salvage was low and similar between scenarios. The lowest salvage at the combined facilities for both scenarios occurred in critical water years (Figure 6-2).



Note: The horizontal line is the median value, the box defines the interquartile range and vertical lines define the minimum and maximum values. Single points are outliers.

Figure 6-2. Box and Whisker Plots of Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvaged at the Skinner Delta Fish Protective Facility of the State Water Project and the Tracy Fish Facility of the Central Valley Project as a Function of SWP Exports and Sacramento River Flow for the Existing Conditions and Proposed Project Scenarios

Several of the take mechanisms discussed earlier in this section pertain to combined SWP and CVP effects on Winter-run Chinook Salmon, in particular through-Delta survival (see the *Delta Passage*

Model and *Survival, Travel Time, and Routing Analysis (STARS, Based on Perry et al. 2018)* analyses in Section 4.2.3.2 *Outmigrating Juveniles*).

The proposed action for the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project includes the following main components with the potential to affect Winter-Run Chinook Salmon, as summarized by NMFS (2019, p.749-752; asterisks indicate components that are part of the Proposed Project, including components that are part of the Proposed Project as minimization/mitigation measures):

- Temperature Management and Performance Metrics
- Fall and Winter Reservoir Flows and Reservoir Management
- Delta Cross Channel
- Delta Performance Objectives and Old and Middle River Management*
- Conservation Measures[18]
    - Battle Creek Winter-run Chinook Salmon Reintroduction Plan and Battle Creek Salmon and Steelhead Restoration Project
    - Spawning and Rearing Habitat Restoration
    - Winter-run Chinook Salmon Conservation Hatchery Production and Tier 4 Intervention Measures
    - Small fish screen program
    - Knights Landing Outfall Gates
    - Spring Management of Spawning Locations
    - Temperature Modeling Platform
    - Shasta Temperature Control Device Evaluations
    - Tidal Habitat Restoration*
    - Predator Hot-spot Removal
    - SRS Contractors Salmon Recovery Program

As described for other covered species, a number of other water supply and water management projects potentially could affect Delta conditions and therefore Winter-run Chinook Salmon, including long-term and short-term water transfers and the Sites Reservoir Project, for example. Each of these would be subject to their own permitting analyses to meet CESA requirements, including full mitigation. A number of habitat restoration projects beyond those described in Section 5, including projects under the California EcoRestore program, have the potential to positively affect Winter-run Chinook Salmon, depending on location in relation to typical Winter-run Chinook Salmon distribution, by increasing food availability, for example.

[18] These are the most significant conservation measures, per NMFS (2019, p.752).

Other cumulative effects discussed for Delta Smelt in Section 4.6.1.1 *Cumulative Effects* also are relevant to Winter-run Chinook Salmon. These include effects from water diversions, agricultural practices, increased urbanization, waste water treatment plants, and various other activities such as dumping of garbage and oil and gas development and production. It is recognized that Winter-run Chinook Salmon are vulnerable to climate change effects (Moyle et al. 2015), and incidental harvest in fisheries for Chinook Salmon is estimated to result in an age-3 impact rate of around 16% in recent years (NMFS 2016a:25).

6.3.2 Potential to Jeopardize the Species

The issuance of the ITP will not jeopardize the continued existence of Winter-run Chinook Salmon for the following reasons.

6.3.2.1 Level of Take

As described in Section 4, "Analysis of Take and Effects," the overall potential for take of Winter-run Chinook Salmon by the Proposed Project is high, but take would be limited to a low proportion of the population. Covered activities have a high likelihood of mortality of individuals. The principal means of potential take is by direct entrainment at the SWP intake at Clifton Court Forebay, although potential take is anticipated to be similar for the Proposed Project and Existing Conditions scenarios. Based on analyses conducted herein (see the *Salvage Analysis* based on Zeug and Cavallo [2016] in Section 4.2.3.2 *Outmigrating Juveniles*), take of Winter-run Chinook Salmon juveniles by entrainment at the SWP South Delta export facilities would be expected to be similar to take under the Existing Conditions scenario, which in recent years has been well below the authorized 2% of Winter-run-sized Chinook Salmon entering the Delta (Islam et al. 2018).

