Effects Analysis

State Water Project Effects on Winter-run and Spring-run Chinook Salmon

November 2024

Prepared by California Department of Fish and Wildlife

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List of Acronyms and Abbreviations

7DADM	7-day average of the daily maximum
°C	degrees Celsius
°F	degrees Fahrenheit
ANOVA	analysis of variance
ARIS	Adaptive Resolution Imagining Sonar
BAFF	Bio-Acoustic Fish Fence
Banks Pumping Plant	Harvey O. Banks Pumping Plant
BDT	San Joaquin River at Road Bridge monitoring station
BET	Bethel Island monitoring station
BLP	Blind Point monitoring station
BO	Biological Opinion
BSOG	Butte Slough Outfall Gates
BSPP	Barker Slough Pumping Plant
CalSim	California Simulation
CCF	Clifton Court Forebay
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CFPS	Clifton Court Forebay Predation Studies
cfs	cubic feet per second
CHNFR	fall-run Chinook Salmon
CHNLFR	late fall-run Chinook Salmon
CHNSR	spring-run Chinook Salmon
CHNWR	winter-run Chinook Salmon
CLC	Clifton Court Forebay monitoring station
cm	centimeter(s)
CNFH	Coleman National Fish Hatchery
CVP	Central Valley Project
CWT	coded-wire tag
D-1641	SWRCB Water Rights Decision 1641
DCC	Delta Cross Channel
DCI	Delta-Mendota Canal/California Aqueduct Intertie
DEIR	Draft Environmental Impact Report
Delta	Sacramento-San Joaquin Delta
DIDSON	Dual-frequency Identification Sonar
DOSS	Delta Operations for Salmonids and Sturgeon
DPM	Delta Passage Model
DS	Delta Smelt
DSM2	Delta Simulation Model 2
DSM2-HYDRO	Delta Simulation Model 2 hydrodynamic
DTUs	Daily Temperature Units
DWR	California Department of Water Resources

ECO-PTM	Ecological Particle Tracking Model
EDI	Environmental Data Initiative
ESA	Endangered Species Act
Estuary	San Francisco Bay Estuary
ESU	Evolutionary Significant Unit
FETT	Fisheries Engineering Technical Team
FEIR	Final Environmental Impact Report
FR	Federal Register
FRFH	Feather River Fish Hatchery
ft	foot (feet)
ft/s	foot (feet) per second
FNU	Formazin Nephelometric Units
GSEWG	Guidance Structure Evaluation Working Group
GYSO	Goodyear Slough Outfall
HLT	Middle River near Holt monitoring station
HOL	Hollands Cut monitoring station
HRL	Healthy Rivers and Landscapes Program (previously Voluntary Agreements)
ITP	Incidental Take Permit
Jones Pumping Plant	C.W. Bill Jones Pumping Plant
JPE	Juvenile Production Estimate
km	kilometer(s)
LAD	length-at-date
LFS	Longfin Smelt
LSNFH	Livingston Stone National Fish Hatchery
MAF	million acre-feet
MHO	Middle River near Howard Road Bridge monitoring station
MIDS	Morrow Island Distribution System
mm	millimeter(s)
mph	miles per hour
MSD	Mossdale monitoring station
m/s	meter(s) per second
NAVD88	North American Vertical Datum of 1988
NFH	Nimbus Fish Hatchery
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OBI	Old River at Bacon Island monitoring station
OH4	Old River at Highway 4 monitoring station
OSJ	Old River at Franks Tract near Terminous monitoring station
OMR	Old and Middle River
ORQ	Older River at Quimby Island near Bethel Island monitoring station
DWR	California Department of Water Resources
PFRS	Clifton Court Forebay Predator Fish Relocation Study
PPT	San Joaquin River at Prisoner's Point monitoring station
PIT	passive integrated transponder
POMP	Partially Observed Markov Process

PRES	Clifton Court Forebay Predator Reduction Electrofishing Studies
Project	State Water Project
PTM	particle tracking model
QA/QC	quality assurance/quality control
QWEST	net flow on the San Joaquin River at Jersey Point
RBDD	Red Bluff Diversion Dam
Reclamation	United States Bureau of Reclamation
RM	river mile
RMPC	Regional Mark Processing Center
RPA	Reasonable and Prudent Alternative
RRDS	Roaring River Distribution System
RST	rotary screw trap
SacPAS	Central Valley Prediction and Assessment of Salmon
Salvage facilities	John E. Skinner Delta Fish Protective Facility and Tracy Fish Collection Facility
SDM	structured-decision making
sDPS	southern Distinct Population Segment
SHAP	Shapely Additive Explanations
SHERLOCK	Specific high-sensitivity Eezymatic reporter UnLOCKing
SJG	San Joaquin River at Garwood Bridge monitoring station
SJRRP	San Joaquin River Restoration Program
Skinner Fish Protective Facility	John E. Skinner Delta Fish Protective Facility
SMSCG	Suisun Marsh Salinity Control Gates
SST	Salmonid Scoping Team
STARS	Survival, Travel Time, and Routing Simulation
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TRN	Turner Cut near Holt monitoring station
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WOMT	Water Operations Management Team
WRCML Model	Winter-Run Chinook Salmon Machine Learning Model
WS	White Sturgeon
X2	Distance (km) up the axis of the estuary measured from the Golden Gate Bridge where the near-bottom daily average salinity is 2 practical salinity units (psu)
YBFMP	Yolo Bypass Fish Monitoring Program
YBSHRFP Project	Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
YOY	young-of-year

1. Introduction

In response to the California Department of Water Resources (DWR) request for authorization for the incidental take of Longfin Smelt (*Spirinchus thaleichthys*, LFS), Delta Smelt (*Hypomesus transpacificus*, DS), winter-run Chinook Salmon (*Oncorhynchus tshawytscha*, CHNWR), spring-run Chinook Salmon (*Oncorhynchus tshawytscha*, CHNSR), and White Sturgeon (*Acipenser transmontanus*, WS) under the California Endangered Species Act (CESA) for existing and future operations of the State Water Project (SWP; Project) in the Sacramento-San Joaquin Delta (Delta) and Suisun Marsh and Bay (collectively the Bay-Delta), California Department of Fish and Wildlife (CDFW) conducted an analysis of potential Project[1] effects (Effects Analysis) for each Covered Species based on DWR's Incidental Take Permit (ITP) Application for Long-term Operation of the SWP dated November 1, 2023 (ITP Application; DWR 2023f), DWR's Draft and Final Environmental Impact Reports (DEIR and FEIR, SCH No. 2023060467), existing data, and literature. This document is CDFW's Effects Analysis for CHNWR and CHNSR. In this Effects Analysis, CDFW provides background information on the Covered Species, methodologies and approaches used to assess potential Project impacts, and discussions and definitions of the terminology and information available for the analysis. Analyses conducted for LFS and DS are provided in a separate Effects Analysis as Attachment 5 to the 2024 SWP ITP. Additionally, analyses conducted for WS are provided in a separate Effects Analysis as in Attachment 7 to the 2024 SWP ITP. Together the three Effects Analysis documents serve as companion analyses for the issuance of the ITP for Long-term Operation of the SWP in the Sacramento-San Joaquin Delta (No. 2081-2023-054-00; 2024 SWP ITP).

In the following CHNWR and CHNSR Effects Analysis, CDFW considered that Project operations will be consistent with existing water supply contracts, flood control needs, and certain operational criteria and other actions set forth in the FEIR, U.S. Fish and Wildlife Service (USFWS) Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project (CVP) and SWP issued on October 21, 2019 (2019 USFWS BO; USFWS 2019), and the National Marine Fisheries Service (NMFS) Endangered Species Act Section 7 Biological Opinion on Long-term Operation of the CVP and the SWP issued on October 21, 2019 (2019 NMFS BO; NMFS 2019a). However, given the limitations on California Simulation (CalSim) 3 modeling, modeled Proposed Project operations provided in this Effects Analysis include CVP and SWP joint operations in the Delta, specifically Old and Middle river (OMR) flow management measures (see Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon). In addition, CDFW considered that the Project will comply with all applicable State, federal, and local laws and regulations in existence or adopted after the issuance of the 2024 SWP ITP as well as State Water Resources Control Board (SWRCB) Water Rights Decision 1641 (D-1641).

[1] As used in this Effects Analysis, "Project" refers to all operations as permitted and conditioned under the 2024 Incidental Take Permit for Long-term Operation of the SWP in the Sacramento-San Joaquin Delta (No. 2081-2023-054-00). "Proposed Project" refers to operations included in DWR's ITP Application (DWR 2023f) and included in CalSim 3 modeling inputs that represent those operations. The Proposed Project does not include all minimization measures (see Appendix C – CalSim Modeling Results) or mitigation requirements that are required by the 2024 Incidental Take Permit.

2. Project Description Summary

Under the 2024 SWP ITP, DWR will continue to operate the SWP facilities in the Delta and Suisun Marsh. The SWP includes water, power, and conveyance systems, conveying an annual average of 2.9 million acre-feet (MAF) of water for agricultural, municipal, industrial, recreational, and environmental purposes while also providing flood control. The principal facilities of the SWP are Oroville Reservoir and related facilities, San Luis Dam and related facilities, facilities in the Delta, the Suisun Marsh Salinity Control Gates (SMSCG), the California Aqueduct including its terminal reservoirs and the Delta-Mendota Canal/California Aqueduct Intertie (DCI), and the North and South Bay Aqueducts. 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. DWR holds contracts with 29 public agencies in northern, central, and southern California for water supplies from the SWP.

The Project includes operations of the following facilities in the Delta: Harvey O. Banks Pumping Plant (Banks Pumping Plant), the Clifton Court Forebay (CCF), the John E. Skinner Delta Fish Protective Facility (Skinner Fish Protective Facility), the Barker Slough Pumping Plant (BSPP), the South Delta Temporary Barriers Project, San Luis Reservoir, the DCI, the Georgiana Slough Salmonid Migratory Barrier, and Suisun Marsh facilities including the SMSCG, Roaring River Distribution System (RRDS), Morrow Island Distribution System (MIDS), and Goodyear Slough Outfall (GYSO).

The Project is located within the following geographic area (Project Area, see Figure 1 attached to the 2024 SWP ITP):

- 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.

Project operations will be in all fish-bearing waterways within the Project Area. The northern edge of the Project Area is located at the confluence of the Sacramento River and Feather River in Yolo County at approximately 38.785281 latitude, -121.621825 longitude and extends downstream on the Sacramento River to the Delta. To the south and east, the Project Area is bounded by the legal boundary of the Delta. To the west, the Project Area is bounded by the legal Delta, Suisun Marsh, and Suisun Bay.

Covered Activities contemplated under the 2024 SWP ITP are detailed in the permit and include operations of the Banks Pumping Plant (including water transfers), Skinner Fish Protective Facility, CCF (including herbicide and algaecide application and mechanical aquatic weed removal), South Delta Temporary Barriers Project, Georgiana Slough Salmonid Migratory Barrier, BSPP (including fish screen cleaning, sediment removal, and aquatic weed removal), and the Suisun Marsh Facilities that include the SMSCG, the RRDS, the MIDS, and GYSO.

3. List of Covered Species

The 2024 SWP ITP provides DWR with incidental take authorization for the Project for the following species, referred to collectively as "Covered Species":

1. Longfin Smelt (*Spirinchus thaleichthys*), CESA-listed as Threatened
2. Delta Smelt (*Hypomesus transpacificus*), CESA-listed as Endangered
3. Spring-run Chinook Salmon of the Sacramento River drainage (*Oncorhynchus tshawytscha*), CESA-listed as Threatened
4. Winter-run Chinook Salmon (*Oncorhynchus tshawytscha*), CESA-listed as Endangered
5. White Sturgeon (*Acipenser transmontanus*), Candidate for CESA listing

4. Covered Species Life History

4.1. Winter-run Chinook Salmon

4.1.1. Listing History

On September 22, 1989, the California Fish and Game Commission listed CHNWR as endangered under CESA (Figure 1; see Cal. Code Regs., tit. 14, § 670.5, subd. (a)(2)(M)). The Sacramento River CHNWR Evolutionary Significant Unit (ESU), which includes CHNWR populations in the Sacramento River and its tributaries in California, was listed as threatened by NMFS under the Endangered Species Act (ESA) on August 4, 1989 (54 FR 32085) and subsequently uplisted to endangered on January 4, 1994 (59 FR 440). CHNWR were reaffirmed as endangered under the ESA on June 28, 2005, with an extension of the ESU to include CHNWR produced at the Livingston Stone National Fish Hatchery (LSNFH; 70 FR 37160). NMFS reaffirmed Sacramento CHNWR as endangered under the ESA again on August 15, 2011 (76 FR 50447). Critical habitat for CHNWR includes the Sacramento River from Keswick Dam (river mile [RM] 302) to Chipps Island (RM 0) at the westward margin of the Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzy Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay from San Pablo Bay to the Golden Gate Bridge (58 FR 33212).

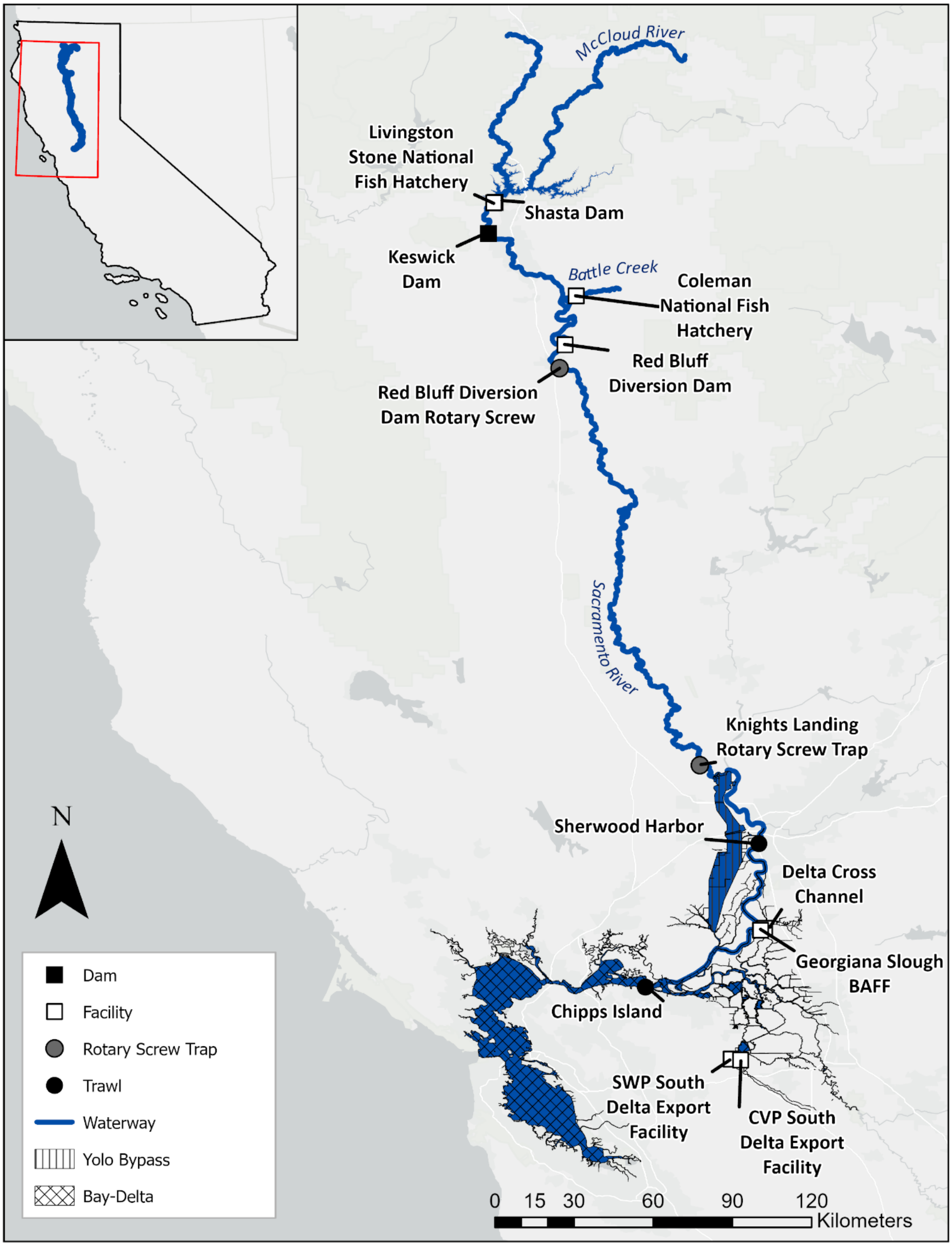

Figure 1. CHNWR distribution and relevant management related locations.

4.1.2. Population Status and Trends

CHNWR annual adult returns were as high as 120,000 fish in the 1960s, but by the 1990s had declined to less than 200 fish (NMFS 2019a). From 1967 through 2000, CHNWR escapement estimates were based on counts of salmon passing through one of three of Red Bluff Diversion Dam (RBDD) fish ladders (RM 243). From 1967 through 1986, Tehama-Colusa Canal Authority, in coordination with United States Bureau of Reclamation (Reclamation), typically operated RBDD throughout the entire CHNWR migration period, which allowed for a complete accounting of CHNWR escapement (Killam et al. 2016). In 1987, the operation of RBDD was modified to improve CHNWR migration, with dam gates typically raised from mid-September through mid-May of the following year to allow unimpeded upstream passage of most CHNWR adults (Killam et al. 2016). By 2011, NMFS mandated Reclamation to raise the gates out of the water year-round to provide for improved fish passage (NMFS 2009; Killam et al. 2016).

Beginning in 2001, CDFW replaced the RBDD escapement estimates with carcass surveys that were already being conducted on the Sacramento River by the USFWS, coupled with adult returns to LSNFH, Coleman National Fish Hatchery (CNFH), Battle Creek, and Clear Creek, as the official means to obtain an annual CHNWR escapement estimate (Killam et al. 2016; CDFW 2023d).

Since 2001, adult escapements (in river and hatchery; Sacramento River system) were highest in 2005 and 2006 with estimated total returns of 15,839 and 17,296 adults, respectively (Figure 2; CDFW 2023d). Between 2001 and 2010, the average adult escapement was 7,639 adults; however, in the following decade (2011-2020) there was a precipitous decline in returns with an average of 3,676 adults observed. The lowest escapement since 2001 occurred in 2011 with an estimated return of 827 adults. The largest return of adults since 2005 and 2006, occurred in 2021 with an estimate of 10,548 adults (CDFW 2023d). The 2021 escapement estimate was greater than the 2001 to 2010 average, but well below the 2005 and 2006 estimates.

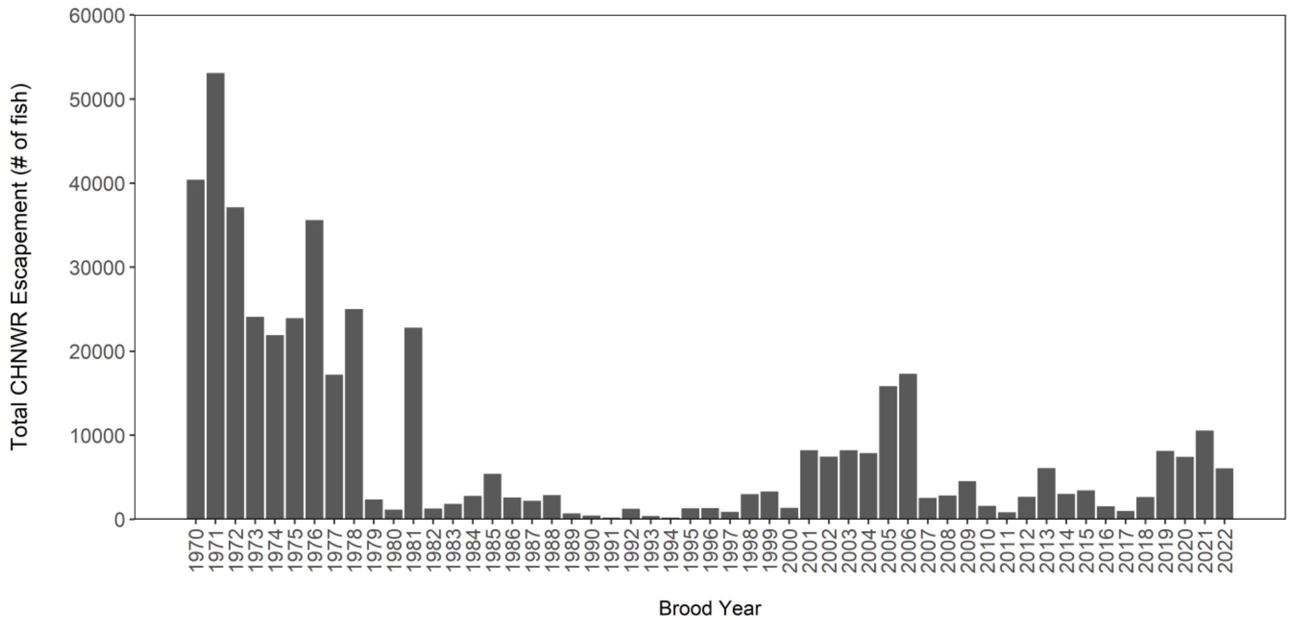

Figure 2. Total Sacramento River system annual CHNWR escapement estimates for brood years 1970-2022 (CDFW 2023d). Escapement estimates include the number of adult CHNWR returning annually in the Sacramento River, Battle Creek, and Clear Creek, and those propagated at the LSNFH or CNFH.