6.3.2.2 Minimization and Mitigation Measures

Minimization and mitigation measures applicable to Winter-run Chinook Salmon are discussed in Section 5.4 *Sacramento River Winter-run Chinook Salmon* (see also Table 5-2). Among the main measures are proposed entrainment protections, export reductions for additional spring Delta outflow through adaptive management, habitat restoration, and incidental take limits from the NMFS (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion (Table 5-2).

6.3.2.3 Conclusion

Considering the level of take, the minimization and mitigation measures outlined in Section 5, "Take and Effect Minimization and Mitigation Measures,", together with known population trends and threats to the species (see Section 2.3 *Sacramento River Winter-run Chinook Salmon*), and reasonably foreseeable impacts on the species from other related projects and activities (see Section 6.3.1 *Cumulative Effects*), the issuance of the ITP for the covered activities will not jeopardize the continued existence of Sacramento River Winter-run Chinook Salmon.

6.4 CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

6.4.1 CUMULATIVE EFFECTS

The CVP has the potential to cumulatively affect Spring-run Chinook Salmon in addition to the SWP. Consistent with the analysis of *Entrainment* presented for the SWP in Section 4.2.4.2 *Outmigrating Juveniles*, the salvage-density method suggested that entrainment loss of juvenile Spring-run Chinook Salmon at the CVP South Delta export facility could be appreciably greater under the Proposed Project scenario compared to the Existing Conditions scenario (Table 6-13). (Table 6-13). This is because most juvenile Spring-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in South Delta exports is projected to occur between the Existing Conditions and Proposed Project scenarios[19]. As previously noted, the modeling of operations effects using CalSim modeling do not include proposed larval and juvenile Delta Smelt entrainment protections, which would reduce south Delta exports relative to what was modeled, and therefore the predicted difference in entrainment between scenarios. In addition, as also previously noted, the modeling of operations effects does not account for the inclusion of additional adaptively managed Delta outflow under the Proposed Project in spring through SWP export curtailments by operating to the SWP proportional share of the SJR I:E ratio during April 1–May 31, which would increase Delta outflow relative to the Proposed Project results presented herein and would reduce differences in South Delta exports between the Proposed Project and Existing Conditions scenarios; this would give smaller differences between scenarios than those modeled in this Application. As described for Spring-run Chinook Salmon in the analysis of the SWP effects, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria, which are particularly pronounced in Spring-run (Harvey et al. 2014). Studies of coded-wire-tagged Spring-run Chinook Salmon suggest very few are salvaged at the South Delta export facilities (Zeug and Cavallo 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to assess and limit potential entrainment loss of Spring-run Chinook Salmon. During the April-May period, Spring-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management described in the project description that would be undertaken for other species (e.g., Winter-run Chinook Salmon and Central Valley Steelhead), and incidental take would be required to be within the protective criteria required by the NMFS (2019) BiOp.

Several of the take mechanisms discussed earlier in this section pertain to combined SWP and CVP effects on Spring-run Chinook Salmon, in particular through-Delta survival (see the *Delta Passage Model* and *Survival, Travel Time, and Routing Analysis* (STARS, based on Perry et al. 2018) analyses in Section 4.2.4.2 *Outmigrating Juveniles*).

[19] As noted in the analysis of the SWP entrainment, fish entrained during April-May would be expected to primarily be young-of-the-year; yearlings would tend to occur somewhat earlier in the winter, during a period when the Existing Conditions and Proposed Project scenarios would not be expected to differ greatly in exports, based on CalSim modeling.