While the 2021 escapement estimate was relatively high, the natural-origin CHNWR juvenile production estimate (JPE), a prediction of the number of juvenile CHNWR that will enter the Delta, was comparatively low (124,521; Figure 3). This low estimate was thought to be due to thiamine deficiency complex and temperature-dependent egg mortality (WR PWT 2022). High escapement estimates may not necessarily result in correspondingly high JPE numbers. JPE numbers may remain low due to environmental factors that depress juvenile survival. The JPE is an important population forecast that takes into account annual fry counts and estimated survival at different life and migration stages (O'Farrell et al. 2018). Specifically, the JPE is extrapolated from juvenile CHNWR passage at RBDD and survival rates for fry to smolts and smolts from RBDD to the Delta. Since brood year 2021, the JPE has continued to decrease with the second lowest JPE calculated for brood year 2022 (49,9240) since 1994 (Figure 3).

Declining trends observed in CHNWR populations from 2007 through 2020 were likely due to a combination of factors such as poor ocean productivity, extreme drought, and low in-river survival as a result of low flows and high water temperatures (NMFS 2019a, 2022a). California has faced long-term drought conditions (2007-2009, 2012-2016, 2020-present) that have led to lower-than-normal coldwater pool storage at Shasta Reservoir, which has led to increased temperature-dependent egg mortality (see Section 4.1.4 – Egg and Fry Development).

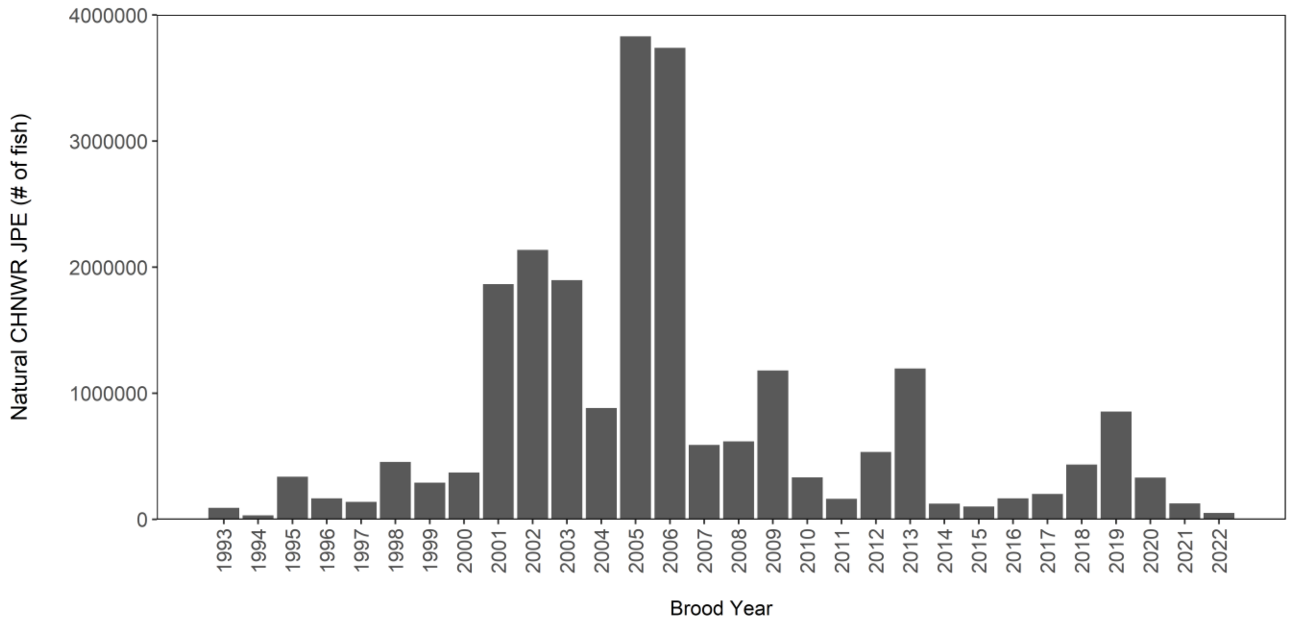

Figure 3. Natural-origin CHNWR JPE for brood years 1993-2022 (corresponding to water years 1994-2023; NMFS 2019b, 2020; CDFW 2020e; WR PWT 2021, 2022, 2023).

4.1.3. Extinction Risk

The CHNWR population consists of a single spawning population in the Sacramento River below Keswick Dam (Figure 1). This population has been completely displaced from its historical spawning habitat upstream of Keswick Dam and persists in a section of the river where coldwater habitat is artificially maintained by releases from Shasta Reservoir (Williams et al. 2011). Due to limited supply of cold water in Shasta Reservoir, persistence of this population is precarious (NMFS 2014). NMFS's *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead* (NMFS Recovery Plan) notes that the CHNWR ESU is extremely vulnerable to catastrophic events that could lead to its extinction (NMFS 2014).

In 1989, USFWS initiated a hatchery supplementation program at CNFH on Battle Creek to supplement CHNWR production, but ultimately led to adult CHNWR returning to Battle Creek to spawn instead of remaining on the Sacramento River. In 1998, USFWS relocated the supplementation program to LSNFH, which is located at the base of Shasta Dam on the Sacramento River. This conservation hatchery consists of both an integrated-recovery supplementation program and a captive broodstock program (USFWS 2015). The average annual hatchery production of CHNWR at LSNFH is 216,015 juveniles per year (2001 to 2018 average; NMFS 2019a) compared to the estimated natural production that passes RBDD, which is 2.9 million juveniles per year based on the 2002 to 2018 average (see Section 4.1.9.1 – LSNFH Production Efforts; USFWS 2018).

Lindley et al. (2007) developed extinction risk criteria for Central Valley salmonid populations based on viability parameters for abundance, population decline rate, and hatchery influence. Applying Lindley et al. (2007) criteria, NMFS (2016b) most recent 5-year status review concluded that extinction risk of the CHNWR ESU has increased, largely due to extreme drought and poor ocean conditions. To buffer against drought conditions and reduce extinction risk, USFWS increased juvenile CHNWR production at LSNFH in 2014 and 2015 by approximately three times the normal production amount (NMFS 2022c, 2023c). Increased hatchery supplementation appeared to have been successful, as adult escapement through 2018 met the low extinction risk criterion for abundance (i.e., a census population size of 2,500). However, the high extinction risk for the population was triggered by the increased hatchery influence, with a mean of 66% hatchery-origin spawners from 2016 through 2018. Although adult CHNWR returns have been increasing since 2018, the NMFS 2020 *Viability Assessment for Pacific Salmon and Steelhead Listed Under ESA* (NMFS Viability Assessment) considered the population at a high extinction risk in 2020 with population viability declining since the NMFS (2016b) assessment (NMFS 2022c, 2023c). CHNWR extinction risk remains high in part due to a high hatchery influence (68% hatchery-origin spawners from 2018 through 2020) and a lack of population redundancy in the ESU (NMFS 2022c, 2023c). NMFS does not consider the CHNWR ESU a viable population because there is only one naturally spawning population, with spawning limited to outside the historical spawning range. To increase spatial diversity and abundance, efforts were initiated in 2017 to establish a self-sustaining population of CHNWR in Battle Creek, which has shown some success with adults returning as early as 2019 (see Section 4.1.9 – Supplementation and Reintroduction Efforts).

4.1.4. Egg and Fry Development

4.1.4.1. Temperature Management

The embryo life stage begins with fertilization, followed by egg incubation, and ends with fry emergence from the gravel. Within the appropriate water temperature range, eggs normally hatch 40 to 60 days after fertilization. Newly hatched fry (alevin) remain in the gravel for an additional four to six weeks until the yolk sac has been absorbed (NMFS 2014). NMFS (2014) describes CHNWR fry emergence occurring from mid-June through mid-October. However, recent monitoring of late spawning CHNWR (from mid-July to mid-August) by CDFW suggests fry emergence occurs through October and into early November (CalFish 2023b). Water temperature greatly influences the duration of egg incubation and time of emergence in different river drainages, with emergence occurring after the yolk sac is absorbed (Williams 2006). Approximately 900 to 1,000 thermal units are required for incubation of Chinook Salmon eggs (1 thermal unit = 1°C above freezing x 24 hours; Raleigh et al. 1986). Research on incubation survival at constant exposure indicates that the optimum water temperature for salmonid egg survival ranges from 6°C to 10°C (42.8-50°F) with complete mortality noted at incubation temperatures ranging from 13.9°C to 19.4°C (57-66.9°F; USEPA 2001). Additionally, USEPA (2001) suggests that subsequent mortality may occur in successfully hatched fry from eggs incubated in warm water. For example, coagulated yolk disease, in which a portion of the yolk coagulates and cannot be absorbed by the fry, is responsible for much of the mortality of hatched fry reared in higher than optimal water temperatures (Boles et al. 1988). These effects make water temperature an important environmental influence on early salmon survival.

Sacramento River temperatures are artificially maintained through coldwater releases in the summer from Shasta Reservoir to provide adequate spawning and rearing habitat downstream. Water temperatures in the upper Sacramento River are the result of interactions among ambient air temperature, water volume, water temperature at release from Shasta and Trinity dams, total reservoir storage, location of reservoir thermocline, ratio of Spring Creek Power Plant release to Shasta Dam release, operation of the Temperature Control Device on Shasta Dam, and tributary inflows (NMFS 2014). In general, water released from Keswick Dam warms as it moves downstream during the summer and early fall months at a critical time for the successful development and survival of CHNWR embryos and emergent fry (NMFS 2014). Reclamation has struggled to maintain an adequate coldwater pool in Shasta Reservoir in dry and critical water years and extended drought periods to provide suitable water temperatures for CHNWR egg incubation, fry emergence, and juvenile rearing in the Sacramento River (NMFS 2016d). While Reclamation has created and implemented improved Shasta Reservoir storage plans since 2010, the threat of warm water releases from Shasta Dam remains a significant stressor to CHNWR. Insufficient releases from Shasta Reservoir in 2014 and 2015 contributed to 5.6% and 4.2% egg-to-fry survival rates to RBDD, respectively (NMFS 2016d). More recently, the ongoing drought (2020-present) has contributed to suboptimal in-river water temperatures, and as a result the egg-to-fry survival rates to RBDD for the 2021 and 2022 brood years were 2.6% and 2.2%, respectively (WR PWT 2022, 2023).

In 2017, in response to the low egg-to-fry survival rates during the drought, NMFS submitted a proposed amendment to Reasonable and Prudent Alternative (RPA) Action Suite I.2 of the 2009 Biological Opinion and Conference Opinion on the Long-Term Operation of the CVP and SWP (2009 NMFS BO; NMFS 2009) related to Shasta Reservoir operations to address temperature-dependent mortality of CHNWR embryos (NMFS 2017). Specifically, the amendment recommended temperature-dependent mortality thresholds for CHNWR embryos based on water year type as managed through Shasta Reservoir minimum storage targets for the late spring (April 1 through May 31) and end of September (NMFS 2017). Additional measures recommended by NMFS (2016b) to reduce temperature-dependent mortality and improve Shasta Reservoir coldwater pool management include: improving reservoir, meteorological, and hydrologic modeling and monitoring to most efficiently manage the reservoir's limited amount of cold water; installation of additional temperature monitoring stations in the upper Sacramento River to better monitor real-time water temperatures; and enhanced CHNWR redd, egg, and juvenile monitoring. Under the 2019 Biological Opinion on the Long-Term Operation of the CVP and SWP (2019 NMFS BO; NMFS 2019a), Reclamation targets a temperature of 53.5°F in the upper Sacramento River above Clear Creek during CHNWR egg incubation, May 15 through October 31, by managing water temperatures through a tiered approach that requires intervention measures if temperatures are not achieved. If needed, intervention measures are developed through coordination with NMFS, USFWS, CDFW, and DWR, and can range from increasing CHNWR hatchery production to trapping and hauling juvenile and adult CHNWR in the Sacramento River.

4.1.4.2. Dewatering

Stable and continuous river flows are important to the early life history of salmonids, from egg incubation to emergence from the gravel. If redds are dewatered or exposed to warm, deoxygenated water, incubating eggs and/or larval fish may not survive. Dewatering can occur anytime a stream flow reduction occurs. On the Sacramento River below Keswick Dam, the transition from summer to winter flow regimes involves flow reductions from September to November as less water is needed for agricultural purposes (Revnak et al. 2017). Late spawning CHNWR (mid-July to mid-August) are of particular concern because redds constructed in shallow areas are susceptible to dewatering under typical flow reduction actions undertaken by Reclamation that occur beginning in late August (Revnak et al. 2017). In response, CDFW has increased monitoring of shallow CHNWR redds to allow near real-time management recommendations to protect redds as flows are reduced (Revnak et al. 2017).

4.1.5. Rearing and Outmigrating Juveniles in the Upper and Middle Sacramento River System

4.1.5.1. Juvenile Migration and Rearing

CHNWR juveniles primarily express an ocean-type life history pattern, with juveniles leaving spawning areas in the Sacramento River as fry. After emerging from gravel, Chinook Salmon fry swim or are displaced downstream to either rear in the river for a period that varies from weeks to a year or continue sustained movement downstream until reaching the estuarine environment (Healey 1991). Within the river, fry seek out habitats on channel margins, which provide slower water velocities for resting, and riparian vegetation or other forms of cover that provide refuge from predators and sources of aquatic and terrestrial invertebrates for food (NMFS 2014). NMFS (2014) describes juvenile salmon downstream movement as primarily crepuscular, while Poytress et al. (2014) notes that rotary screw trap (RST) passage data indicates fry exhibit decreased nocturnal passage levels during and around the full moon phase in the fall. Larger CHNWR juveniles (including pre-smolt and smolt life stages) appear to be less influenced by nighttime light levels and much more influenced by changes in stream discharge levels (Poytress et al. 2014).

There is a growing body of research showing that juvenile CHNWR utilize diverse rearing habitats before entering the Delta. Juvenile CHNWR have been documented using non-natal streams located downstream of RBDD for rearing, and an analysis of adult CHNWR otolith strontium isotope ratios ($^{87}Sr/^{86}Sr$) revealed that 44 to 65% of adults examined reared in non-natal habitats as juveniles including upper Sacramento River tributaries, the Feather River, American River, and Delta (Maslin et al. 1998; Phillis et al. 2018).

While ephemeral habitat and non-natal tributaries of the Sacramento River provide some rearing habitat for juvenile CHNWR, more than 95% of historical floodplain rearing habitats have been leveed and drained in California's Central Valley (Whipple et al. 2012). Floodplains and other off-channel habitats when hydraulically connected to the mainstem river for substantial lengths of time provide refuge from high flows and sediment loads, reduce competition, increase prey availability, and potentially reduce encounters with predators, all of which can improve rearing conditions and increase growth and survival rates (Sommer et al. 2001; Limm and Marchetti 2003; Moyle et al. 2007; Jeffres et al. 2008).

4.1.5.2. Juvenile Migration Survival

Juvenile salmon mortality during migration to the ocean is a critical component of salmon population dynamics (Healey 1991; Williams 2006). The Sacramento River's hydrology has been highly modified and releases from Keswick Reservoir are generally lower than unimpaired conditions in the winter and spring and higher in the summer and fall (SWRCB 2017).

Juvenile salmonids migrating through altered habitats may experience prolonged exposure to predators as well as decreased predator evasion due to stress. Predation is recognized as a probable contributing factor in the declines of many populations of both Chinook Salmon and steelhead (*Oncorhynchus mykiss*) in California's Central Valley (NMFS 2014). Reduced channel margin habitat coupled with longer residence and travel times due to lower outflow may increase predator densities and predation of juvenile CHNWR in the Delta. DWR and Reclamation (2022) indicate that lower outflow may increase the density of littoral predators into smaller, shallower areas and decrease escape cover for juvenile salmonids. Lower Delta outflow may also increase the abundance and distribution of invasive aquatic plant communities that provide habitat for non-native predators. Warm-water and drought tolerant predator species rarely show population declines during low Delta inflow periods (Mahardja et al. 2021; DWR and Reclamation 2022).

Acoustic tagging studies show that significant mortality of juvenile Chinook Salmon occurs upstream of the Delta (Michel et al. 2012, 2015; Iglesias et al. 2017; Cordoleani et al. 2019; Notch et al. 2020). Flow has repeatedly been cited as the most important factor affecting overall survival of Chinook Salmon in the Central Valley (Kjelson and Brandes 1989; Zeug et al. 2014; Michel et al. 2015; Iglesias et al. 2017; Notch et al. 2020; Hassrick et al. 2022), likely because of concurrent increases in habitat and food availability, temperature suitability, velocity, and turbidity effects associated with flow that directly improve the ability of juvenile salmon to avoid predation. Iglesias et al. (2017) found that smolt mortality during migration in the Sacramento River is spatially heterogeneous, with certain reaches exhibiting elevated levels of mortality. This finding is likely a result of the dynamic nature of the Sacramento River system and the effects of hydrologic alterations across the 302-mile migration corridor. Hassrick et al. (2022) found that the middle section of the Sacramento River, between Red Bluff and Colusa, had the lowest survival and slowest travel times for outmigrating smolts. This section of the river is characterized by having bare banks and the potential for off-channel habitat during wet years. Modification of the natural hydrograph, including suppression of winter pulse flows, has resulted in contraction of migratory windows, reducing the variability in migration timing, and suppressing full expression of CHNWR life histories (Sturrock et al. 2015). The resulting reduction in life history diversity could significantly reduce the resiliency of CHNWR and increase the risk of a temporal mismatch between favorable ocean conditions and CHNWR ocean residency (Satterthwaite et al. 2014).

4.1.5.3. Juvenile Passage at Red Bluff Diversion Dam

Quantifying fry and smolt passage through RBDD is a crucial step for calculating the CHNWR JPE, which is a brood year specific estimate of juvenile CHNWR entering the Delta each year. Emigration of juvenile CHNWR past RBDD may begin as early as mid-July, typically peaks in September, and can continue through as late as mid-March in dry years (Williams et al. 2011; NMFS 2014; Poytress et al. 2014). For brood years 1995 to 1999, all juvenile CHNWR migrating as fry passed RBDD by October, and all migrating pre-smolts and smolts passed RBDD by March (Martin et al. 2001). For the recent brood year 2022, fry completed passage at RBDD by the end of November and smolts completed passage by the end of May (Scott Voss, personal communication, 6/2023). Total annual RBDD passage estimates for juvenile CHNWR, during the period of April 4, 2002 through September 30, 2013, ranged between 848,976 and 8,363,106 juveniles (brood years 2002-2012; Poytress et al. 2014). These data also document that on average, estimated juvenile CHNWR passage at RBDD was composed of 80% fry and 20% pre-smolt/smolt size-class fish (Poytress et al. 2014). For the recent brood years of 2021 and 2022, estimates of RBDD passage have decreased to 572,656 and 240,060, respectively (Voss and Poytress 2022a, 2022b).

Once CHNWR juveniles pass RBDD, the duration of their residency and habitat use are relatively unknown due to the lack of reliability of the length-at-date (LAD) criteria (Fisher 1992) used to determine juvenile Chinook Salmon run in the mainstem Sacramento River (i.e., LAD criteria cannot definitively distinguish CHNWR amongst sampled fish) and because monitoring downstream is less intensive (Williams et al. 2011).

4.1.6. Rearing and Outmigrating Juveniles in the Bay-Delta

Natural-origin CHNWR juveniles can migrate into the Delta as early as September (Schaffter 1980) and have been observed leaving the Delta at Chipps Island from January to April (Dekar et al. 2013), although some may reside in the Delta into May (Windell et al. 2017). CDFW's Knights Landing RST program and USFWS's trawl and beach seine monitoring programs provide information on juvenile Chinook Salmon movement through the lower Sacramento River and into the Delta. LAD CHNWR juvenile passage at Knights Landing occurs as early as August and as late as April, with most catches recorded between October and April (CalFish 2023c). Timing of migration varies somewhat due to changes in river flows, dam operations, and water year type (NMFS 2014). Under past water operations management (1999-2007), peak Delta entry timing was strongly correlated with the first high flows of the migration season, measured at Wilkins Slough (RM 118; del Rosario et al. 2013); however, a recent unpublished analysis conducted by DWR suggests this relationship is no longer highly correlated under current water operations (DWR 2020a). Studies have shown that in years with large precipitation storms and subsequent flow events on the Sacramento River in the late fall, a bimodal pulse of downstream CHNWR migrants occurs (del Rosario et al. 2013; Windell et al. 2017). The initial pulse of CHNWR typically follows the first large storm in November or December, with a second pulse in the February through March period when those rearing upstream of the Delta are cued to migrate downstream and into the San Francisco Bay (Dekar et al. 2013; Israel et al. 2015; Windell et al. 2017). In years lacking early season precipitation events, the CHNWR pulse tends to be unimodal, with the majority of Bay-Delta entry occurring in the late winter and early spring months (Israel et al. 2015; Windell et al. 2017). Observed differences in timing of cumulative catch at Knights Landing and Chipps Island (the downstream boundary of the Delta) indicate that residence time in the Delta ranges from 41 to 117 days, with longer apparent residence times for juveniles arriving earlier at Knights Landing (del Rosario et al. 2013). The online Central Valley Prediction and Assessment of Salmon (SacPAS) also provides Sacramento River trawl catch data at Sherwood Harbor (RM 55) as an indicator of salmonid entry into the Delta. Historical presence of LAD CHNWR at Sherwood Harbor begins as early as September and ends in late April (CDFW 2020e; SacPAS 2023a). Genetic data from Sherwood Harbor trawls confirm genetically-identified natural-origin juvenile CHNWR enter the Delta from October through April (Buttermore et al. 2021b; Brian Pyper, personal communication, 5/2023). While Delta residency is apparent, the importance of Delta occupancy in the life history of CHNWR is not well understood (NMFS 2014).

Munsch et al. (2019) found that warm, dry winters constrain the rearing period for migrating juveniles such that a 1°C increase in April water temperatures corresponds to fish departing Delta nearshore habitat four to seven days earlier. Studies also show that juveniles reared in temperatures from 17°C (62.6°F) to 24°C (75.2°F) experience significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared to juveniles reared at 13°C to 16°C (55.4- 60.8°F; optimum temperatures 10-15.6°C [50-60.1°F]; Marine and Cech 2004).

During juvenile outmigration, some fish are entrained into the interior Delta, where they experience increased mortality and prolonged travel times compared to juveniles that remain in the Sacramento River mainstem or those that are routed into Sutter or Steamboat sloughs, which are branches of the Sacramento River (Perry 2010; Newman and Brandes 2010). The Delta Cross Channel (DCC) and Georgiana Slough are the two primary routes of entrainment of juvenile salmon into the interior Delta from the Sacramento River. The DCC is a manmade, gated canal operated by Reclamation that links the Sacramento River with the Lower Mokelumne and San Joaquin rivers. When the DCC gates are open, water flows from the Sacramento River through the canal to improve poor water quality and water circulation associated with south Delta SWP and CVP export operations. Operations of both the Project and CVP contribute to the routing of juvenile CHNWR and other salmonids into the interior Delta through the open DCC gates (NMFS 2016d).

Much like the DCC, Georgiana Slough is another junction to the Sacramento River where water flows into the interior Delta; however, this waterway lacks a control gate. The Sacramento River at the junctions of the DCC and Georgiana Slough has both unidirectional and bidirectional flows depending on tidal oscillation and Sacramento River outflow. When the DCC gates are closed, juvenile entrainment into the interior Delta is decreased. However, the free-flowing Georgiana Slough remains an entrainment risk for fish regardless of DCC gate operations. When routed through the DCC gates or Georgiana Slough, juvenile fish enter the highly altered interior Delta where they are subjected to higher levels of contaminants, increased predation, and altered food webs that can cause either direct mortality or impaired growth (NMFS 2016d). Routing into the interior Delta also causes migration delays and entrainment of fish into the south Delta CVP and SWP export facilities.

To reduce the risk of juvenile CHNWR and CHNSR entrainment into Georgiana Slough, the 2020 SWP ITP (CDFW 2020d) Condition of Approval 8.9.1 required DWR to install and operate a migratory barrier at Georgiana Slough to increase survival for emigrating juvenile CHNWR and CHNSR that encounter the Sacramento River-Georgiana Slough junction. In 2011 and 2012, DWR tested a Bio-Acoustic Fish Fence (BAFF) at the Sacramento River-Georgiana Slough junction, and a Floating Fish Guidance Structure (FFGS) was tested in 2014, in response to the 2009 NMFS BO, RPA Action IV.1.3 (DWR 2015a, 2016). These studies demonstrated that a BAFF, which is a non-physical barrier that consists of strobe lights, sound, and a bubble curtain, can provide meaningful reduction in juvenile salmon entrainment into Georgiana Slough. To fulfill the 2020 SWP ITP requirement, DWR installed a BAFF at the Sacramento River-Georgiana Slough junction in the late fall of 2023, with operations continuing each year through April or May, concurrent with CHNWR and CHNSR presence in the Sacramento River (see Section 6.1.1; Condition of Approval 8.11.1).

4.1.7. Juvenile Ocean Entry

Migration of juvenile Chinook Salmon from the lower Sacramento River and Delta into San Francisco Bay is monitored using trawl surveys at Chipps Island (RM 18). USFWS trawl data collected at Chipps Island show juvenile LAD CHNWR leaving the Delta from December to May with a peak in March and April (del Rosario et al. 2013; SacPAS 2023a). Genetic data from Chipps Island trawls confirm juvenile CHNWR exit the Delta from December to April, peaking in March and April (Buttermore et al. 2021a; Brian Pyper, personal communication, 5/2023).

The condition in which juvenile Chinook Salmon enter the ocean is an important determinant of survival to the adult life stage. Larger, faster growing individuals are more likely to survive their first month in the ocean (Woodson et al. 2013). Regardless of where fish experience faster growth and achieve larger size before ocean entry, it appears that this early growth is important for success during unproductive ocean conditions (Woodson et al. 2013).

4.1.8. Adult Migration and Holding in the Upper Sacramento River

4.1.8.1. Adult Migration

Adult CHNWR enter the San Francisco Bay Estuary (Estuary) in November to begin their upstream spawning migration and continue to proceed up the Sacramento River through August of the following year, finally holding near spawning areas in the upper reaches of the river (Yoshiyama et al. 1996, 1998; NMFS 1998; Moyle 2002). Boles et al. (1988) cites water temperatures less than 18.3°C (65°F) are preferable for adult Chinook

Salmon migration, and Lindley et al. (2004) reports that water temperature acts as a migration barrier and leads to stress when reaching 21.1°C (70°F). Studies have also shown that adult Chinook Salmon exposure to constant or average temperatures greater than 15.5°C (60°F) results in a detrimental effect on adult survival and egg viability (Windell et al. 2017). In addition to temperature barriers, dissolved oxygen concentrations can also create barriers to migration, with adult Chinook Salmon in the San Joaquin River exhibiting an avoidance response when dissolved oxygen is below 4.2 mg/L (Hallock et al. 1970; Carter 2008). Warm water temperatures and decreased dissolved oxygen can increase physiological stress and metabolic rates in adult Chinook Salmon, while also reducing their immune response to pathogens (Windell et al. 2017).

Adult Chinook Salmon passage through the upper Sacramento River is well documented by historical observations at RBDD. From 1967 to 1986, year-round operation of RBDD provided a comprehensive method of monitoring adult passage of all four salmon runs in the Sacramento River (Killam et al. 2016). Historical fish passage monitoring at RBDD showed that CHNWR entry into the upper Sacramento River begins in mid-December and continues into early August of the following year, with peak passage in mid-March (Hallock and Fisher 1985).

4.1.8.2. Adult Holding and Spawning

Adult CHNWR entering freshwater are sexually immature and hold in coldwater pools for several months until early summer when air temperatures usually approach their yearly maximum (Moyle 2002; NMFS 2014). The evolution of this unique spawn-timing was dependent upon cold spring water sources generated from glacier and snow melt percolating through porous volcanic formations surrounding Mount Shasta and Mount Lassen, which protected embryos and juveniles from the warm ambient conditions in summer (Moyle 2002; NMFS 2014). These conditions are found in spring-fed tributaries in the upper Sacramento River watershed, especially the McCloud River (Moyle 2002).

Following the construction of Shasta Dam in 1945 and Keswick Dam in 1950, CHNWR lost access to their historical spawning habitat in the upper Sacramento River (upstream of Shasta Dam), McCloud River, and Pitt River, restricting them to a single population inhabiting a relatively small coldwater reach just downstream of Keswick Dam (Yoshiyama et al. 1998; del Rosario et al. 2013). Coldwater habitat in Battle Creek, a tributary to the Sacramento River located at RM 271, historically supported a population of CHNWR, however construction and operation of hydropower facilities led to extirpation of the population. Current restoration and recovery efforts for CHNWR involve removal or retrofitting of hydropower facilities and reintroducing fish to Battle Creek (see Section 4.1.9 – Supplementation and Reintroduction Efforts).

CHNWR are semelparous salmonids that deposit their eggs within a redd (nest) that they build in the substrate and guard prior to dying. Redds are often constructed in riffles at the tails of holding pools. Adult fish have been observed spawning in water depths as shallow as 0.8 foot (ft; 24.4 cm) and in water velocities of 1.2 to 3.5 feet per second (ft/s; 0.37-1.1 meter per second [m/s]). Optimum redd substrate is a gravel/cobble mixture with a mean diameter of 1 to 4 inches with less than 5% fine sediment (CDFG 1998). Incubation, hatching, and subsequent emergence of fry take place within a redd. CHNWR spawn in the mainstem Sacramento River between Keswick Dam and RBDD (NMFS 2014). The adult CHNWR spawning population is composed primarily of age-3 fish (91%), but also includes age-2 fish (1%) and age-4 fish (8%; Fisher 1994). Average fecundity for CHNWR is 3,743 eggs per female (Fisher 1994). Spawning occurs between late-April and mid-August, with a peak in June and July as reported by CDFW annual escapement surveys (2000-2022; CalFish 2023b). The spawning distribution of CHNWR, as determined by aerial redd surveys conducted by CDFW, is somewhat dependent on the operation of the RBDD gates (historically), river flow, and water temperature (NMFS 2014). In recent years CHNWR spawning distribution has shifted upstream, and since 2001, most CHNWR redds have occurred within the first 16 km (10 RM) downstream of Keswick Dam (CalFish 2023b).

4.1.9. Supplementation and Reintroduction Efforts

4.1.9.1. Livingston Stone National Fish Hatchery Production Efforts

In brood years 2014 and 2015, juvenile CHNWR experienced low egg-to-fry survival due to prolonged extreme drought conditions that resulted in increased water temperatures in the upper Sacramento River (NMFS 2016a). In anticipation of this lower-than-average egg-to-fry survival, additional adult CHNWR trapped at Keswick Dam were taken into LSNFH and production of juvenile brood year 2014 CHNWR was tripled (~600,000 released) to offset the impact of the drought (Killam et al. 2015). Due to ongoing drought conditions the following year, production of juvenile brood year 2015 CHNWR was doubled (~420,000 released) to compensate for expected losses in natural production (NMFS 2016a). Adult CHNWR returns in water years 2017 and 2018 were low, as expected, due to poor in-river conditions for brood year 2013 to 2015 juveniles during drought years (NMFS 2019a). As a consequence of increased juvenile CHNWR production in brood years 2014 and 2015 at LSNFH, the adult escapement of 979 fish in water year 2017 was estimated as 85% hatchery-origin, while the water year 2018 adult return of 2,639 fish was estimated as 82.5% hatchery-origin (Killam and Mache 2018; Killam 2019; CDFW 2023d). Environmental conditions improved during water years 2016 and 2017 which was anticipated to have had a positive effect on returning adults in water years 2019 and 2020. Adult CHNWR returns in water years 2019 and 2020 were 8,128 and 7,428, respectively (CDFW 2023d). The adult return average from 2011-2019 is estimated as 3,092 CHNWR; therefore, water year 2019 and 2020 adult returns were above average for CHNWR (NOAA 2021). The estimated proportion of in-river hatchery-origin CHNWR returns decreased in water years 2019 and 2020 to 37.2% and 45.5%, respectively (Killam 2020, 2021).

Drought conditions returned in water year 2020; therefore, LSNFH increased juvenile brood year 2020 CNHWR production to approximately 310,000 juveniles to mitigate for the reduced in-river production due to the expected unsuitable in-river temperatures for natural spawning CHNWR (WR PWT 2021). The following year, LSNFH increased juvenile brood year 2021 production to approximately 600,000 CHNWR due to the continued drought conditions (Reclamation and DWR 2021). Increasing hatchery propagation of CHNWR can help prevent precipitous population declines in critical years; however, it is important to prioritize natural-origin production long-term rather than relying on hatchery production to sustain the CHNWR population.

4.1.9.2. Reintroduction Efforts

4.1.9.2.1. Battle Creek

Expanding and restoring habitat for CHNWR is critical to decrease the risk of CHNWR extinction and to increase CHNWR drought resiliency. To address this need, the U.S. Department of Interior and Reclamation signed a memorandum of understanding in 1999 with support from federal and State agencies, as well as PG&E, to initiate the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project; ICF 2016; Schraml and Earley 2021). The goal of the Restoration Project is to restore approximately 42 miles of prime spawning habitat in Battle Creek, plus an additional six miles on its tributaries (Schraml and Earley 2021). The Restoration Project will be completed in three phases, Phase 1A, 1B, and 2. Phase 1A was completed in 2013 and focused on actions in the North Fork Battle Creek where cold, spring-fed habitat is most suitable for CHNWR (ICF 2016; Reclamation 2022). This phase included the removal of Wildcat Diversion Dam and Canal, construction of a fish barrier weir on Baldwin Creek, and the construction of automated fish screens and fish ladders at the Eagle Canyon Diversion Dam and North Battle Creek Feeder Diversion Dam (Reclamation 2022). Phase 1B was completed in 2012 with the construction of a 1-mile long Inskip Powerhouse bypass and tailrace connector. Phase 2 is currently ongoing and includes the removal of several facilities (i.e., South Diversion Dam, South Canal, Soap Creek Feeder Diversion Dam, lower Ripley Creek Feeder Diversion Dam, Coleman Diversion Dam), including the Inskip Diversion Dam planned for removal in 2023 (Reclamation 2022). Completion of the Restoration Project will enable safe passage for natural-origin CHNWR, as well as CHNSR and steelhead, in Battle Creek and support reintroduction efforts for CHNWR in the upper Sacramento River watershed.

The Battle Creek Winter-Run Chinook Salmon Reintroduction Plan (Reintroduction Plan; ICF 2016) was developed in response to NMFS's (2014) Recovery Plan for CHNWR with the goal of reestablishing a viable, self-sustaining and locally adapted population of CHNWR in the North Fork Battle Creek to support the recovery of CHNWR. CDFW, NMFS, and USFWS, in partnership with PG&E, developed the Reintroduction Plan with the intent of implementing the plan once the Restoration Projects were complete. However, with the drought of 2013 to 2016, natural CHNWR production was severely diminished and resource agencies decided to jump-start the reintroduction efforts into Battle Creek (Schraml and Earley 2021). As a result, approximately 215,000 juvenile CHNWR reared at CNFH were released into Battle Creek in March 2018 as part of the "Battle Creek Jumpstart Project" (Schraml and Earley 2021). These reintroduction efforts have continued and approximately 182,000 juveniles were released in 2019 (Schraml and Earley 2021), approximately 168,000 juveniles released in 2020, approximately 214,500 juveniles released in 2021 (SacPAS 2023a), and approximately 131,000 juveniles released in 2022 (Kevin Offill, personal communication, 10/2022). Consequently, adults have returned to Battle Creek starting in 2019. In 2020, over 1,000 adults returned to Battle Creek to spawn naturally (NOAA 2021), but since then adult escapement has decreased in both 2021 and 2022, to 191 and 137 adults, respectively (R.J. Bottaro, personal communication, 6/2023). In continuing these efforts, the resource agencies developed a plan to transition from the Jumpstart Project to formal reintroduction, which requires specific criteria be met to manage for adult returns (USFWS 2020).

4.1.9.2.2. McCloud River

In response to RPA Action V of the 2009 NMFS BO, Reclamation established the Interagency Fish Passage Steering Committee in 2010 to develop pilot reintroduction efforts of Chinook Salmon above CVP dams (ESA 2020). The focus of the steering committee has been on reintroducing CHNWR above Shasta Dam by evaluating the feasibility and viability of collecting juvenile CHNWR as they emigrate out of upstream historical habitat prior to entry into the Shasta Reservoir. Reclamation awarded DWR funds in 2018 to design, construct, install, and operate juvenile fish collection devices in the lower McCloud River and the McCloud River arm of the Shasta Reservoir (NOAA 2021). In the fall of 2022, DWR deployed and tested a Juvenile Salmonid Collection System, consisting of guidance nets, a downstream temperature curtain, and an upstream debris boom, in the McCloud River arm of Shasta Reservoir as part of a 3-to-5-year pilot study to investigate the viability of collecting juvenile CHNWR (DWR 2021a). The results from this pilot study will help determine the functionality of the system to collect juvenile CHNWR released upstream and the feasibility of reintroducing CHNWR above Shasta Reservoir (DWR 2021a). Results of the study will also inform the design of a long-term collection facility and support future phases to determine adult fish passage options for passage above Shasta and Keswick dams.

In addition to this pilot study, USFWS and CDFW, in partnership with the Winnemem Wintu Tribe, NMFS, and Reclamation, initiated a collaborative study effort in the summer of 2022 to transfer 35,313 CHNWR eggs from the LSNFH to a remote site incubator to incubate along the McCloud River in effort to reestablish CHNWR in their historical habitat (Matt Johnson, personal communication, 5/2023). This effort was an urgent response to reduce the extinction risk of CHNWR following three years of severe drought. After hatching, juvenile CHNWR were volitionally released into the McCloud River for rearing (NMFS 2022b). Approximately, 20 miles downstream of the incubation and fry release site, CDFW collected the juveniles with RSTs and frame nets and then transported and released the juveniles into the Sacramento River downstream of Shasta and Keswick dams (Matt Johnson, personal communication, 10/2022). Between September 6 and December 12, 2022, approximately 1,600 juvenile CHNWR were returned to the Sacramento River at Redding to continue their outmigration (Matt Johnson, personal communication, 5/2023). Although this specific action was not a part of the reintroduction program, it is expected to inform future reintroduction efforts on the McCloud River.

CDFW has allocated an additional $32.5 million to fund continued research to inform and improve the CHNWR reintroduction efforts in the McCloud River. Continued research activities supporting future McCloud River CHNWR reintroductions will be led by the Winnemem Wintu Tribe, DWR, University of California Santa Cruz, United States Geological Survey, Jubilee Gift Galaxy Inc, Pacific States Marine Fisheries Commission, and CDFW (Jason Roberts, personal communication, 7/2024).

4.2. Spring-run Chinook Salmon

4.2.1. Listing History

On February 5, 1999, the California Fish and Game Commission listed CHNSR of the Sacramento River drainage as threatened under CESA (Figures 4 and 5; see Cal. Code Regs., tit. 14, § 675.5, subd. (b)(2)(c)). The Central Valley CHNSR ESU, which includes CHNSR populations in the Sacramento River and its tributaries including the Feather River, was proposed for listing as endangered by NMFS on March 9, 1998 (63 FR 11482) following CHNSR extirpation from the San Joaquin River Basin. During listing review, data showed that a large run of CHNSR on Butte Creek in 1998 was produced naturally rather than the result of straying from the Feather River Fish Hatchery (FRFH). Subsequently, NMFS listed CHNSR as threatened under the ESA on September 16, 1999 (64 FR 50394) and reaffirmed the listing status on June 28, 2005, with an extension of the ESU to include CHNSR produced at the FRFH (70 FR 37160). Critical habitat for CHNSR includes the Sacramento River Basin, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay from San Pablo Bay to the Golden Gate Bridge (70 FR 52488).