Table 6-13. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 6-13 a – Table 6-13 f

Table 6-13a. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	15	2,242	5,412	4,268	803	0	0	0	0	0	1
Proposed Project	1	14	2,147	11,924	9,748	792	0	0	0	0	0	1

Table 6-13b. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7	19	2,256	3,713	916	17	0	0	0	0	0	0
Proposed Project	7	18	2,108	10,632	3,039	17	0	0	0	0	0	0

Table 6-13c. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	5	663	761	379	9	0	0	0	0	0	0
Proposed Project	1	5	548	1,877	1,214	8	0	0	0	0	0	0

Table 6-13d. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4	3	418	1,762	234	6	0	0	0	0	0	0
Proposed Project	4	3	350	3,164	510	6	0	0	0	0	0	0

Table 6-13e. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	123	770	406	2	0	0	0	0	0	0
Proposed Project	0	2	126	984	490	2	0	0	0	0	0	0

Table 6-13f. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the Central Valley Project South Delta Export Facility for Existing Condition and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet Year	Above Normal Year	Below Normal Year	Dry Year	Critical Year
Existing	12,742	6,928	1,818	2,427	1,303
Proposed Project	24,626	15,822	3,654	4,036	1,604
Proposed Project vs. Existing	11,884 (93%)	8,894 (128%)	1,836 (101%)	1,609 (66%)	300 (23%)

The proposed action for the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project includes a number of main components that have the potential to affect Spring-run Chinook Salmon, including the following as summarized by NMFS (2019:761–763); asterisks indicate components that are part of the Proposed Project, including components that are part of the Proposed Project as minimization/mitigation measures):

- Water Temperature Management in the Upper Sacramento River
- Spring pulse flows in the Mainstem Sacramento River
- Operation of the Delta Cross Channel Gates
- South Delta Export Operations*
- Conservation Measures[20]
  - Battle Creek Salmon and Steelhead Restoration Project
  - Clear Creek Pulse Flows
  - Deer Creek Fish Passage Improvements
  - Small fish screen program
  - Knights Landing Outfall Gates
  - Spring Pulse Flows
  - Tidal Habitat Restoration*
  - Predator Hot Spot Removal
  - SRS Contractors Salmon Recovery Program

As described for other covered species, a number of other water supply and water management projects potentially could affect Delta conditions and therefore Spring-run Chinook Salmon, including long-term and short-term water transfers and the Sites Reservoir Project, for example. Each of these would be subject to their own permitting analyses and, if necessary, full mitigation to meet CESA requirements. A number of habitat restoration projects beyond those described in Section 5, including projects under the California EcoRestore program, have the potential to positively affect Spring-run Chinook Salmon, depending on their location in relation to typical Spring-run Chinook Salmon distribution, which would be expected to encompass areas of designated critical habitat in the Delta, for example.

Other cumulative effects discussed for Delta Smelt in Section 4.6.1.1 *Cumulative Effects* also are relevant to Spring-run Chinook Salmon. These include effects from water diversions, agricultural practices, increased urbanization, waste water treatment plants, and various other activities such as dumping of garbage and oil and gas development and production. It is recognized that Spring-run Chinook Salmon are vulnerable to climate change effects (Moyle et al. 2015), but incidental harvest in

[20] These are the most significant conservation measures, per NMFS (2019:763).

fisheries for Chinook Salmon is not believed to have resulted in overutilization of Spring-run Chinook Salmon (NMFS 2016b:26).

6.4.2 Potential to Jeopardize the Species

The issuance of the ITP will not jeopardize the continued existence of Spring-run Chinook Salmon for the following reasons.