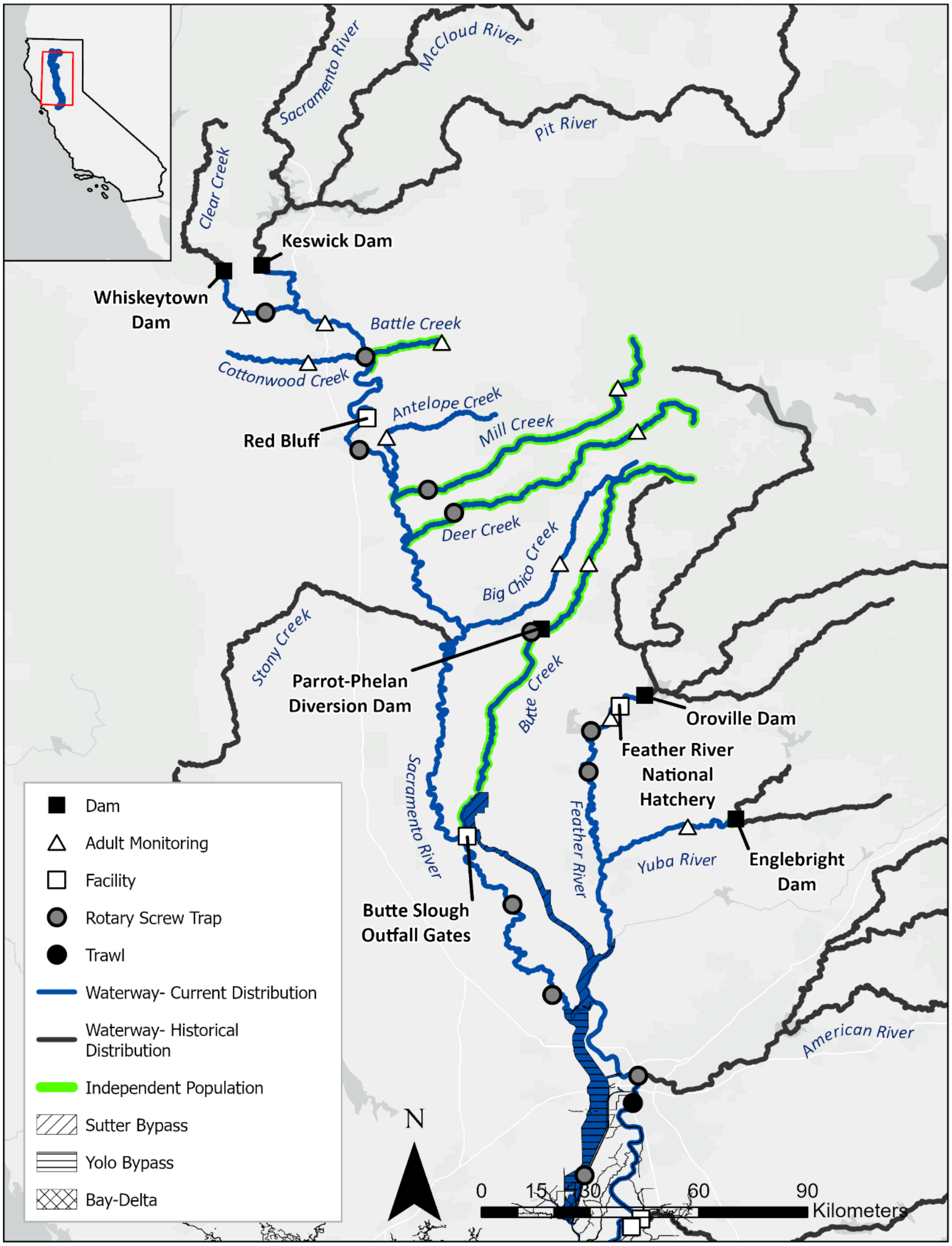

Figure 4. CHNSR current and historical distribution and relevant management related locations north of the Sacramento-San Joaquin Bay-Delta.

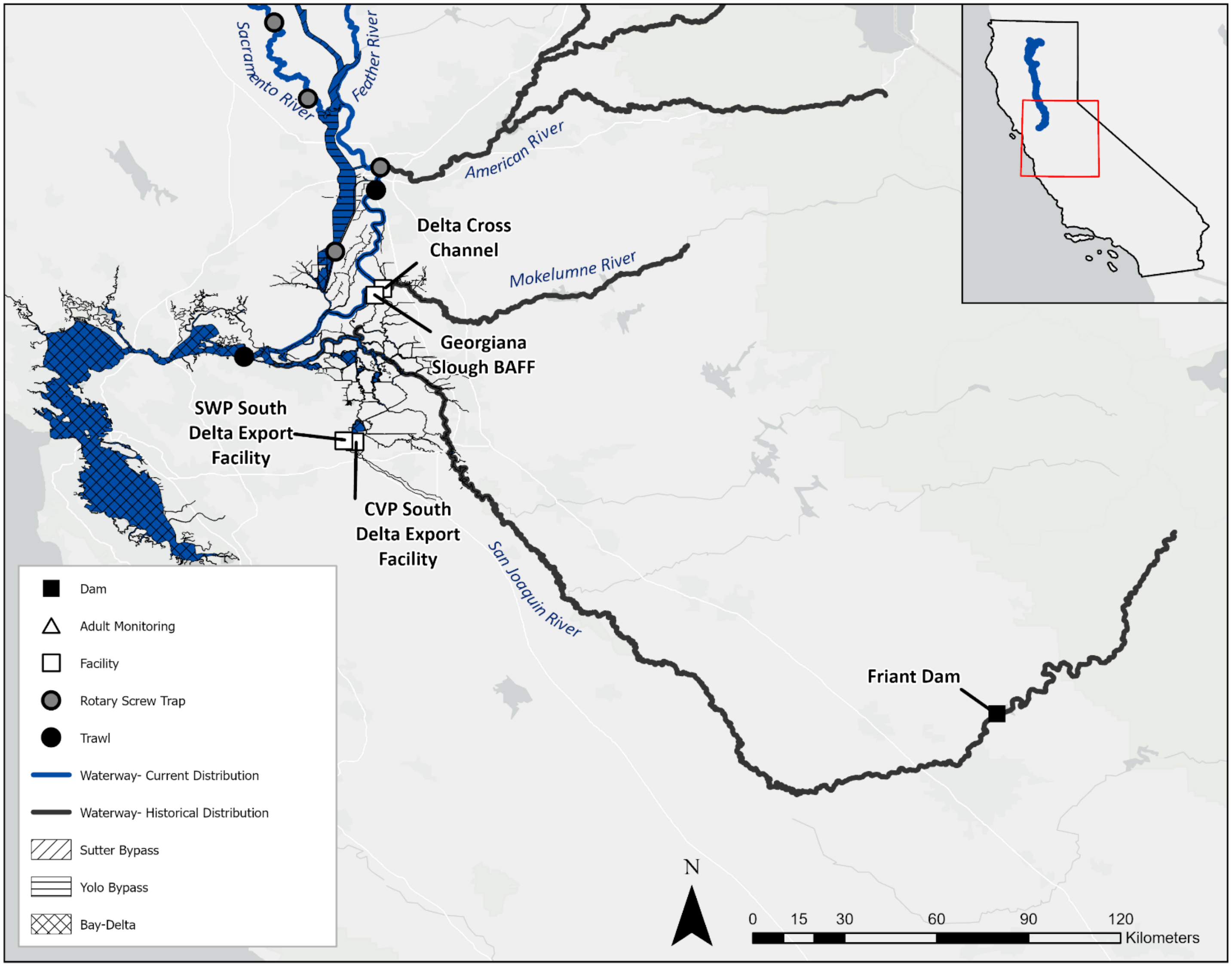

Figure 5. CHNSR current and historical distribution and relevant management related locations within and south of the Sacramento-San Joaquin Bay-Delta.

4.2.2. Population Status and Trends

The Central Valley of California is estimated to have supported CHNSR runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Historically, CHNSR were the second most abundant salmon run in the Central Valley, occurring in all major tributaries to the Delta including the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit rivers. Currently, self-sustaining populations are limited to Battle, Mill, Deer, and Butte creeks, with small populations found in the Feather and Yuba rivers as well as in Antelope, Clear, Big Chico, and Beegum (tributary to Cottonwood Creek) creeks (CDFG 1990; CDFG 1998; Goertler et al. 2020). Hatchery sustained populations are present on the Feather River, via the Feather River Fish Hatchery (FRFH), and the San Joaquin River, via the interim Salmon Conservation and Research Facility (CDFW 2022c).

Genetic analyses have shown that natural and hatchery-origin CHNSR within Mill, Deer, and Butte creeks retain their genetic integrity (Good et al. 2005; Garza et al. 2008). However, the Feather River CHNSR population has shown introgression with fall-run Chinook Salmon (CHNFR) due to overlaps in spatial and temporal run timing which are constrained by Oroville Dam (Good et al. 2005; Garza et al. 2008; DWR and CDFW 2023a).

4.2.2.1. Sacramento River Basin

Historically, CHNSR comprised 19 independent populations with 14 of those populations originating from the Sacramento River Basin alone (Lindley et al. 2004; NMFS 2022c, 2023c). Over the past century many of these independent populations have become extirpated due to the habitat degradation and loss of spawning and rearing habitat resulting from hydropower operations, water diversions, and recent droughts (Lindley et al. 2004; NMFS 2022c, 2023c). Currently, only four independent populations remain on the Sacramento River – Battle, Mill, Deer, and Butte creeks – in addition to smaller, dependent populations that likely persist from immigration from other streams.

The NMFS (2022c) and NMFS (2023c) Viability Assessments for CHNSR indicated that population declines have been substantial for all independent populations and are close to qualifying as catastrophic declines (>90% decline). Table 1 shows that there has been a precipitous decline in adult CHNSR returns in the recent decade for the Sacramento River, Feather River, Mill Creek, and Deer Creek with some increases on Clear and Battle creeks (Figure 6).

Table 1. CHNSR escapement trends as decadal averages across regions (CDFW 2023d). Butte Creek carcass survey estimates are included in the Butte Creek total escapement estimates and include pre-spawn mortalities. Total escapement estimates include the numbers of adult CHNSR returning annually in the Sacramento River system, including independent and dependent populations, and those propagated at the FRFH. Ranges included in parentheses.

Decade Average Timeframe	Sacramento River	Clear Creek	Battle Creek	Mill Creek	Deer Creek	Butte Creek	Feather River Fish Hatchery	Total Escapement
2001-2010	152 (0-621)	87 (0-200)	170 (73-291)	929 (237-1,594)	1,331 (140-2,759)	10,977 (1991-18,670)	3,118 (989-8,662)	16,218 (4,446-30,697)
2011-2020	61 (0-414)	121 (8-659)	256 (30-799)	343 (80-768)	420 (90-830)	6,837 (515-16,782)	2,589 (532-4,294)	10,685 (1,591-23,810)

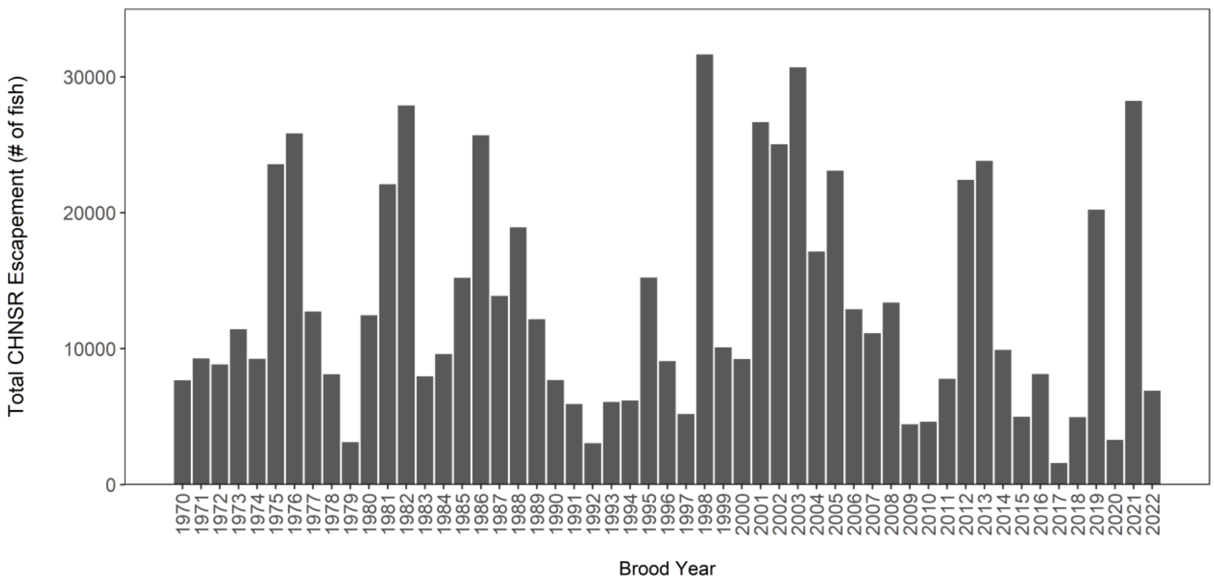

Figure 6. Total Sacramento River system annual CHNSR escapement estimates for brood years 1970-2022 (CDFW 2023d). Escapement estimates include the number of adult CHNSR returning annually in the Sacramento River system, including independent and dependent populations, and those propagated at the FRFH. Butte Creek carcass survey estimates are included in total escapement estimates and include pre-spawn mortalities. In 2021, an estimated 19,773 of 21,580 CHNSR died in Butte Creek prior to spawning.

4.2.2.1.1. Juvenile Production Estimate Development

The 2020 SWP ITP Condition of Approval 7.5.2 required DWR to convene a team to develop a monitoring plan to continue existing and conduct new CHNSR monitoring to obtain the necessary data to inform development of a draft CHNSR JPE by March 31, 2024 (CDFW 2020d). As a result, a CHNSR JPE Core Team was established with membership from DWR, CDFW, NMFS, Reclamation, USFWS, and SWP Contractors. In 2021, the Core Team began a structured decision-making (SDM) approach to develop a monitoring plan that includes juvenile and adult monitoring needs on Clear, Battle, Mill, Deer, and Butte creeks as well as Yuba, Feather, and Sacramento rivers.

Additionally, methods to improve the accuracy of identifying CHNSR are underway as a result of the 2020 SWP ITP Condition of Approval 7.5.2. These methods include 1) developing a new probabilistic length-at-date (PLAD) model to improve current LAD run identification methods and 2) conducting rapid genetic identification of CHNSR using the Specific high-sensitivity Eezymatic reporter UnLOCKing (SHERLOCK) methodology (Baerwald et al. 2023) that will be verified with more traditional genetic techniques (Campbell et al. 2014). Together, the new and existing monitoring combined with additional methods to accurately identify CHNSR will be used to produce a CHNSR JPE. Once developed, the CHNSR JPE will serve a similar purpose as the existing CHNWR hatchery and natural-origin JPEs, which are used by NMFS and CDFW in developing minimization measures to reduce loss of CHNWR at the CVP and SWP export facilities in the south Delta. The 2024 SWP ITP carries this CHNSR JPE effort forward under Condition of Approval 7.9.3, which extends the deadline for developing the CHNSR JPE until 2026 (see Section 6.1.4; Condition of Approval 7.9.3).

4.2.2.2. San Joaquin River Basin

San Joaquin-origin CHNSR are suggested to have once been one of the largest runs of any Chinook Salmon on the West Coast, with estimates averaging 200,000 to 500,000 adults returning annually (CDFG 1990). However, naturally produced CHNSR were extirpated from the San Joaquin River in the late 1940s, with only remnants of the run persisting through the 1950s in the Merced River (Yoshiyama et al. 1998). In recent years, there has been some evidence of phenotypic CHNSR occurring in the Stanislaus, Tuolumne, and Merced rivers, based on arrival and spawn timing; however, it is unclear if these salmon are residuals of the CHNSR population or if they are strays from other river basins (Franks 2014; NMFS 2016c, 2019a).

As a result of the 2006 *National Resources Defense Council* (*NRDC), et al. v. Kirk Rodgers, et al.* settlement, the federal Implementing Agencies (United States and the CVP Friant Division contractors) were directed to implement the San Joaquin River Restoration Program (SJRRP) to establish a nonessential, experimental population of CHNSR in the San Joaquin River below Friant Dam (78 FR 79622; SJRRP 2015). NMFS prepared a 10(j)/4(d) rule pursuant to the ESA to ensure that reintroduction would not impose more than “de minimus water supply reductions, additional storage releases, or bypass flows on unwilling third parties.” Under the settlement, third party is defined as persons or entities diverting or receiving water pursuant to applicable State and federal laws; this includes CVP contractors outside of the Friant Division of the CVP and SWP Contractors (Pub. L. 111-11, 123 Stat. 1349 (2009)). The 10(j) rule identified the CHNSR released from the SJRRP to be an experimental population not essential to the continued survival of the whole CHNSR ESU. Each CHNSR released is marked with an adipose fin-clip and a coded-wire tag (CWT) so that these fish can be distinguished from all other hatchery Chinook Salmon release groups as they are exempt from take prohibitions. Any loss of these fish at either the CVP or SWP export facilities does not count towards take of CHNSR.

The reintroduced population on the San Joaquin River is the only notable change in distribution since the initial CDFW status review (CDFG 1998), with juvenile releases of CHNSR beginning in 2014 and the first documented returning adults in 2019 (see Section 4.2.9.2.1 – San Joaquin River).

4.2.3. Extinction Risk

In the Candidate Species Status Report, CDFW (1998) cited habitat loss, low diversity, restricted range, and low abundance as major factors contributing to the listing of CHNSR under CESA. The NMFS (2014) Recovery Plan for CHNSR identified ongoing threats to the federal ESU as small population sizes, loss of habitat, water operations, climate variation, and limited spatial distribution within the Central Valley, described as lack of diversity groups within the ESU (NMFS 2014). These threats have contributed to declining abundances as well as limited resilience, or the ability of populations to recover after disturbance and environmental change. This loss of resilience further increases extinction risk of individual populations and the ESU as a whole.

The few remaining populations of CHNSR are small, isolated, and lack spatial diversity. The four demographically independent populations of CHNSR, in Battle, Deer, Mill, and Butte creeks, have seen declining trends in abundance. Dependent populations in other tributaries to the Sacramento River support few spawners, which appear to be primarily strays from independent populations and the FRFH.

The NMFS (2016c) 5-year review of the Central Valley CHNSR ESU determined that the ESU remains at a moderate risk of extinction based on the severity of the drought and low observed escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015. In response to declines in escapement, NMFS and CDFW have developed a draft Emergency CHNSR Action Plan, which aims to identify and outline targeted efforts vital for stabilizing populations most at risk (i.e., Mill, Deer, and Butte creeks; NMFS 2019a).

NMFS (2022c) determined that CHNSR independent populations showed substantially lower total population sizes and mean escapement from the previous assessment in 2015 and elevated the ESU to a moderate to high risk of extinction. NMFS elevated CHNSR populations in Mill, Deer, and Battle creeks from a low/moderate risk of extinction to a high risk of extinction and determined that the Butte Creek population remains at a low risk of extinction but acknowledged population declines. Although data from the Yuba River were included in the previous assessment, no data were provided for escapement years 2015 to 2019 and therefore the Yuba River was omitted from the 2020 assessment (NMFS 2022c, 2023c).

Since the NMFS (2022c) and NMFS (2023c) assessments, CHNSR escapement numbers have indicated that CHNSR populations are continuing to decline. A recent mid-cycle viability assessment included the most current years of data (2019-2021) to reassess CHNSR populations (NOAA 2023). These new data considered a mass pre-spawn mortality event in 2021 in which an estimated 92% of Butte Creek CHNSR died due to a pathogen outbreak. This catastrophic loss and the determination of a high risk of population decline with the addition of the more recent data, led to the conclusion that the Butte Creek CHNSR population is now at a moderate/high risk of extinction. The new data also showed populations continuing to decline in Mill, Deer, and Battle creeks since the NMFS (2022c) and NMFS (2023c) viability assessments.

4.2.4. Egg and Fry Development

4.2.4.1. Temperature Management

Water temperature greatly influences the duration of egg incubation and time of emergence in different river drainages, with emergence occurring after the yolk sac is absorbed (Williams 2006). Approximately 900 to 1,000 thermal units are required for incubation of Chinook Salmon eggs (1 thermal unit = 1°C above freezing x 24 hours; Raleigh et al. 1986). Based on CHNSR redd surveys and RST data from Battle and Clear creeks, 1,850 Daily Temperature Units (DTUs) are normally required for development, emergence, and capture of CHNSR in the RSTs (Giovannetti and Brown 2008; CDFW 2022d).

Water temperatures are typically warmer in Butte Creek than in Mill and Deer creeks. In Butte Creek, juvenile CHNSR first appear in late November, with juvenile emergence continuing through January (McReynolds et al. 2006). However, in Mill and Deer creeks where most adults spawn at higher elevations, juveniles emerge from January through March, up to six months after the onset of spawning (Johnson and Merrick 2012).

4.2.4.2. Dewatering

Stable and continuous river flows are important to the early life history (egg incubation to emergence from the gravel) of salmonids. If redds are dewatered or exposed to warm, deoxygenated water, incubating eggs and/or larval fish may not survive. Dewatering can occur with any reduction in flow. On the upper Sacramento River, the transition from summer to winter flow regimes involves flow reductions from September to November as less water is needed for agricultural purposes (Revnak et al. 2017). Spawning CHNSR (mid-August through mid-October) are at particular risk because redds constructed in shallow areas are susceptible to dewatering under typical flow reduction actions by Reclamation that occur beginning in late August as agricultural water demands decrease (Revnak et al. 2017).

4.2.5. Rearing and Outmigrating Juveniles in the Upper and Middle Sacramento River System

4.2.5.1. Juvenile Migration and Rearing

Sacramento-origin juvenile CHNSR utilize freshwater rearing habitat in natal tributaries, the mainstem Sacramento River and its flood bypass system, and the Delta. CHNSR express greater life history diversity in their juvenile life stages than other Central Valley Chinook Salmon runs by the wide range of sizes, timing, and ages at which CHNSR begin to emigrate from their natal tributaries. CHNSR juveniles can begin their ocean emigration as young-of-year (YOY) fry or parr, or they may over-summer and emigrate the next fall, winter, or spring as yearlings (CDFG 1998). YOY CHNSR typically emigrate soon after emergence as fry and rear for a few months in downstream habitats, such as the mainstem Sacramento River, accessible floodplains (e.g., Sutter or Yolo bypasses), or the Delta. YOY CHNSR may also rear in their natal habitat and out-migrate as parr or smolts. This diversity in emigration timing creates resiliency to catastrophic events and is crucial to preserve the integrity of the remaining CHNSR populations.

Emigration timing of juvenile CHNSR is greatly influenced by many factors including genetics and conditions CHNSR experience in their local environments (Munsch et al. 2019). In the upper Sacramento River, passage of juvenile CHNSR at RBDD occurs between October and May with an observed peak in passage occurring in December. The stage of development at which juveniles are observed emigrating in the upper Sacramento River varies greatly amongst years with fry accounting for 24 to 91% of the emigrant population as seen in brood years 2002 to 2012 (Poytress et al. 2014). For the same brood years, estimated juvenile CHNSR passage at RBDD was composed of on average 54% fry and 46% pre-smolt/smolt size-class fish (Poytress et al. 2014).

In Deer and Mill creeks, CHNSR can rear for up to seventeen months in freshwater habitat before starting their ocean migration (Johnson and Merrick 2012). In data collected from 1994 through 2010, YOY ocean migration typically occurred between November and June, with peak migration times in February and March. For yearlings, the migration window spans from October through June, with a bulk of the migration happening in November after the onset of the first fall rains (Johnson and Merrick 2012).

In Butte Creek, juveniles can be found year-round above Parrott-Phelan Diversion Dam (RM 44), which represents the top reach of CHNSR rearing habitat (Hill and Webber 1999). Emigration of YOY and yearlings on Butte Creek can be observed at Parrott-Phelan Diversion Dam RST between November and June (Cordoleani et al. 2019) with observations in the Sutter Bypass as late as mid-July (Hill and Webber 1999). In 2022, passage data from the Butte Creek RST showed that juvenile CHNSR emigration began in December and continued into mid-June, with a large pulse of fish moving in late-February and early-March (CalFish 2023a).

4.2.5.2. Juvenile Floodplain Use

In the Central Valley, more than 95% of floodplain habitats have been leveed and drained, primarily for flood control or conversion to agriculture (Lund et. al. 2010). Floodplains and other off-channel habitats can provide refuge from high flows and sediment loads, reduce competition, increase prey availability, and potentially reduce encounters with predators, all of which can improve rearing conditions and increase growth and survival rates (Sommer et al. 2001; Limm and Marchetti 2003; Moyle et al. 2007; Jeffres et al. 2008).

Emigration route selection and route availability are variable among populations of CHNSR. Juveniles exiting the spawning reaches of Butte Creek as YOY enter the Sutter Bypass and subsequently the Sacramento River, near the confluence with the Feather River; however, exit to the Sacramento River can also occur at the Butte Slough Outfall Gates (BSOG; RM 139). When Butte Creek stage is higher than that of the Sacramento River, the gates allow Butte Creek water to flow into the Sacramento River. These high Butte Creek flows are likely to coincide with CHNSR presence near the BSOG, allowing salmon entry into the Sacramento River. Acoustic telemetry data of juvenile Butte Creek CHNSR tagged and released at the Parrott-Phelan Diversion Dam demonstrates juvenile salmon entry into the Sacramento River through the BSOG, above Butte Creek’s primary confluence with the Sacramento River (RM 80; Garman 2020).

Juvenile CHNSR exiting Deer and Mill creeks also have alternative routes available to them during emigration to the Delta. YOY CHNSR exit Deer and Mill creeks beginning in November, with peak emigration in February and March (Johnson and Merrick 2012). Frequently during these months, increased flow associated with winter storm flows overtop the Sacramento flood relief structures, allowing juvenile entry into the flood bypass system. Peak emigration for yearling CHNSR exiting natal steams occurs October through December (Johnson and Merrick 2012). During this period, the Sacramento River overtops flood relief weirs less frequently; however, if Sacramento River flood flows occur during the yearling emigration period, alternative route availability would be similar to those described above.

4.2.6. Rearing and Outmigrating Juveniles in the Bay-Delta

The timing of CHNSR juvenile entry into the Delta is highly variable. Williams (2006) suggested that CHNSR Delta entry timing can range from December to May and age at entry appears to be influenced by the timing of winter high flow events with a higher proportion of juveniles entering the Delta earlier in the season in wet years compared to dry years. In the lower Sacramento River, observation data from the RSTs located at Tisdale, Knights Landing, and the City of Sacramento detected YOY LAD CHNSR entering the Delta between the months of November and May (CalFish 2023a; CalFish 2023c). Peak migration appears to have occurred in April, with the exception of Tisdale, which also has seen a spike in migration in December. Additionally, historical presence of YOY LAD CHNSR at Sherwood Harbor and in Sacramento beach seines has occurred as early as November and ends by late June (SacPAS 2023a). Genetic data from Sherwood Harbor trawls confirm genetically-identified natural-origin CHNSR enter the Delta from December to June, with a peak in migration occurring in April (Buttermore et al. 2021b; Brian Pyper, personal communication, 5/2023).

Johnson and Merrick (2012) found large numbers of yearling CHNSR entering the Sacramento River from Mill and Deer creeks in October and November. CHNSR mark and recapture-based studies on Butte Creek suggest that rearing versus migratory behavior can be highly variable between individuals within the same brood year and across water years and that emigration cues can be both flow and temperature related. While a portion of the emigrating population may leave Butte Creek as fry, another portion of the population may decide to rear in Butte Creek for extended periods and not enter the Sacramento River until May or June. Some individuals were observed rearing for 80 days and those that exhibited this behavior tended to rapidly emigrate through the Delta (Hill and Webber 1999; Ward et al. 2004a, 2004b, and 2004c). For Mill, Deer, and Butte creeks, juveniles appear to be entering the Sacramento River during periods when conditions are not always ideal for rearing or downstream migration. Butte Creek juvenile CHNSR were recently found to have distinct outmigration timing from CHNSR in Mill and Deer creeks, exhibiting a more truncated and relatively late outmigration period that can extend into May (Thomson et al. 2024). This later migration timing could expose Butte Creek juvenile CHNSR to worsened environmental conditions compared to other CHNSR populations.

As is the case for CHNWR, CHNSR are subject to emigration delays, entrainment, impaired growth, and direct mortality while migrating through the Delta due to routing through the DCC gates and Georgiana Slough, and into Project facilities (see Section 4.1.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). Actions including the 2020 SWP ITP Condition of Approval 8.9.1 requiring DWR to install and operate a migratory barrier at Georgiana Slough are designed to minimize impacts associated with

Project facilities by increasing survival for emigrating juvenile CHNWR and CHNSR that encounter the Sacramento River-Georgiana Slough junction (CDFW 2020d).

4.2.7. Juvenile Ocean Entry

Migration of juvenile Chinook Salmon from the lower Sacramento River and Delta into San Francisco Bay is monitored using USFWS trawl surveys at Chipps Island. USFWS trawl data has shown that the various juvenile CHNSR life histories and rearing strategies culminate in average saltwater entry in the spring, with mean monthly catch at Chipps Island peaking in April or May (Brandes and McLain 2001; Williams 2006). Juveniles entering the Delta prior to April and May are likely searching for places to rear and grow prior to saltwater entry. Genetic data from Chipps Island trawls confirm that juvenile CHNSR exit the Delta from March to June, peaking in April and May (Buttermore et al. 2021a; Brian Pyper, personal communication, 5/2023).

4.2.8. Adult Migration and Holding

4.2.8.1. Adult Migration

Adult CHNSR leave the Pacific Ocean to begin their upstream spawning migration typically at age-3, with a smaller proportion leaving at age-2, age-4, and, to a lesser extent, age-5 (NMFS 2000a; Palmer-Zwahlen et al. 2019). Boles et al. (1988) cites water temperatures less than 18.3°C (64.9°F) as preferable for adult Chinook Salmon migration, and Lindley et al. (2004) report that water temperature reaching 21.1°C (70°F) acts as a migration barrier and leads to stress. Studies have also shown that exposure of adult Chinook Salmon to constant or average temperatures greater than 15.5°C (59.9°F) result in a detrimental effect on adult survival and egg viability (Windell et al. 2017). In addition to temperature barriers, dissolved oxygen concentrations can also create barriers to migration, with adult Chinook Salmon on the San Joaquin River exhibiting avoidance response when dissolved oxygen is below 4.2 mg/L (Hallock et al. 1970; Carter 2008).

Adult CHNSR enter the Estuary in late January to begin their upstream migration and continue to proceed up the Sacramento River with spawning occurring through October (Yoshiyama et al. 1996, 1998; NMFS 1998; Moyle 2002; Johnson et al. 2011). CHNSR are sexually immature when they enter freshwater, with their gonads maturing over the summer holding period (Marcotte 1984; Moyle 2002).

Adult CHNSR migrate through the Delta, the Sacramento River below Keswick Dam, and tributaries of the Sacramento River to access their natal tributaries and find over-summer holding habitat. CDFW, DWR, and USFWS currently monitor CHNSR tributary entry on the Yuba River and on Butte, Deer, Mill, Antelope, Clear, Battle, and Cottonwood creeks. Based on hydroacoustic and video monitoring in Mill Creek, DWR and Reclamation (2012) back- calculate adult CHNSR migration timing near Fremont Weir to occur between January and mid to late May (Johnson et al. 2011). Recent video monitoring efforts in tributaries of the upper Sacramento River show CHNSR entry into Sacramento River tributaries occurs as early as late February and as late as mid-July, with a peak in presence in May (Killam 2012; YCWA 2014; Killam et al. 2015).

4.2.8.2. Adult Holding and Spawning

Adult CHNSR hold over-summer in deep pools as they mature. Historical holding habitat for CHNSR adults included accessible streams above approximately 610 meters (m; 2,000 ft) above sea level where water temperatures remained cool through summer months (CDFW 2022d). Due to agricultural diversions, dams, and habitat degradation, holding habitat is often limited currently to lower elevations where managed reservoir releases (e.g., Clear Creek, Feather River) or imported cold water (e.g., Butte Creek) are provided.

Preferred holding pools are at least 1 to 3.3 m (3-10 ft) deep with water velocities between 0.15 and 0.4 m/s (0.5-1.3 ft/s; Puckett and Hinton 1974; Marcotte 1984). Adult CHNSR prefer to hold in deep pools with bedrock substrate and avoid cobble, gravel, sand, and especially silt substrate (Campbell and Moyle 1990). Target temperatures for adult holding include a 7-day average of the daily maximum (7DADM) below 15°C (59°F), with temperatures consistently greater than 20°C (68°F) considered lethal (USEPA 2003). However, temperature tolerance appears to differ among populations. Experienced CDFW biologists working in Butte Creek typically regard sustained average daily temperatures above 19.4°C (67°F) as the threshold above which disease pathogens become more virulent and pre-spawn mortality increases in holding pools (Ward 2004).

CHNSR holding habitat on Clear Creek is limited to downstream of Whiskeytown Dam (RM 18.3), which acts as a complete barrier to fish passage (Bottaro and Chamberlain 2019). On Battle Creek, CHNSR holding is limited by the Eagle Canyon Dam on the North Fork (5.23 RM north of the fork) and the Coleman Diversion Dam on the South Fork (2.54 RM north of the fork; Schraml and Earley 2020). Holding habitats on Mill Creek are located between RM 18 and 48. On Deer Creek, CHNSR are found holding in 35 km of stream below Upper Deer Creek Falls (RM 28; Killam et al. 2017). Holding habitats on Butte Creek extend a distance of over 13 RM from the Parrot-Phalen Dam (RM 44) to the Quartz Bowl Pool (RM 58.5) where a natural fish barrier prevents further upstream movement (Garman 2014). Butte Creek holding and spawning areas are lower in elevation (below 284 m [931 ft]) than Deer and Mill creeks, which can expose CHNSR to warmer temperatures, a situation likely to be exacerbated in the future by climate change (NMFS 2014). Holding habitat on the Feather River is limited to the Low Flow Channel, a 12 km stretch between the outlet of the Thermalito Afterbay (RM 59) and the fish barrier dam (RM 66; PFMC 2019). In the Yuba River, CHNSR holding occurs in deep pools (up to 40 ft in depth) in the “Narrows” reach of the river just downstream of Englebright Dam (RM 24) and Yuba County Water Agencies’ Narrows 2 Powerhouse (YCWA 2014).

Pre-spawn mortality of holding CHNSR appears to occur annually in holding habitats and is influenced by a wide range of factors including high water temperature, high population density (i.e., density-dependent mortality), and low habitat availability (Garman 2014; PFMC 2019). On the Feather River, pre-spawn mortalities are attributed to a lack of suitable habitat with high population densities of holding and spawning adults, both CHNSR and CHNFR, in habitats adjacent to the hatchery (PFMC 2019). On Butte Creek, elevated temperatures and adult densities are major contributors to observed pre-spawn mortality (Garman 2014).

CHNSR spawning begins in mid-August and continues through mid-October, with females laying an average of approximately 4,200 eggs in gravel stream beds (CDFG 1998; Moyle 2002; Giovannetti and Brown 2008). On Butte Creek, spawning occurs mid to late-September through October. Peak spawning on Butte Creek is the last week in September or the first week in October, depending on annual variation in ambient air temperatures (Garman 2014). Observed timing of CHNSR spawning on Deer and Mill creeks is mid-September through mid-October (Johnson and Merrick 2012). Harvey (1995, 1996, 1997) observed spawning occurring at higher elevations first in Deer Creek, which is characteristic of coolest reaches, with spawning progressing downstream over the spawning season. Similar CHNSR spawn timing has been observed on Clear and Battle creeks and the Yuba River, where USFWS and Pacific States Marine Fisheries Commission conduct extensive monitoring of spawning locations and timing. Spawning on the Yuba River has been reported as early as September 1 (YCWA 2014). Collection of adult CHNSR for the FRFH broodstock occurs mid-September through the end of September (see Section 4.2.9.1 – Feather River Fish Hatchery Production Efforts).

Natural spawn timing of CHNSR can overlap with CHNFR in tributaries where both are found using the same habitat. These areas of overlap include the Sacramento River mainstem, Deer Creek, Mill Creek, and the Feather River. CHNFR are found in Butte Creek, but their spawning reaches are limited to below the Parrot-Phalen Dam (RM 44) fish ladder due to the installation of an exclusion structure within the fish ladder once CDFW determines CHNSR are present. Spawning of CHNSR and CHNFR occurring in the same habitat reaches can lead to density-dependent mortality caused by redd superimposition. Density-dependent mortality can decrease juvenile production and potentially lead to population level impacts (PFMC 2019).

Spawning and incubation habitat for CHNSR includes gravel bedded reaches within Sacramento River tributaries. Adults are semelparous and often spawn in gravel beds near the tail of holding pools, in water depths of 0.25 m (0.8 ft) or greater (Puckett and Hinton 1974) and water velocities between 0.3 and 1.3 m/s (0.98-4.3 ft/s) prior to dying (McReynolds et al. 2006). Preferred spawning substrate is a mixture of gravel and cobble approximately 2.5 to 10.0 centimeters (cm) in diameter (Reclamation 2010) that contains minimal (i.e., <5%) fine sediment (Raleigh et al. 1986; Kondolf 2000). Optimal temperatures for spawning are less than 13°C (55°F; USEPA 2003).

4.2.9. Supplementation and Reintroduction Efforts

4.2.9.1. Feather River Fish Hatchery Production Efforts

Following the construction of dams, which blocked historical habitat in the Sacramento and San Joaquin river basins, CHNSR began spawning in the same reaches where CHNFR historically spawned, increasing competition and hybridization between the runs. Additionally, historical hatchery practices contributed to hybridization between CHNSR and CHNFR.

DWR constructed the FRFH in 1967 to mitigate for the loss of Chinook Salmon and steelhead spawning and rearing habitat caused by the construction of the Oroville Dam. In addition to owning the FRFH, DWR provides funding to CDFW to conduct fish production and distribution operations and maintain the FRFH. The production of CHNSR at the FRFH is managed as an integrated-recovery program with an annual production target of two million CHNSR smolts to meet DWR mitigation requirements (CDFW 2022c). Former hatchery practices, as well as habitat limitations associated with the Oroville Dam, have led to introgression between CHNSR and CHNFR at the FRFH and in the Feather River (Hedgecock et al. 2001, 2002).

In 2012 the California Hatchery Scientific Review Group reviewed existing hatchery practices and released a report with recommendations to modify hatchery strategies to reduce impacts from hatchery operations on ESA and CESA listed species (CA HSRG 2012). CDFW, in coordination with DWR, has incorporated many of these recommendations at the FRFH. To address concerns over introgression of CHNSR and CHNFR in hatchery broodstock, CDFW marks adult Chinook Salmon returning to the FRFH between April through June (representing the early arriving phenotype) with a pair of uniquely numbered external Hallprint tags. Following marking, CDFW releases these early arriving Chinook Salmon back into the Feather River Low Flow Channel to hold during the summer. During CHNSR spawning operations at FRFH, CDFW spawns only Hallprint-tagged adult Chinook Salmon that re-enter the FRFH in the fall for the production of FRFH CHNSR smolts. Post hoc analysis of CWTs extracted from adipose fin-clipped, Hallprint-tagged Chinook Salmon spawned at FRFH are used to identify any CHNFR incidentally spawned with CHNSR. Any fertilized eggs collected from crosses of CHNSR and CHNFR (identified by CWT) are culled from production to reduce hybridization between runs (CDFW 2022c). Additionally, all CHNSR produced and released by FRFH are marked and tagged, following the California Hatchery Scientific Review Group recommendation, and are released in the Feather River except under the most extreme drought conditions (CDFW 2022c). A Hatchery and Genetic Management Plan that describes these and other FRFH CHNSR program actions intended to assess hatchery program impacts on ESA and CESA listed species has been drafted but not yet adopted (DWR and CDFW 2023a).

Although practices are in place to reduce impacts associated with FRFH operations, FRFH CHNSR may still impact natural-origin CHNSR populations through: (1) introgression with Feather River CHNFR due to overlap in spawn timing and habitat limitations within the spawning reaches of the Feather River Low Flow Channel; (2) straying of FRFH CHNSR into natural-origin CHNSR spawning habitat, though this has been greatly reduced with the transition to in-river Feather River releases of FHFH CHNSR; and (3) disproportionately high levels of returning hatchery spawners in comparison to natural-origin fish, in part due to differences in survival of natural-origin and hatchery-origin eggs and juveniles (NMFS 2016c).

4.2.9.2. Reintroduction Efforts

4.2.9.2.1. San Joaquin River

To support the SJRRP reintroduction effort, Reclamation, in partnership with USFWS, NMFS, DWR, and CDFW, is responsible for restoring and maintaining fish populations in good condition in the San Joaquin River between Friant Dam and the confluence of the Merced River. Efforts to restore populations include improving fish passage, in-stream flows, and habitat within this reach, while also developing a plan to release hatchery CHNSR into these restored areas (Sutphin et al. 2019).