6.4.2.1 Level of Take

As described in Section 4, "Analysis of Take and Effects," the overall potential for take of individual Spring-run Chinook Salmon by the Proposed Project is high, but take would be limited to a low proportion of the population. Covered activities have a high likelihood of mortality of individuals. The principal means of potential take is by direct entrainment at the SWP intake at Clifton Court Forebay, with the Proposed Project scenario potentially having greater entrainment loss than the Existing Conditions scenario because of greater South Delta exports in the spring. As described in the entrainment discussion in Section 4.2.4.2 *Outmigrating Juveniles*, available studies suggest that many Spring-run-sized Chinook Salmon are actually Fall-run Chinook Salmon (Harvey et al. 2014), and studies of coded-wire-tagged Spring-run Chinook Salmon suggest entrainment loss constitutes a very small percentage of the population (Zeug and Cavallo 2014).

6.4.2.2 Minimization and Mitigation Measures

Minimization and mitigation measures applicable to Spring-run Chinook Salmon are discussed in Section 5.5 *Central Valley Spring-run Chinook Salmon* (see also Table 5-2). Among the main measures are proposed entrainment protections, export reductions for additional spring Delta outflow, and habitat restoration; and incidental take limits and the Delta Performance Objective for young-of-the-year Spring-run Chinook Salmon from the NMFS (2019) Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion (Table 5-2).

6.4.2.3 Conclusion

Considering the level of take, the minimization and mitigation measures outlined in Section 5, "Take and Effect Minimization and Mitigation Measures," together with known population trends and threats to the species (see Section 2.4 *Central Valley Spring-run Chinook Salmon*), and reasonably foreseeable impacts on the species from other related projects and activities (see Section 6.4.1 *Cumulative Effects*), the issuance of the ITP for the covered activities will not jeopardize the continued existence of Central Valley Spring-run Chinook Salmon.

7 MONITORING PLAN

California Department of Fish and Wildlife (CDFW) incidental take permit (ITP) regulations require a description of the proposed plan to monitor compliance with the avoidance, minimization, and mitigation measures and the effectiveness of the measures (14 CCR 783.2(a)(9)). This section is intended to fulfill this requirement.

7.1 CONTINUATION OF EXISTING MONITORING

Existing monitoring programs through the Interagency Ecological Program (IEP[21]) and FWS (Enhanced Delta Smelt Monitoring[22] [EDSM] program) includes monitoring to track the status of listed species of fish, and also monitoring to ascertain performance of minimization measures associated with operations of the South Delta export facilities and their fish salvage programs. Existing monitoring programs and proposed modifications to existing IEP programs will facilitate tracking status of listed species of fish and evaluating effectiveness of minimization measures. Incidental take associated with the IEP monitoring programs is authorized via ESA Section 10(a)(1)(A) Research and Enhancement Permits and state FGC Section 2081(a) permits. Monitoring to track performance of the South Delta export facilities and their fish salvage programs is authorized through the existing biological opinions (NMFS 2009 [Section 13.4]; USFWS 2008). Use of scientific collection permits constitutes a conservative approach to take authorization associated with monitoring activities because such permits need periodic renewal, at which time methodology can be updated to ensure that incidental take is minimized consistent with available knowledge and techniques. Thus, it is expected that continuation of existing monitoring would receive take authorization either through issuance of scientific collection permits, or through an alternative consultation pathway.

7.1.1 PROPOSED MODIFICATIONS TO IEP SAMPLING PROGRAMS

Through IEP's science management plan review process (IEP 2014), DWR will undertake a review of existing IEP larval monitoring programs to propose modifications to CDFW SLS and 20 mm programs given new information showing that longfin smelt have a more robust distribution, both temporally (i.e., spawning window) and spatially (i.e., habitat and regions) than what is monitored by these programs (MacWilliams et al. 2016; Grimaldo et al. 2017; Lewis et al. 2019; Grimaldo et al. submitted manuscript). This review will be completed within one year of ITP issuance.

As part of the mitigation program, the construction of RVERS is included, which should improve IEP's sampling program. This facility has been permitted through a separate state and federal environmental review process.

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[21] This program is described and data are archived at http://www.water.ca.gov/iep/activities/monitoring.cfm.