The SJRRP began releasing hatchery-origin CHNSR in April 2014 when an estimated 60,114 juvenile CHNSR translocated from the FRFH and released at the downstream end of the restoration area (Sutphin et al. 2019). CHNSR hatchery releases from FRFH continued through 2016 until the construction of an interim facility was complete and became available for spawning of mature SRJRRP broodstock and production of juvenile CHNSR for release. Between 2014 and 2023, the SJRRP has released over 1,000,000 juvenile CHNSR into the restoration area (SacPAS 2023a). There are plans to increase CHNSR production to 1,000,000 smolts annually once construction of the permanent Salmon Conservation and Research Facility is complete (Patrick Ferguson, personal communication, 7/2024).

Since the implementation of the SJRRP, several monitoring programs in the lower San Joaquin River and Delta, including the Mossdale trawl and the CVP and SWP export facilities, have recovered CWT juvenile CHNSR released from the SJRRP between February and June, consistent with the emigration timing of Sacramento-origin CHNSR (CDFW 2020c; SacPAS 2023b).

On April 9, 2019, the SJRRP recovered the first adult CHNSR since the program began with an additional 22 adult CHNSR captured in April and May 2019 (Sutphin et al. 2019). Adult CHNSR have returned to spawn in the restoration area every year since, with 57 adults returning in 2020, 93 adults in 2021, and 11 adults in 2022 (NMFS 2021, 2022a, 2023a). These data may indicate some success in the restoration program and the potential for developing a CHNSR population on the San Joaquin River in the future.

4.2.9.2.2. North Fork Yuba River

The NMFS 2014 Recovery Plan for Central Valley salmonids, specifically Recovery Action YUR-1.1, prioritizes the need to develop and implement a program to reintroduce CHNSR and steelhead to historic habitats upstream of Englebright Dam (NMFS 2014). The NMFS 2014 Recovery Plan also states that the program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program. In December 2020, NMFS proposed a rule to authorize the reintroduction of CHNSR to the upper Yuba River above Englebright Dam (85 FR 79980) and issued a final rule in December 2022 (87 FR 79808). CDFW issued a consistency determination in July 2023 (No. 2080-2023-008-02; CDFW 2023c). California Governor Gavin Newsom's recently released strategy for California salmon population resiliency and aquatic ecosystem restoration (Salmon Strategy for a Hotter, Drier Future) also identified reintroduction of CHNSR in the North Fork Yuba River as Action 1.5 of California's Priority 1 to remove barriers and modernize infrastructure for salmon migration. Specifically, Action 1.5 priorities taking the first steps to re-establish CHNSR populations in the North Fork Yuba River by 2025 (Office of California Governor Gavin Newsom 2024a).

The goal of this reintroduction effort is to establish a viable and independent CHNSR population in historical habitat and increase the abundance, spatial structure, and diversity of CHNSR. The high-elevation habitat above Englebright Dam would be less vulnerable to the effects of climate change and an additional population in the upper Yuba River would increase species resilience in a warming climate with more variable precipitation and longer periods of drought. The reintroduced population is designated as a nonessential, experimental under the ESA, as is the population in the San Joaquin River below Friant Dam (78 FR 79622). Similar to the initiation of the SJRRP, FRFH CHNSR would serve as a donor source for reintroduction.

CDFW is leading CHNSR reintroduction efforts with the support of the Yuba Reintroduction Working Group formed in 2021 and comprised of representatives from NMFS, USFWS, United States Forest Service, Yuba County Water Agency, Placer County Water Agency, Nevada Irrigation District, Pacific Gas and Electric Company, Mechoopda Indian Tribe, Strawberry Valley Rancheria, South Yuba River Citizens League, California Sportfishing Protection Alliance, Save California Salmon, and American Rivers. Current planning efforts include the development of the following pilot studies anticipated to begin fall 2024: 1) egg incubation; 2) juvenile collection and transport; 3) habitat characterization and utilization; and 4) parentage-based tagging (Duane Linander, personal communication, 8/2024).

4.3. Additional Chinook Salmon Stressors

4.3.1. Juvenile Stranding

Juvenile CHNWR and CHNSR can become stranded as a result of fluctuations in water released from dam operations, storm events, flood control structures, and other infrastructure that causes abrupt changes in flow (Beccio 2016; CDFW 2017). Sudden changes in flow or unnatural flow patterns may inhibit natural migration cues, causing fish to become trapped in isolated pools or channels that at higher flows were connected to the Sacramento River (Revnak et al. 2017). Stranding can lead to direct mortality when these areas drain or dry up. Indirect mortality can result through increased susceptibility to predation or water quality deterioration in shallow or stagnant stranding locations (Revnak et al. 2017).

CDFW conducted a juvenile stranding monitoring program on the Sacramento River below Keswick Dam from the summer of 2016 to the spring of 2017. Sixty-nine stranding sites were surveyed between Keswick Dam (the uppermost limit of anadromy on the Sacramento River) and Tehama Bridge (a total of 73 RM). CDFW rescued a total of 240 juvenile CHNWR and 19,892 juvenile CHNSR and returned them to the Sacramento River. One adult CHNWR and eleven adult CHNSR or CHNFR were observed dead in a stranding pool (Revnak et al. 2017).

CDFW has also documented adult and juvenile Chinook Salmon stranding in the Sacramento and Yolo bypasses following Sacramento River flooding events (Beccio 2016; CDFW 2017). From 1958 to 2016, an estimated 4,515 juvenile Chinook Salmon, of all runs and life stages, have been collected by CDFW downstream of the Fremont Weir within the Yolo Bypass. In the Tisdale Bypass, which drains into the Sutter Bypass, an estimated 440 juvenile Chinook Salmon, of all runs and life stages, have been collected downstream of the Tisdale Weir between 1986 and 2016 (Beccio 2016). These numbers do not include un-surveyed swales and pools within the bypass, as rescue efforts were limited to the spill aprons and close adjacent areas of the Fremont and Tisdale weirs (Beccio 2016). During water year 2018, 197 juvenile Chinook Salmon were collected in the Fremont Weir stilling basin following an overtopping event (Beccio 2019a). The Sacramento River overtopped Fremont Weir three times during water year 2019 with an estimated 1,407 juvenile Chinook Salmon collected from the Fremont Weir stilling basin and 27 juvenile Chinook Salmon collected from the scour pool downstream of the adult fish passage structure (Beccio 2019b). In water year 2019, an additional 3,829 juvenile Chinook Salmon were collected from the Sacramento Weir stilling basin and 108 juvenile Chinook Salmon were collected from the scour pond near the Sacramento Weir. In water year 2023, an estimated 618 juvenile Chinook Salmon were collected from the Fremont Weir stilling basin (Marc Beccio, personal communication, 6/2023). It is likely that significant numbers of stranded juvenile Chinook Salmon are predated upon prior to rescue and significantly more juveniles are stranded than have been identified in un-surveyed waters within the bypasses. Juvenile Chinook Salmon rearing within the bypasses can experience delayed Delta entry with an increase in their travel distance if they do not exit the bypasses on the receding hydrograph of the river. This delay may subject juveniles to unfavorable hydraulic conditions in the Delta. Current Sacramento River hydrology is flashy, with large swings in flow over short periods of time. Fish rearing during high flows and exiting as bypass inundation subsides can be exposed to decreased flows and experience lower survival (Perry 2010; Cordoleani et al. 2019; Notch et al. 2020). The delay in Delta entry can also lessen the benefit of protections by CVP and SWP operational triggers designed to decrease entrainment of emigrating salmonids into the interior Delta.

4.3.2. Adult Stranding

Adult CHNWR and CHNSR migrating through freshwater require enough flow for passage and olfactory cues as well as adequate water quality and temperature (CDFG 1998). Attraction of adults into terminal waterways and migration barriers results in delays or stranding, ultimately affecting spawning success. Flood bypasses and drainage canals are known stranding areas for CHNWR and CHNSR as documented by CDFW fish salvage efforts (Beccio 2016; Gahan et al. 2016; CDFW 2017).

Adult CHNSR fish kills due to stranding have been observed in the Sutter Bypass and on the Sacramento River at the BSOG because of poor passage conditions and attraction into the outfall gates, respectively (Garman 2018). Adult CHNSR have been rescued from the Yolo Bypass during low Sacramento River flows (as measured at Freeport), suggesting tidal related flow fluctuation at the confluence of the Sacramento River and the Cache Slough Complex creates strong attraction cues for migrating adults (CDFW 2017). Additionally, the Yolo Bypass has been identified to increase route timing or prevent access to holding and spawning habitats for entrained adults salmonids. Flows from the Yolo Bypass/Cache Slough Complex junction into the Sacramento River (near RM 14) as low as 1,000 cubic feet per second (cfs) are suggested to attract adult Chinook Salmon and sturgeon (*Acipenser spp.*) migrating to spawning reaches of the Sacramento River and associated tributaries (DWR 2015b). Adult salmonids can also enter the Yolo Bypass via the northern extent by the Fremont Weir, which acts as a flood relief structure for the Sacramento River. When Sacramento River stage exceeds the top of the Fremont Weir, water spills over and inundates portions of the Yolo Bypass. This influences adult CHNWR and CHNSR migration by: 1) increasing attraction flows into the Yolo Bypass, 2) providing passage through the Yolo Bypass to the Sacramento River above the confluence with the Feather River and Sutter Bypass/Butte Creek, and 3) stranding fish in the Yolo Bypass as flows recede. Presence of adult CHNWR and CHNSR has been confirmed within the Yolo Bypass throughout their migration window through operations at Wallace Weir and post-flood monitoring below the Fremont Weir (Beccio 2016; Gahan et al. 2016).

Flows around Delta water conveyance structures, such as the DCC, have also been demonstrated to delay or strand adult Chinook Salmon attempting to return to natal streams. An acoustic telemetry study of CHNFR movement throughout the Delta highlighted route confusion when interacting with the DCC and associated flows (McKibbin 2019). In this study, San Joaquin River origin adult CHNFR were implanted with an acoustic tag and tracked as they moved through the Delta. Individuals interacting with the DCC and associated flow complexity experienced increased travel time during their migration to the spawning reaches of their natal streams (McKibbin 2019).

4.3.3. Pathogens

Juvenile Chinook Salmon are more susceptible to disease and parasites when exposed to unfavorable environmental factors such as poor water quality, contaminants, and low food availability (Lehman et al. 2020). Numerous pathogens have been documented within CHNWR and CHNSR ranges, including *Ceratonova shasta* (*C. shasta*), an intestinal parasite of salmonids that is a significant contributor to mortality of fish in the Pacific Northwest (Bartholomew et al. 1997). DWR and CDFW biologists on the Feather River speculate that *C. shasta* is responsible for killing up to half of the CHNSR juvenile population exiting the Feather River each year due to the overlap in peak infectious period with juvenile presence (Harvey et al. 2022). There are also some indications that *C. shasta* infection rates may also be high in the Sacramento River (Harvey et al. 2022).

During drought conditions in 2015, USFWS conducted a pilot sentinel trial in late September to assess potential disease risk to CHNWR fry (Foott 2016). Results of this study showed that sentinel juvenile late fall-run Chinook Salmon (CHNLFR) exposed to the Sacramento River for five days in late September at Balls Ferry and Red Bluff were infected with *C. shasta*. Eighty juvenile CHNWR were collected at the RBDD RST between October 15 and November 19 of the same year and sampled for histological examination. *Ceratonova shasta* was observed in 15% of the samples (Foott 2016). NMFS (2016d) concluded that *C. shasta* infection could have impaired survival of emigrating CHNWR fry in 2015 because *C. shasta* is a progressive disease and early-stage infections could develop into disease states in these fish over time.

Since CHNWR comprise a single population with low abundance, naturally occurring pathogens pose a greater threat to this population than to other Central Valley salmon runs. If CHNWR population abundance were to decline even further, the probability would increase that disease outbreak could significantly impact the remaining population (NMFS 2016d). Migrating juveniles may be particularly susceptible to the effects of pathogens since those effects may be magnified by environmental changes that have occurred in the Sacramento River and Delta over the last 100 years. Bartholomew et al. (2022) identify river water temperature and flow conditions as the primary environmental drivers for disease, including *C. shasta* infections. Higher water temperatures lead to increased rates of parasite replication, which correlates with disease progression, severity, and mortality.

The 2020 SWP ITP Condition of Approval 7.5.3 required DWR to initiate pathogen monitoring to inform the source and magnitude of CHNSR loss prior to Delta entry by conducting studies in the Sacramento and Feather rivers and Delta (CDFW 2020d). By expanding monitoring across *C. shasta* life stages, DWR and CDFW's goal is to develop a model that evaluates environmental covariates to determine population level infection and mortality rates. Monitoring will also help inform other pathogen issues in the Sacramento River watershed, including *Parvicapsula minibicornis* (glomerulonephritis), *Tetracapsuloides bryosalmonae* (proliferative kidney disease [PKD]), *Ichthyophthirius multifiliis* (white spot disease), *Flavobacterium columnare* (columnaris), *Renibacterium salmoninarum* (bacterial kidney disease [BKD]), and *Salmonid novirhabdovirus* (infectious hematopoietic necrosis [IHN]). DWR will continue to support pathology monitoring efforts through DWR's newly developed Feather River Program, which will incorporate pathology monitoring and research focused on *C. shasta* in the Feather River. DWR will also continue to fund an Environmental Scientist within CDFW through 2026 to conduct monitoring on the Feather River and tributaries of the Sacramento River as well as other research efforts conducted by University of California at Santa Cruz, USFWS, Oregon State University, and Pacific States Marine Fisheries Commission (Grimaldo 2024b).

4.3.4. Contaminants

Contamination can lead to either acute toxicity, which results in death when concentrations are above a known threshold, or in chronic toxicity, which results from long-term exposure at lower concentrations. Chronic exposure has sublethal effects that reduce the physical health and development of an organism and can lead to behavioral changes (NMFS 2016d). Common forms of contaminants found in the Sacramento River Basin are insecticides such as pyrethroids, organochlorines, organophosphates, and phenylpyrazoles (Anzalone et al. 2022), and pharmaceuticals and personal care products such as antibiotics and microplastics (Fong et al. 2016). These contaminants can enter waterways through various mechanisms; however, the most common form of entry is through surface run-off (Anzalone et al. 2022; Fuller et al. 2022). Contaminants can enter CHNWR and CHNSR exposed via direct contact with the scales and gills or through consumption of contaminated prey items (Anzalone et al. 2022).

In the Sacramento River Basin, salmonids are exposed to a multitude of contaminants, but their exposure risk largely depends on where they rear and forage. In a recent study, salmon collected in the Yolo Bypass had significantly higher concentrations of organochlorines in their bodies than salmon collected in the Sacramento River, and salmon collected from the Sacramento River had a greater number of pyrethroid detections overall (Anzalone et al. 2022). It is presumed that these differences in contaminant types and levels result from the modes of transmission. For example, in the mid-20th century the use of organochlorine pesticides, like DDT, were common on farmlands across the United States. Even though the use of these pesticides is no longer legal, legacy impacts are still detectable in the soils and sediments of the Central Valley today (Fuller et al. 2022). When the Yolo Bypass floods, the disrupted soils release trace amounts of the organochlorines that can be directly absorbed by salmonids, or their zooplankton prey items as they rear on the floodplain (Anzalone et al. 2022). In the mainstem Sacramento River, pyrethrin pesticides are more commonly found in macroinvertebrates, another salmonid prey item, which rely on biofilms as a food source. Many of the biofilms in the Sacramento River are believed to contain pyrethrin residues which get ingested by macroinvertebrates and eventually passed to salmonids (Anzalone et al. 2022).

Juvenile salmon rearing in the Yolo Bypass may also experience increased accumulation of methylmercury than those reared in the Sacramento River (Henery et al. 2010). Juveniles reared on the Yolo Bypass also showed higher methylmercury levels per weight than the Sacramento River. Methylmercury poses a threat to the aquatic environment because it acts as a neurotoxin that bioaccumulates and biomagnifies in the food web. Floodplain inundation can mobilize mercury, which may result in increased methylmercury loads throughout the Delta and Estuary. Despite improvements to water quality in the Sacramento River and Delta, water pollution remains a threat to the conservation and recovery of all runs of Chinook Salmon and their habitat (Macneale et al. 2010; Meador 2013).

4.3.5. Predation

Predation is an ongoing threat to juvenile CHNWR and CHNSR throughout the Sacramento River and Delta where both non-native and native species prey on juvenile salmon (NMFS 2016c 2016d). Altered and simplified habitats, the presence of man-made structures, and altered flow regimes including Shasta Reservoir operations and water diversions in the Sacramento River and Delta contribute to increased predation levels by favoring predatory species and predator contact rates with prey (NMFS 2016d). Grossman et al. (2013) state there is clear evidence juvenile salmon are consumed by fish predators, and that the population of predators in the freshwater migratory corridor of juvenile CHNWR is large enough to effectively consume all juvenile salmon production. However, it is not clear what proportion of juvenile mortality can be directly attributed to piscivory. Specifically, in the context of extreme modification of the Sacramento River’s natural flow regime, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and overall reduction in historical salmon population size, predation may serve as the proximate mechanism of mortality in a large proportion of the population, but the ultimate causes of mortality and declines in productivity are less clear (Grossman et al. 2013). For example, stress caused by harsh environmental conditions or toxicants will render fish more susceptible to all sources of mortality including predation, disease, or physiological stress.

Nobriga et al. (2021) found a significant inverse relationship between inflows from the Sacramento and San Joaquin rivers and water temperatures in the Delta, reaffirming previous studies that reported low juvenile Chinook Salmon survival (due to increased predation and reduced swimming ability) as seasonal water temperatures approach 20°C (68°F) during the spring (Kjelson and Brandes 1989). In contrast, higher flows and associated cooler water temperatures reduce predator metabolic rates and may also reduce the presence of predators in juvenile salmon habitats (Munsch et al. 2019). Studies continue to be conducted in the Delta to understand the effects of predation on salmonid populations while Grossman et al. (2013) offer that the most productive management strategy for decreasing predation on Chinook Salmon and other Delta fishes is to restore natural habitat and flows, especially in predation hot spots. High rates of predation occur in certain predation hot spots; however, studies have shown that predation rates do not scale with predator density (Abrams 1993; Michel et al. 2019; Zeug et al. 2019).

Under the 2019 NMFS BO, Reclamation and DWR are required to plan and implement measures to reduce predation intensity at known hot spots, specifically at the scour hole located at the junction of the San Joaquin River and the Old River. In 2022, Reclamation convened a group of consultants and State and federal fish agencies to work through a SDM process to identify six projects that meet the plan’s objective to modify channel geometry and associated habitats to reduce predation. The six projects will later be narrowed down to three and the effects will be fully analyzed in a forthcoming environmental process.

4.3.6. Thiamine Deficiency Complex

Thiamine deficiency complex (TDC) is a recent ongoing threat to Chinook Salmon stocks that was first noticed in Central Valley hatchery populations in 2019, resulting in widespread early life stage mortality (NMFS 2022c, 2023c). TDC is hypothesized to be caused by a greater abundance of Northern Anchovy in salmon diets as a result of a reorganization of food webs in the ocean due to climate change (NMFS 2022c, 2023c). Northern Anchovy possess thiaminase, which is an enzyme that causes the breakdown of vitamin B1 and can lead to thiamine deficiency. Adult Chinook Salmon that are thiamine deficient when spawning produce progeny with increased early life stage mortality. Juvenile Chinook Salmon with TDC experience loss of equilibrium, swimming in a spiral pattern, lethargy, hyperexcitability, and hemorrhage (Mantua 2021). Since the discovery of TDC in Central Valley Chinook Salmon populations, hatchery fish, including those at LSNFH and FRFH, are treated with various thiamine treatments depending on their age (i.e., injecting the adults with thiamine or bathing the eggs in a thiamine bath). However, natural-spawning populations of Chinook Salmon are still at risk.

4.4. Importance of Life History Diversity for Chinook Salmon

California’s Central Valley contains the southernmost runs of native Chinook Salmon in the world, and experiences some of the most extreme climatic variations in North America. As a result, Chinook Salmon in the Central Valley exhibit exceptionally diverse life-history traits compared to other stocks, particularly with respect to adult immigration and juvenile emigration timing (Healey 1991; Sturrock et al. 2019a). This “portfolio effect” contributes to population sustainability and abundance by distributing risk throughout the run among multiple life-history strategies and reducing intra-specific competition (Healey 1991; Greene et al. 2010; Carlson and Satterthwaite 2011; Sturrock et al. 2015). Additionally, genetic and life-history diversity are important for species and population viability because genetic and phenotypic diversity allow a species to use a wider array of environments, protect species against short-term spatial and temporal changes in the environment, and provide the raw materials for surviving long-term environmental change (NMFS 2000b). Restoring and maintaining this diversity is critical, especially as climactic conditions become more unpredictable as a result of climate change in a spatially and temporally varying environment such as the Central Valley.

CHNSR juveniles can emigrate to the ocean as sub-yearlings, including fry, parr, and smolts, during the spring, or they can over-summer and emigrate the following fall, winter, or spring as yearlings (CDFG 1998). Juvenile life-history diversity is particularly variable within CHNSR populations in Deer and Mill creeks because they spawn over a large elevational range (1,200 to 5,203 ft), which results in significant variation in the duration of egg incubation and timing of fry emergence in the watershed (Johnson and Merrick 2012). As a result, depending upon the elevation at which an adult female spawned, CHNSR juveniles from a given brood year may emigrate as sub-yearlings from January through June, or as yearlings the following fall, winter, and spring (Johnson and Merrick 2012). In the Central Valley, juvenile Chinook Salmon sampled in various locations throughout the Sacramento-San Joaquin River systems are classified by run using the LAD criteria based upon projected annual growth (Fisher 1992). Diverse juvenile life-history expression, slow growth rates, and variable emigration timing can result in CHNSR juveniles in Deer and Mill creeks being misidentified. Specifically, fall emigrants (yearlings) often are incorrectly classified as CHNLFR or CHNWR, and a significant portion of YOY CHNSR are classified as CHNFR and CHNLFR (Johnson and Merrick 2012). The inability to correctly identify CHNSR juveniles in Deer and Mill creeks in the freshwater environment has significant management implications with respect to preserving life-history diversity.

Sacramento River CHNWR also exhibit diverse juvenile life histories. CHNWR juveniles primarily express an ocean-type life-history pattern, with juveniles leaving spawning areas in the upper Sacramento River and emigrating as fry in the late summer or early fall. USFWS RST monitoring at RBDD (RM 243) from April 2002 through September 2013 documented that on average, juvenile CHNWR passage was composed of 80% fry and 20% pre-smolt/smolt size-class fish (Poytress et al. 2014). Emigration past RBDD begins in July and lasts into March the following year, with 75% of average annual passage occurring by mid-October with sporadic pulses of smolts through March (Poytress et al. 2014). For brood year 2022, fry passed RBDD by November and smolts completed passage by the end of May (Scott Voss, personal communication, 6/2023). RST monitoring on the lower mainstem Sacramento River at Knights Landing (RM 89.5) is used to inform entry of CHNWR juveniles into the tidal Delta environment. CHNWR juveniles have been recorded at Knights Landing as early as August and as late as April, with most catches recorded between October and April (CalFish 2023c). Poytress et al. (2014) describes the significance of first flush of the season based on the relationships between river discharge, turbidity, and fish passage, and that the importance of the first storm event of the fall or winter period in triggering juvenile fish migrations cannot be overstated.

While spatial and temporal juvenile Chinook Salmon life-history diversity in the Central Valley is revealed through RST monitoring, studies of otoliths recovered from adult Chinook Salmon document that spawning populations are composed of individuals reflecting diverse early life-history strategies

(Cordoleani et al. 2018; Phillis et al. 2018; Sturrock et al. 2019a). Deer and Mill creeks CHNSR otolith research conducted by Cordoleani et al. (2018) highlighted multiple juvenile rearing strategies contributing to adult Mill Creek and Deer Creek CHNSR populations, with the contribution of different strategies varying across years. These studies also documented diverse habitat utilization and non-natal rearing, adding to existing research highlighting the importance of maintaining a portfolio of juvenile life-history strategies in Pacific salmon (Greene et al. 2010; Carlson and Satterthwaite 2011; Schroeder et al. 2015). Otolith isotope profiles from adult CHNSR returning to Mill and Deer creeks showed three discrete emigration types – early, intermediate, and late – that differed in age and size at the time when juveniles left their natal stream (Cordoleani et al. 2021). Although late migrants (yearlings) made up the smallest proportion of outmigrants observed in juvenile monitoring (10%), they were the most prominent life history type in adult returns on average from 2007 to 2018 (60%). Late migrants may experience substantially different freshwater, estuarine, and ocean conditions compared to early and intermediate migrants. Additionally, spreading out the juvenile migration window may reduce intraspecific competition. Late migrants emigrating in the fall of years under drought conditions and warm ocean temperatures were critical to maintaining the Mill and Deer creeks CHNSR populations, with very few early and intermediate juvenile migrants from the same brood years returning as adults. The late juvenile migration phenotype is an important life history type to maintain in the face of predicted increases in frequency and intensity of extreme climate conditions. Conserving life history diversity increases population resilience via the portfolio effect by spreading risk spatially and temporally (Cordoleani et al. 2021).

NMFS (2000b) emphasizes the importance of conserving the genetic and phenotypic diversity of salmonid populations by: 1) protecting key components of the environment to which they are adapted, including allowing natural process of disturbance and regeneration to occur and 2) preventing human-caused alterations which could reduce fitness by weakening the adaptive fit between a salmonid population and its environment or limit a population's ability to respond to natural selection. Juvenile salmon mortality during emigration to the ocean is considered a critical phase contributing to overall adult salmon population dynamics (Healey 1991; Williams 2006).

The hydrology of the major Central Valley rivers and Delta has been highly modified. Dam releases on the major rivers are now generally much lower than unimpaired conditions in the winter and spring and higher in the summer and fall, and exports in the Delta remove up to 50% of the freshwater from the system during certain time periods (Cloern and Jassby 2012; Hutton et al. 2017; SWRCB 2017). Modification of the natural hydrograph, including suppression of winter pulse flows, has resulted in contraction of migratory windows, reducing the variability in emigration timing, and suppressing full expression of juvenile Chinook Salmon life histories. Additionally, the changes in timing and magnitude of flow combined with water diversions negatively impacts rearing habitat, connectivity, and ecosystem processes to which salmon have adapted (Lloyd et al. 2004; Lytle and Poff 2004; Flitcroft et al. 2019), hence native species may be poorly equipped to survive new flow regimes (Poff et al. 1997; Poff and Zimmerman 2010). The resulting reduction in life history diversity could significantly reduce the resiliency of the Sacramento River watershed’s four Chinook Salmon runs and increase the risk of a temporal mismatch with favorable ocean conditions (Satterthwaite et al. 2014).

Supporting life history diversity requires a broad migratory window that includes both early and late migrants, available rearing habitat throughout the migratory corridor, and sufficient flow to support migration, habitat connectivity, and ecosystem processes in freshwater habitats and in the Estuary

(Bunn and Arthington 2002; Montagna et al. 2002; Greene et al. 2010; Poff and Zimmerman 2010; Carlson and Satterthwaite 2011; Schroeder et al. 2015; Goertler et al. 2018; Phillis et al. 2018; Flitcroft et al. 2019; Sturrock et al. 2019a).

5. Take and Impacts of Taking on Winter- and Spring-run Chinook Salmon

The following sections describe take of and impacts of taking on CHNWR and CHNSR by Project infrastructure and operations. "Take" is defined by California Fish and Game Code Section 86 as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." Take of CHNWR and CHNSR eggs, juveniles, and adults by the Project can occur either directly or indirectly in the form of "capture" and "kill". South Delta export operations may result in take of juvenile and adult CHNWR and CHNSR through impacts on rearing, routing, and survival (see Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon). South Delta export operations may also result in take through entrainment of juvenile and adult CHNWR and CHNSR into the interior Delta and south Delta CVP and SWP export facilities (see Section 5.2 – Effects of South Delta Export Operations on Entrainment of Chinook Salmon). Operations and/or maintenance activities associated with other Project facilities that may pose a threat to CHNWR and CHNSR are also described including maintenance at CCF, operations and maintenance at BSPP, the South Delta Temporary Barriers Project, water transfers, and operations at the Suisun Marsh facilities (see Sections 5.3-5.7).

5.1. Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon

Take of juvenile CHNWR and CHNSR in the form of impacts related to altered rearing, routing, and through-Delta survival will occur as a result of Project-related effects on Delta hydrodynamics. Take of adult CHNWR and CHNSR will also occur in the form of impacts related to altered routing and Delta survival as a result of Project-related effects on Delta hydrodynamics. Project-related hydrodynamic changes may reduce the suitability of the Delta for supporting successful rearing and migration, including by routing and entrainment of juvenile and adult CHNWR and CHNSR into the interior Delta, increasing the susceptibility of juvenile CHNWR and CHNSR to predation, and increasing juvenile and adult CHNWR and CHNSR exposure to poor water quality conditions.

Project-related effects to Delta hydrodynamics may impact juvenile and adult CHNWR and CHNSR migration timing and duration, behavior, and survival through the Delta. Key drivers of Delta hydrodynamics are freshwater inflow, combined CVP and SWP Delta exports, operations of the DCC, and historically the presence or absence of the Head of Old River Barrier (no longer installed following its removal in November 2018; DWR 2022d). These drivers interact with tidal influences over much of the interior and south Delta and are often correlated with one another (e.g., exports tend to be higher at higher San Joaquin River inflows). As a result, regulatory constraints on multiple drivers may simultaneously be in effect. DWR's modeling of Baseline Conditions versus Proposed Project[2] scenarios reflects those realities and, while those scenarios are appropriate for Project analyses, they have limited value for evaluating the isolated effects of one driver versus another.

[2] "Proposed Project" refers to operations included in DWR's ITP Application (DWR 2023f) and included in CalSim 3 modeling inputs that represent those operations. The Proposed Project does not include all minimization measures (see Appendix C – CalSim Modeling Results) or mitigation requirements that are required by the 2024 SWP ITP.

In the ITP Application, DWR utilizes a single concept of velocity changes at distributary junctions to evaluate the effects of Project operations on entrainment of CHNWR and CHNSR into the interior Delta (DWR 2023f). Based on the Delta Simulation Model II (DSM2) analysis, DWR concludes that Project operations have little to no effect on velocity changes at distributary junctions; therefore, DWR assumes little difference in rearing, routing, and through-Delta survival of juvenile CHNWR and CHNSR under the Proposed Project. The ITP Application also assumes little difference in adult CHNWR and CHNSR straying during immigration through the Delta. This single concept underlying the analyses includes simplifying assumptions and does not account for the complex and diverse life history strategies of CHNWR and CHNSR.

The ITP Application includes the following analyses that rely primarily on studies conducted with CWT smolts and acoustically tagged hatchery CHNLFR (and CHNWR for Zeug and Cavallo 2014) smolts to evaluate routing and through-Delta survival of juvenile CHNWR and CHNSR (DWR 2023f):

- Delta Hydrodynamics (based on Zeug and Cavallo 2014 and Salmonid Scoping Team [SST] 2017)
- Delta Passage Model (DPM)
- Survival, Travel Time, and Routing Simulation (STARS, based on Perry et al. 2018)
- Ecological Particle Tracking Model (ECO-PTM, based on Wang 2019)
- San Joaquin River-Origin Spring-Run Chinook Salmon Structured Decision Model

These analyses utilize CalSim 3 modeling for water years 1922 through 2021. CalSim 3 is primarily a comparative water operations and supply model that produces water supply values on a monthly timestep and was not developed to incorporate biological data or model Proposed Project operations at a finer timescale. CalSim 3 is not a predictive model that can forecast future water supply. CalSim 3, which is the most recent version of the CalSim model, incorporates both CVP and SWP operations (DWR 2017). Modeled Baseline Conditions assume existing CVP operations (under the implementation of the 2019 NMFS BO and the 2019 USFWS BO) and existing SWP operations (under the implementation of the 2019 NMFS BO, the 2019 USFWS BO, and the 2020 SWP ITP). Modeled Proposed Project assumes existing CVP operations and proposed SWP operations (under the implementation of the 2024 SWP ITP) except for OMR flow management measures, which are modeled consistently for CVP as SWP measures in the Proposed Project. Reclamation's proposed changes to CVP operations (Proposed Action) as part of ongoing federal reinitiation of consultation for long-term operations for CVP and SWP (Reclamation 2023) establishes consistent OMR flow management measures with the 2024 SWP ITP. For modeling results presented in this Effects Analysis, water year type was determined based on the 50% exceedance forecast in May of the Sacramento Valley "40-30-30" water year hydrologic classification index (i.e., May Bulletin 120; DWR 2024a) unless otherwise noted. See Appendix C – CalSim Modeling Results for additional information on CalSim 3 modeling assumptions and caveats for Baseline Conditions and Proposed Project scenarios.

The ITP Application includes two proposals for spring outflow under the Proposed Project; therefore, there are two Proposed Project scenarios that were modeled in CalSim 3 – interim operations under the ITP_Spring scenario and SWP operations via the Healthy Rivers and Landscapes Program (HRL) under the 9A_V2A scenario (see Section 6.1.3; Condition of Approval 8.12; DWR 2023f). The ITP_Spring CalSim 3 modeling scenario includes proposed SWP operations as well as SWP implementation of the 2020 SWP

ITP Condition of Approval 8.17 – Export Curtailments for Spring Outflow. The 2020 SWP ITP Condition of Approval 8.17 includes export curtailments for all water year types, determined by the 75% exceedance forecast for the San Joaquin Valley Index, by requiring DWR to manage exports to achieve a specific inflow to export (I:E) ratio for each water year type using San Joaquin River flow at Vernalis and combined CVP and SWP exports from April 1 through May 31. The 9A_V2A scenario includes proposed SWP operations as well as DWR's contribution to the HRL, which includes a Delta inflow block of water and SWP export curtailments. The increase in Delta inflow equates to a 50 thousand acre-feet (TAF) inflow block of water in March of dry, below normal, and above normal water year types. The SWP export curtailment equates to a 92.5 TAF Delta outflow block of water in April through May of dry and below normal water year types and a 117.5 TAF Delta outflow block of water April through May of above normal water year types. No Delta inflow block or export curtailments are proposed for critical or wet water year types. Sacramento River, Feather River (besides those associated with SWP contributions), Yuba River, American River, Putah Creek, and Mokelumne River components of the HRL, were not modeled as part of the Proposed Project and are not considered in the Effects Analysis. The Effects Analysis also does not include CVP contributions to the HRL or CVP operations outside of OMR Management measures associated with the federal Proposed Action resulting from ongoing reinitiation of consultation for long-term operations of CVP and SWP.

The modeled results for the DPM and the San Joaquin River-Origin Spring-Run Chinook Salmon Structured Decision Model do not include either spring outflow scenario under the Proposed Project; therefore, this Effects Analysis does not include results from either model. The NMFS Southwest Fisheries Science Center's Winter-run Life Cycle Model (Hendrix et al. 2024) was not run for the operational scenarios included in the ITP Application (9A_V2A and ITP_Spring), so life cycle modeling is not discussed in this Effects Analysis.

Analyses included in this Effects Analysis have some applicability for evaluation of routing of highly mobile emigrating CHNWR and CHNSR smolts, which transit the Delta in approximately seven days, into the interior Delta and through-Delta survival based on north Delta inflow and DCC gate operations. However, these analyses are limited in their ability to evaluate Project effects on natural-origin CHNWR and CHNSR fry, parr, and smolts which rear in the Delta and comprise the bulk of these populations (see Section 5.1.3.1 – Survival, Travel Time, and Routing Simulation Analysis [STARS] and Section 5.1.3.2 – Ecological Particle Tracking Model [ECO-PTM]; SST 2017). Project effects on rearing juvenile CHNWR and CHNSR were not quantified in the ITP Application (DWR 2023f), and to CDFW's knowledge cannot currently be quantified or analyzed using existing biological modeling tools. However, a qualitative analysis of Project effects on rearing juvenile CHNWR and CHNSR is provided in Section 5.1.1 – Effects of South Delta Export Operations on Juvenile Chinook Salmon Rearing. The impact of Project operations on rearing, routing, and through-Delta survival of juvenile CHNWR and CHNSR is likely greater than what is quantitatively estimated in the ITP Application (DWR 2023f) due to the limited scope of the biological modeling which does not account for all life stages of Chinook Salmon.

Many of the mechanisms through which changes in Delta hydrodynamics and other factors related to SWP operations, including CVP operations, may contribute to salmonid mortality (e.g., change in vulnerability to predation in Delta channels, change in migration routing, reduced fitness due to impacts to rearing habitat and food webs, and impacts to ecosystem processes in the Estuary) and to what degree they impact different life stages have not been determined (SST 2017). The Collaborative

Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST) stated the following with respect to both the CVP and SWP export facilities (SST 2017):

> *Water export operations contribute to salmonid mortality in the Delta via direct mortality at the facilities, but direct mortality does not account for the majority of the mortality experienced in the Delta; the mechanism and magnitude of indirect effects of water project operations on Delta mortality outside the facilities is uncertain*.

Estimates of direct juvenile mortality (e.g., mortality resulting from pre-screen losses and losses at CVP and SWP louver and salvage facilities) have been developed from CWT data by several authors and show, in general, that the magnitude of direct loss (e.g., percentage of a marked release group observed in salvage) is typically low for juvenile Chinook Salmon (less than approximately 1%; SST 2017). However, such estimates do not include export-induced mortality prior to entering the CVP and SWP export facilities that is indirectly related to CVP and SWP operations (e.g., mortality resulting from changes in habitat caused by CVP and SWP operations). Estimates of direct mortality at the CVP and SWP export facilities as a proportion of total migration mortality have been as high as 5.5% for CHNWR and 17.5% for Chinook Salmon released in the San Joaquin River (Zeug et al. 2014; SST 2017).

It is unknown whether equivocal findings regarding the existence and nature of a relationship between CVP and SWP exports and juvenile Chinook Salmon through-Delta survival are due to the lack of a relationship, the concurrent and confounding influence of other variables, or the effect of low overall juvenile Chinook Salmon survival in recent years (SST 2017). Further analysis of available data, as well as additional investigations to test hypotheses regarding CVP and SWP export effects on migration and survival of Sacramento River and San Joaquin River origin salmonids migrating through the Delta are needed to address these data gaps (SST 2017). Some of these data gaps will be filled through 2024 SWP ITP requirements to support ongoing monitoring, implement new monitoring, and new science (Condition of Approval 7.9 – Winter and Spring-run Chinook Salmon Monitoring and Science Requirements).

Minimization of Project effects on rearing, routing, and survival of CHNWR and CHNSR are discussed in Section 6.1 – Minimization of Project Effects on Rearing, Routing, and Survival of Chinook Salmon of this Effects Analysis and include the implementation of Conditions of Approval required by the 2024 SWP ITP.

5.1.1. Effects of South Delta Export Operations on Juvenile Chinook Salmon Rearing

Currently, there is a need for additional monitoring and science to bolster our understanding of natural-origin juvenile CHNWR and CHNSR behavior, habitat utilization, feeding strategies, occupancy, residence time, use of tidal surfing/selective tidal stream transport, predation effects, long-term routing, and other aspects that would be necessary to populate life cycle models or enable other methods of quantitative evaluation. As a result of these long-standing data limitations, a quantitative evaluation of Project-related effects on CHNWR and CHNSR in-Delta rearing has not been conducted; however, the following section evaluates impacts on rearing qualitatively, based on published literature.

While Delta waterways function as migratory corridors for CHNWR and CHNSR smolts, these waterways also provide holding and rearing habitat for these fish. Juvenile salmonids use the region for rearing for several months during the winter and spring before migrating to the marine environment. CHNWR have been observed to be present in the Delta for an extended period of time, with apparent residence times ranging from 41 to 117 days and longer apparent residence times for juveniles arriving earlier at Knights Landing (del Rosario et al. 2013). For Central Valley CHNFR, sizeable fractions of the adult escapement are made up of fish that left freshwater and entered the estuarine environment as fry or parr life stages in addition to the expected smolt life stage (Miller et al. 2010; Sturrock et al. 2015). Among the CHNFR parr and fry life stages leaving the freshwater environment, a large fraction (25% of parr and 55% of fry migrants) spent time rearing in the brackish waters of the Bay-Delta region (Miller et al. 2010). Similar life history diversity strategies likely exist for CHNWR and CHNSR (Flitcroft et al. 2019). Recent monitoring data from Sherwood Harbor trawl, which is considered the Delta entry point for migrating juvenile Chinook Salmon, includes observations of fry, parr, and smolt life stages for genetically-identified natural-origin CHNWR and CHNSR (see Appendix D – Juvenile Size Distribution in Delta Monitoring and Salvage). About 21% and 7.1% of genetically-identified natural-origin CHNWR and CHNSR observations, respectively, were categorized as fry, while 18.5% and 11.1%, respectively, were categorized as parr, suggesting that a substantial proportion of juveniles utilize the Delta for rearing.