[22] This program is described and data are archived at https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm

7.2 MONITORING ADDRESSING HABITAT RESTORATION SITES

DWR will develop monitoring plans to assess environmental characteristics of restored habitat (e.g., salinity and zooplankton abundance) and evaluate the benefit to listed fish, lower trophic consumers, water quality, and effects on listed botanical and wildlife species. Aquatic monitoring will focus on regional and site-specific habitat characteristics associated with listed fish species.

Monitoring plans will be developed as part of each restoration action that will include both pre- and post-project monitoring requirements. These plans will be independently reviewed and evaluated by technical teams or a science panel. Monitoring will rely as much as possible on data from existing regional monitoring efforts under the IEP. In addition, site-specific monitoring data will be collected within each project site prior to restoration action. Expansion of long-term Delta-wide monitoring efforts will assist with the fulfillment of monitoring requirements.

7.3 REPORTING

7.3.1 CONTINUED MONITORING REPORTING REQUIREMENTS

Fulfillment of continued monitoring reporting requirements associated with SWP operations is the responsibility of DWR and Reclamation through coordination with the IEP and FWS EDSM program. DWR will track and ensure continued monitoring, including any enhancements to the existing continued monitoring elements (e.g., SLS and 20 mm surveys) is conducted in accordance with provisions of all permits and authorizations provided to the SWP, and will provide results to CDFW as outlined in their monitoring commitments per their take authorization conditions.

7.3.2 HABITAT RESTORATION REPORTING REQUIREMENTS

Monitoring reports will be developed as part of each restoration action. These reports will include information on the progress of each project towards meeting the intended mitigation goals and implementation schedule, and the current status, barriers, and relative accrued benefits of those projects.

7.3.3 REAL-TIME REPORTING

DWR, in coordination with Reclamation, would implement activities, monitor performance, and report on compliance with the commitments in the Proposed Project. Implementing the proposed action would require coordination between CDFW, DWR, USFWS, NMFS, Reclamation, and the SWP and CVP water contractors. The federal government is proposing a Real-Time Operations Charter to facilitate federal coordination with the State.

8 FUNDING

Section 2081(b) requires that the impacts of the authorized take are minimized and fully mitigated, and that the applicant “ensure adequate funding to implement the measures required … and for monitoring compliance with, and effectiveness of, those measures” (Fish & Game Code Section 2081(b)(4)). This section describes the estimated costs and the funding sources to implement the measures of the proposed project to minimize and fully mitigate the impacts of take of species listed under the California Endangered Species Act (see 14 CCR Section 783.2(a)(10)). Estimated costs are summarized first, followed by funding sources.

8.1 COST

Costs to implement the minimization and mitigation program are shown in Table 8-1. These costs were estimated to determine the funding needs over the term of the 2081(b) permit. Costs of all minimization and mitigation measures supporting minimization and mitigation for state listed species are included.

Table 8-1. Estimated Species Minimization and Mitigation Costs

Cost Item	Land (acres)	Total Cost (over 10 years)	Average Annual Cost
8,000 Acres of Habitat Restoration from 2008 Biological Opinion[1]	8,000	$248,000,000	$24,800,000
800 Acres of Habitat Restoration from 2009 Longfin Smelt Incidental Take Permit[1]	800	$24,800,000	$2,480,000
New Mesohaline Tidal Habitat Restoration	396.3	$12,285,300	$1,228,530
Yolo Bypass Restoration	—	$62,500,000	$62,500,000
Tidal Habitat Restoration Monitoring (8,000 acres + 800 acres)	—	$18,128,000	$1,812,800
Proposed Modifications to Interagency Ecological Program (IEP) Sampling Programs	—	$10,000,000	$1,000,000
Longfin Smelt Science Program	—	$10,000,000	$1,000,000
Longfin Smelt Life Cycle Model	—	$500,000	N/A
Cultured Delta Smelt Studies	—	$10,000,000	$1,000,000
Rio Vista Estuarine Field Station	—	$48,000,000	$4,800,000
Total	**9,196.7**	**$449,213,300**	**$449,213,300**

1. DWR has completed 1,571 acres of habitat restoration at Decker Island (114 acres), Tule Red (610 acres), Yolo Flyway Farms (294 acres), and Winter Island (553 acres). The total expended costs for these four projects $24,427,000 but costs listed include the entirety of the restoration acreages required by the 2008 USFWS BiOp (8,000 acres) and 2009 Longfin Smelt ITP (800 acres).

“—” indicates blank cell

8.1.1 MINIMIZATION AND MITIGATION COST ESTIMATE METHODS

Costs were developed for the mitigation (i.e., habitat restoration), monitoring (habitat and modifications to Interagency Ecological Program (IEP) sampling), and Longfin Smelt Science Program. Cost estimate methods were as follows:

- Habitat restoration: $31,000 per acre based on the total estimated cost for recently completed and planned fish restoration projects including Arnold Slough, Bradmoor Island, Chipps Island, Decker Island (complete), Lookout Slough, Lower Yolo Ranch, Prospect Island, Tule Red (complete), Yolo

Flyway Farms, Wings Landing, and Winter Island (complete) (DWR FRP Schedule Budget Summary 2019)[23];

- Habitat restoration monitoring: $206 per acre per year based on Fish Restoration Program monitoring for 8,000 acres of tidal habitat restoration required by the U.S. Fish and Wildlife Service (USFWS) 2008 Biological Opinion (Riordan, pers. comm.);
- Proposed modifications to IEP sampling programs: $1,000,000 per year for additional sampling for Longfin Smelt, based on similar sampling programs recently implemented (Grimaldo et al. 2017; Lewis et al. 2019);
- Longfin Smelt Science Program: $1,000,000 per year based on recent experience with Longfin Smelt projects. (Sommer, pers. comm.).
- Cultured Delta Smelt Studies: $1,000,000 per year (Baerwald, pers. comm., 2019).
- Rio Vista Estuarine Research Station: $4.8 million per year. The State's current project delivery method for RVERS is lease-to-own, which would entail annual payments to a developer over the course of a 25-year agreement. This estimate is based on 65% lease cost share for the state.

The total estimated costs are $449,213,300 over the 10-year duration of the Proposed Project (Table 8-1).

8.2 FUNDING

Payment of the costs of operating the State Water Project, including associated mitigation projects, is assured by DWR's long-term water supply contracts and applicable state law. DWR is a party to a long-term water supply contract with each of its 29 water supply customers, who are generally referred to as "Contractors." These contracts are the foundation of the State Water Project's fiscal strength.[24] The Department has not experienced payment delinquencies or defaults by Contractors in the 43 years since its founding.[25] The revenue requirements of the long-term water supply contracts together with reserves and other available funds ensure that the Department would continue to have the ability to pay its obligations when due even in the event of a default by a Contractor.

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[23] DWR has completed 1,571 acres of habitat restoration at Decker Island (114 acres), Tule Red (610 acres), Yolo Flyway Farms (294 acres), and Winter Island (553 acres) for a total cost of $24,427,000 but costs listed in Table 8-1 include the entirety of the restoration acreages required by the 2008 USFWS BiOp (8,000 acres) and 2009 Longfin Smelt ITP (800 acres).

[24] The quality, and hence reliability, of the Department's revenue bonds has been recognized by the California Debt and Investment Advisory Commission, as well as two globally recognized ratings agencies familiar with SWP finances. The California Debt and Investment Advisory Board stated in its report on the affordability and financing considerations for the proposed water facility (California Debt and Investment Advisory Commission 2014): SWP contractors that contract with DWR to pay for the operation, maintenance, planning and capital costs of the State Water Project are subject to a number of important requirements under the terms of their water supply contracts, which provide the security for DWR's revenue bonds. For example, the contracts include a so-called "take or pay" provision. This requirement ensures that revenues to cover bond debt service are available regardless of whether water deliveries are reduced because of drought or other conditions. In addition to a take-or-pay requirement, these contracts include provisions that require DWR to charge amounts sufficient to repay all project costs and produce net revenues at least equal to 1.25 times annual debt service on DWR's bonds plus the amount needed for operation and maintenance costs. Most contracts also include so called "step-up" provisions whereby DWR can increase amounts billed to other contractors by up to 25% if needed if another contractor defaults on a payment. These and other provisions of the DWR contracts have resulted in very strong credit ratings of AAA/Aa1 on DWR's bonds, enabling DWR to borrow at low interest rates.

[25] DWR was founded in 1956.

The existing contracts will begin to expire in 2035, with the last contract expiring in 2042. In May 2013, DWR and the Contractors began negotiations to extend the term of the long-term water supply contracts and make some other changes to the financial provisions of these contracts. In June 2014, the negotiators for DWR and the Contractors reached a general agreement on principles for such an amendment (the "Agreement in Principle"). Under the Agreement in Principle the term of the long-term water supply contract for each Contractor that signs an amendment would be extended until December 31, 2085. DWR prepared a Draft Environmental Impact Report (EIR) for the project and certified the Final EIR on November 13, 2018. On December 11, 2018, DWR approved the extension of the long-term water supply contracts. As of December 2, 2019, 20 of the 29 Contractors have executed the amendment. DWR has not started implementing the extension amendment because the threshold number of Contractors have not yet signed the amendment, and there is pending litigation. The extension amendment does not change the Contractors' obligation for funding mitigation associated with the State Water Project (SWP).

8.2.1 Current Process for Funding Mitigation Associated With the SWP

SWP costs allocable to water supply fall into two general categories. Construction costs and certain major O&M costs (e.g., facility refurbishment) are capitalized and are financed by the issuance of short-term debt (commercial paper) and long-term debt (revenue bonds). The commercial paper program is designed to be an ongoing source of interim (i.e., short-term) financing for water system projects prior to long-term financing from the sale of revenue bonds. SWP projects, and major maintenance and mitigation projects that are capitalized, are funded in the short term through issuance of commercial paper. When the short-term debt outstanding approaches DWR's maximum commercial paper capacity available, long-term debt is issued through issuance of long-term revenue bonds to pay off the commercial paper, which allows for a longer-term amortization and cost recovery period for SWP capital project costs. Other costs, such as routine operation, maintenance, and power (e.g., monitoring of mitigation sites) are not financed, but are instead paid in monthly installments in the calendar year, incurred based upon estimates developed by DWR and delivered to the Contractors in July of the preceding year.

Ratings agencies conduct detailed research of the financial health of bond issuers (including issuers of municipal bonds such as the Department) and assign ratings to an issuer's bonds based on the issuer's creditworthiness. DWR's credit ratings are an indication of its financial health and ability to pay its obligations. DWR's revenue bonds are rated AAA by S&P Global Ratings Services, its highest possible rating for municipal bonds, and Aa1 by Moody's Investor Service, one step lower than its highest municipal rating, which has only been issued to a handful of municipal utilities nationwide. The Department's strong bond ratings recognize the Contractors' record of reliably paying SWP charges for the past half-century, the strong default provisions of the long-term water supply contracts, and the rate covenants and security provisions of the Department's bond resolutions.

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9.6 **CHAPTER 7**

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10 CERTIFICATION

I hereby certify that the information submitted in this application is complete and accurate to the best of my knowledge and belief. I understand that any false statement herein may subject me to the suspension or revocation of this permit and to civil and criminal penalties under the laws of the State of California.

Michelle Banonis, Assistant Chief Deputy Director

Department of Water Resources

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