Individual rearing fish entrained into the interior Delta are subject to tidal forcing and may move through the San Joaquin River into the channels of Old and Middle rivers, as well as other channel junctions in the reach, rather than moving towards the western Delta. Juvenile CHNWR and CHNSR from the Sacramento River Basin have been observed in salvage at the CVP Tracy Fish Collection Facility and SWP Skinner Fish Protective Facility in the south Delta (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon) verifying that juvenile CHNWR and CHNSR are present in the waterways leading to both the CVP and SWP export facilities. Smaller juvenile CHNWR and CHNSR, i.e., fry- and parr-sized juveniles, are occasionally observed in salvage and are likely underrepresented due to pre-screen loss (see Appendix D – Juvenile Size Distribution in Delta Monitoring and Salvage). Due to extensive tidal movement and reverse flows from exports in the two main channels (Old and Middle rivers) leading to the CVP and SWP export facilities, juvenile CHNWR and CHNSR may disperse into many of the waterways adjacent to the CVP and SWP export facilities, including waterways that contain the South Delta Temporary Barriers Project (Old River, Middle River, and Grant Line Canal; see Section 5.5 – Effects of the South Delta Temporary Barriers Project on Chinook Salmon).

Juvenile CHNWR and CHNSR rearing in the Delta are exposed to reduced Delta outflow associated with CVP and SWP export operations, which reduces the quality and quantity of habitat available in the Delta that is dependent on inflows from the Sacramento and San Joaquin rivers to support habitat diversity (Brandes and McLain 2001; Sommer et al. 2001). The Proposed Project has the potential to increase exports during critical outmigration months in the spring, which may lead to reduced Delta outflow (see Appendix C – CalSim Modeling Results). Reduced flows are associated with a reduction in total inundated acres of channel margin habitat for juvenile CHNWR and CHNSR, which frequently rear in shallow waters around the edges of tidal wetlands and dendritic channels in the Delta. Reduced channel margin habitat along with longer residence and travel times due to lower outflow may increase predator densities and predation of juvenile CHNWR and CHNSR rearing in the Delta. Lower Delta outflow may increase the density of littoral predators into smaller, shallower areas and decrease escape cover for juvenile salmonids (DWR and Reclamation 2022). Lower Delta outflow may also increase the abundance and distribution of invasive aquatic plant communities that provide better habitat for non-native predators. Warm-water and drought tolerant predator species rarely show declines during low Delta inflow periods (Mahardja et al. 2021; DWR and Reclamation 2022). Additionally, lower Delta outflow coupled with higher temperatures, associated with climate change, may increase juvenile CHNWR and CHNSR susceptibility and exposure to pathogens and parasites in the Delta (see Section 4.3.3 – Pathogens; Carter 2008) as a result of longer travel times, increased residence times, and less available rearing habitat. Together, these stressors tied to CVP and Project operations may truncate juvenile CHNWR and CHNSR rearing in the Delta, which may further diminish life history diversity (specifically late-rearing juveniles) and population resilience (diminished portfolio effect; Munsch et al. 2019; Sturrock et al. 2019a).

Analyses that rely on parameters for migrating fish, but not rearing fish, to characterize CVP and Project impacts on CHNWR and CHNSR will likely underestimate take. Specifically, quantitative evaluations of routing and through-Delta survival are primarily based on CWT and acoustic tag data for hatchery smolts which are larger, highly migratory, and exhibit Delta transit times averaging approximately seven days (SST 2017). Application of a 7-day transit time is not well suited for analyses involving rearing fish, which spend extended periods of time in the Delta and comprise the bulk of annual natural CHNWR and CHNSR outmigration production (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles and Sections 4.1.7 and 4.2.7 – Juvenile Ocean Entry).

The broad conceptual model developed by the South Delta Salmonid Research Collaborative Effort predicts that CVP and SWP operations could affect juvenile salmon migration timing, migration rates and route selection, and locations of rearing and habitat use in the tributaries influenced by CVP and SWP operations such as the Feather, American, Sacramento, and Stanislaus rivers and the Delta (SST 2017). CVP and SWP operations have the potential to constrain life history diversity as a result of altering instream flows, export operations, and other habitat conditions by favoring one type of life history attribute over others (SST 2017). Over time, this can represent a selective pressure that reduces diversity within and abundance of a population (SST 2017). The cumulative effect of CVP and SWP operations on juvenile salmonid mortality in and beyond the Delta, in relation to other stressors, merits further study and data collection (SST 2017).

5.1.2. Effects of South Delta Export Operations on Juvenile Chinook Salmon Routing

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 towards and into the CVP and SWP 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 CWT studies (e.g., Zeug and Cavallo 2014). A foundation for assessing far-field effects has been provided by work of the SST (2017). The SST completed a thorough review of this subject and defined a driver-linkage-outcome 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 (SST 2017).

Hance et al. (2021) found that higher Sacramento River discharge is associated with faster travel times and greater through-Delta survival of juvenile hatchery-origin CHNWR. Notch et al. (2020) determined that increases in flow throughout Mill Creek and the Sacramento River were associated with higher rates of reach-specific survival for juvenile natural-origin CHNSR. Faster migration times of juvenile natural-origin CHNSR in Mill Creek and the Sacramento River were also observed in wetter years and were correlated with higher survival rates during those years (Notch et al. 2020). Lower Sacramento River flow leads to greater potential for flow to enter Georgiana Slough and the DCC, which are routes that lead to the interior Delta where survival of CHNWR and CHNSR is lower than in the mainstem Sacramento River (Perry et al. 2018; Hance et al. 2021). Salmon likely react to changes in water velocity rather than river flow (SST 2017). Additionally, SST (2017) concluded that salmonid route selection is generally proportional to the flow split at channel junctions, and the effect of exports on route selection is strongest at the junction leading directly to the export facilities. Evaluating changes in channel velocity and flow direction throughout the Delta can inform routing and through-Delta survival of juvenile Chinook Salmon.

5.1.2.1. Delta Hydrodynamic Assessment and Junction Routing Analysis

5.1.2.1.1. Velocity

To evaluate potential impacts of Project operations on routing and through-Delta survival of juvenile Chinook Salmon, DWR assessed changes in Delta hydrodynamics between DSM2 velocity outputs stratified by month and water year type for Baseline Conditions and the two Proposed Project scenarios (ITP_Spring and 9A_V2A) at Freeport on the Sacramento River and Walnut Grove (location of DCC gates). See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon for additional information on each modeling scenario. DSM2 hydrodynamic (DSM2-HYDRO) modeling results obtained from DWR's ITP Application (DWR 2023f) and subsequent coordination with DWR show minimal changes in velocity in any month (September-June) or water year type at Freeport or Walnut Grove for either Proposed Project scenario as compared to Baseline Conditions (see Appendix B – Velocity Density Distribution for Sacramento River at Freeport and Walnut Grove). The only apparent changes between Baseline Conditions and the 9A_V2A scenario were slight decreases in velocity in September of above normal and wet water years at Freeport and very slight decreases in velocity at Walnut Grove in above normal water years. In contrast, there were minor increases in velocity in September of above normal and wet water years at Freeport for the ITP_Spring scenario and at Walnut Grove for above normal water years. September is not a peak migration month for juvenile CHNWR, and juvenile CHNSR are not present in the Delta during September (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). Velocities at Freeport and Walnut Grove were similar across all months evaluated including the main months of CHNWR and CHNSR migration. Velocities appeared to be greater in wetter water year types compared to drier water year types for both Proposed Project scenarios. Reverse flows were shown to occur at Walnut Grove some portion of the time during most months and water year types under Baseline Conditions and Proposed Project scenarios, especially the drier water year types. Reverse flows seemed to occur at Freeport less frequently, but they were shown to occur a small portion of the time during most months in critical water years under Baseline Conditions and Proposed Project scenarios.

5.1.2.1.2. Junction Routing

Mean daily proportion of flow entering Delta junctions was compared between Baseline Conditions and the two Proposed Project scenarios (ITP_Spring and 9A_V2A) using DSM2-HYDRO outputs. See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon for additional information on each modeling scenario. As stated above, proportionality of salmonid route selection generally corresponds with the proportionality of flow splits at junctions. The mean daily proportion of flow entering Delta junctions was generally similar between Baseline Conditions and Proposed Project scenarios (Table 2). However, in October of below normal and dry years, and November of critical years, the proportion of flow entering the DCC was substantially greater under both Proposed Project scenarios compared to Baseline Conditions. The underlying causes of the increases in proportion of flow entering the DCC are unclear, and DWR has attributed them to a modeling artifact not associated with the Proposed Project. Although the DSM2-HYDRO outputs showed minimal changes in mean daily proportion of flow entering junctions between Baseline Conditions and Proposed Project scenarios, it is worth noting that SST (2017) caveated that DSM2 and other hydrodynamic models lack accuracy in evaluating juvenile salmonid routing behavior, and direct monitoring would be more reliable. Routing analyses using the STARS model and ECO-PTM could also be conducted to better understand the proportion of Chinook Salmon entrained into different routes in the Delta.

Table 2. Mean daily proportion of flow entering Delta junctions by month and water year type. Percent differences between Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Columbia Cut	September	Wet	0.136	0.138 (1.6%)	0.139 (1.9%)
Columbia Cut	September	Above Normal	0.130	0.131 (1.3%)	0.133 (2.5%)
Columbia Cut	September	Below Normal	0.135	0.134 (-0.3%)	0.135 (0.1%)
Columbia Cut	September	Dry	0.124	0.124 (-0.3%)	0.124 (-0.4%)
Columbia Cut	September	Critical	0.118	0.118 (0.0%)	0.118 (0.0%)
Columbia Cut	October	Wet	0.130	0.129 (-0.1%)	0.129 (-0.1%)
Columbia Cut	October	Above Normal	0.121	0.121 (-0.2%)	0.121 (0.0%)
Columbia Cut	October	Below Normal	0.128	0.128 (0.3%)	0.128 (0.4%)
Columbia Cut	October	Dry	0.125	0.125 (0.0%)	0.125 (0.1%)
Columbia Cut	October	Critical	0.116	0.116 (0.1%)	0.116 (-0.4%)
Columbia Cut	November	Wet	0.135	0.136 (0.1%)	0.136 (0.1%)
Columbia Cut	November	Above Normal	0.128	0.127 (-0.1%)	0.127 (-0.1%)
Columbia Cut	November	Below Normal	0.131	0.131 (-0.1%)	0.131 (-0.1%)
Columbia Cut	November	Dry	0.129	0.129 (0.1%)	0.129 (0.1%)
Columbia Cut	November	Critical	0.117	0.117 (0.5%)	0.117 (0.0%)
Columbia Cut	December	Wet	0.134	0.134 (-0.1%)	0.134 (-0.1%)
Columbia Cut	December	Above Normal	0.126	0.126 (0.0%)	0.126 (0.0%)
Columbia Cut	December	Below Normal	0.126	0.126 (0.1%)	0.126 (-0.1%)
Columbia Cut	December	Dry	0.125	0.124 (-0.4%)	0.124 (-0.3%)
Columbia Cut	December	Critical	0.119	0.119 (0.2%)	0.119 (0.1%)
Columbia Cut	January	Wet	0.133	0.132 (-0.4%)	0.132 (-0.4%)
Columbia Cut	January	Above Normal	0.129	0.129 (-0.3%)	0.129 (-0.3%)
Columbia Cut	January	Below Normal	0.123	0.123 (-0.3%)	0.123 (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Columbia Cut	January	Dry	0.121	0.120 (-0.4%)	0.120 (-0.4%)
Columbia Cut	January	Critical	0.120	0.119 (-1.0%)	0.119 (-0.7%)
Columbia Cut	February	Wet	0.137	0.137 (0.1%)	0.137 (0.0%)
Columbia Cut	February	Above Normal	0.133	0.133 (-0.6%)	0.133 (-0.1%)
Columbia Cut	February	Below Normal	0.129	0.128 (-0.5%)	0.128 (-0.5%)
Columbia Cut	February	Dry	0.122	0.121 (-0.8%)	0.121 (-0.8%)
Columbia Cut	February	Critical	0.121	0.121 (-0.4%)	0.121 (-0.5%)
Columbia Cut	March	Wet	0.132	0.132 (0.1%)	0.132 (0.3%)
Columbia Cut	March	Above Normal	0.129	0.129 (0.3%)	0.129 (0.2%)
Columbia Cut	March	Below Normal	0.125	0.125 (0.0%)	0.125 (-0.1%)
Columbia Cut	March	Dry	0.120	0.120 (-0.2%)	0.120 (-0.2%)
Columbia Cut	March	Critical	0.117	0.117 (0.0%)	0.117 (0.0%)
Columbia Cut	April	Wet	0.130	0.130 (0.2%)	0.130 (0.1%)
Columbia Cut	April	Above Normal	0.122	0.123 (0.6%)	0.122 (0.0%)
Columbia Cut	April	Below Normal	0.115	0.116 (0.5%)	0.115 (0.0%)
Columbia Cut	April	Dry	0.113	0.113 (0.1%)	0.113 (0.0%)
Columbia Cut	April	Critical	0.111	0.111 (0.3%)	0.111 (0.0%)
Columbia Cut	May	Wet	0.129	0.133 (2.6%)	0.130 (0.7%)
Columbia Cut	May	Above Normal	0.122	0.124 (2.1%)	0.123 (0.7%)
Columbia Cut	May	Below Normal	0.113	0.116 (1.8%)	0.114 (0.1%)
Columbia Cut	May	Dry	0.111	0.112 (0.5%)	0.111 (0.0%)
Columbia Cut	May	Critical	0.108	0.109 (0.6%)	0.108 (0.0%)
Columbia Cut	June	Wet	0.133	0.132 (-0.5%)	0.132 (-0.5%)
Columbia Cut	June	Above Normal	0.128	0.127 (-1.0%)	0.126 (-1.0%)
Columbia Cut	June	Below Normal	0.126	0.124 (-0.9%)	0.124 (-0.9%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Columbia Cut	June	Dry	0.122	0.121 (-1.2%)	0.121 (-1.2%)
Columbia Cut	June	Critical	0.114	0.113 (-0.5%)	0.114 (-0.2%)
Delta Cross Channel	September	Wet	0.401	0.397 (-0.9%)	0.397 (-1.1%)
Delta Cross Channel	September	Above Normal	0.419	0.410 (-1.9%)	0.407 (-2.7%)
Delta Cross Channel	September	Below Normal	0.444	0.444 (-0.1%)	0.444 (0.0%)
Delta Cross Channel	September	Dry	0.445	0.444 (-0.1%)	0.444 (-0.1%)
Delta Cross Channel	September	Critical	0.412	0.412 (0.0%)	0.413 (0.0%)
Delta Cross Channel	October	Wet	0.262	0.262 (0.0%)	0.262 (-0.1%)
Delta Cross Channel	October	Above Normal	0.281	0.281 (-0.1%)	0.281 (0.0%)
Delta Cross Channel	October	Below Normal	0.298	0.319 (7.2%)	0.320 (7.4%)
Delta Cross Channel	October	Dry	0.276	0.291 (5.6%)	0.293 (6.2%)
Delta Cross Channel	October	Critical	0.202	0.200 (-0.8%)	0.175 (-13.6%)
Delta Cross Channel	November	Wet	0.195	0.194 (-0.2%)	0.194 (-0.2%)
Delta Cross Channel	November	Above Normal	0.125	0.127 (1.0%)	0.127 (1.0%)
Delta Cross Channel	November	Below Normal	0.230	0.230 (0.2%)	0.230 (0.0%)
Delta Cross Channel	November	Dry	0.244	0.245 (0.5%)	0.244 (0.2%)
Delta Cross Channel	November	Critical	0.134	0.157 (17.3%)	0.162 (20.8%)
Delta Cross Channel	December	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	December	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	December	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	December	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	December	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	January	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	January	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	January	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Delta Cross Channel	January	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	January	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	February	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	February	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	February	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	February	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	February	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	March	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	March	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	March	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	March	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	March	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	April	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	April	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	April	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	April	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	April	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	May	Wet	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	May	Above Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	May	Below Normal	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	May	Dry	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	May	Critical	0.000	0.000 (0.0%)	0.000 (0.0%)
Delta Cross Channel	June	Wet	0.202	0.202 (-0.2%)	0.202 (-0.3%)
Delta Cross Channel	June	Above Normal	0.268	0.268 (-0.1%)	0.267 (-0.2%)
Delta Cross Channel	June	Below Normal	0.369	0.368 (-0.2%)	0.368 (-0.2%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Delta Cross Channel	June	Dry	0.380	0.377 (-0.8%)	0.377 (-0.7%)
Delta Cross Channel	June	Critical	0.353	0.350 (-0.8%)	0.351 (-0.5%)
Fishermans Cut	September	Wet	0.014	0.014 (0.3%)	0.014 (0.5%)
Fishermans Cut	September	Above Normal	0.014	0.013 (-5.2%)	0.014 (-1.0%)
Fishermans Cut	September	Below Normal	0.014	0.014 (0.0%)	0.014 (0.2%)
Fishermans Cut	September	Dry	0.014	0.013 (-0.5%)	0.013 (-1.4%)
Fishermans Cut	September	Critical	0.013	0.013 (0.4%)	0.013 (0.1%)
Fishermans Cut	October	Wet	0.014	0.014 (-0.7%)	0.014 (0.0%)
Fishermans Cut	October	Above Normal	0.013	0.013 (-0.2%)	0.013 (-0.5%)
Fishermans Cut	October	Below Normal	0.013	0.013 (2.0%)	0.013 (1.3%)
Fishermans Cut	October	Dry	0.013	0.013 (-0.4%)	0.013 (-0.4%)
Fishermans Cut	October	Critical	0.013	0.013 (-0.2%)	0.013 (0.1%)
Fishermans Cut	November	Wet	0.014	0.014 (0.0%)	0.014 (0.1%)
Fishermans Cut	November	Above Normal	0.013	0.013 (-0.1%)	0.013 (0.0%)
Fishermans Cut	November	Below Normal	0.013	0.013 (0.4%)	0.013 (0.3%)
Fishermans Cut	November	Dry	0.013	0.013 (-0.4%)	0.013 (-0.4%)
Fishermans Cut	November	Critical	0.013	0.012 (-0.7%)	0.013 (0.1%)
Fishermans Cut	December	Wet	0.016	0.017 (0.7%)	0.017 (1.6%)
Fishermans Cut	December	Above Normal	0.014	0.014 (-0.5%)	0.014 (-0.4%)
Fishermans Cut	December	Below Normal	0.014	0.013 (-1.0%)	0.013 (-0.9%)
Fishermans Cut	December	Dry	0.014	0.014 (0.0%)	0.014 (0.5%)
Fishermans Cut	December	Critical	0.013	0.013 (0.3%)	0.013 (-0.1%)
Fishermans Cut	January	Wet	0.020	0.020 (0.6%)	0.020 (0.5%)
Fishermans Cut	January	Above Normal	0.016	0.016 (0.2%)	0.016 (0.1%)
Fishermans Cut	January	Below Normal	0.014	0.014 (-0.2%)	0.014 (-0.6%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Fishermans Cut	January	Dry	0.013	0.013 (1.1%)	0.013 (1.1%)
Fishermans Cut	January	Critical	0.013	0.014 (1.9%)	0.014 (1.5%)
Fishermans Cut	February	Wet	0.023	0.023 (-1.1%)	0.023 (-1.0%)
Fishermans Cut	February	Above Normal	0.018	0.017 (-1.1%)	0.017 (-1.1%)
Fishermans Cut	February	Below Normal	0.015	0.015 (1.7%)	0.015 (1.3%)
Fishermans Cut	February	Dry	0.014	0.014 (-0.1%)	0.014 (-0.3%)
Fishermans Cut	February	Critical	0.014	0.014 (1.8%)	0.014 (2.1%)
Fishermans Cut	March	Wet	0.020	0.020 (-0.4%)	0.020 (0.1%)
Fishermans Cut	March	Above Normal	0.017	0.017 (0.0%)	0.017 (-0.6%)
Fishermans Cut	March	Below Normal	0.015	0.015 (-0.8%)	0.015 (0.1%)
Fishermans Cut	March	Dry	0.014	0.014 (2.8%)	0.014 (1.2%)
Fishermans Cut	March	Critical	0.013	0.013 (0.2%)	0.013 (0.3%)
Fishermans Cut	April	Wet	0.016	0.016 (0.6%)	0.016 (-0.2%)
Fishermans Cut	April	Above Normal	0.015	0.015 (1.8%)	0.015 (1.9%)
Fishermans Cut	April	Below Normal	0.014	0.014 (-0.1%)	0.014 (0.6%)
Fishermans Cut	April	Dry	0.013	0.013 (0.3%)	0.013 (0.5%)
Fishermans Cut	April	Critical	0.013	0.013 (-0.4%)	0.013 (0.1%)
Fishermans Cut	May	Wet	0.016	0.015 (-2.8%)	0.015 (-1.7%)
Fishermans Cut	May	Above Normal	0.014	0.014 (-2.6%)	0.014 (-1.8%)
Fishermans Cut	May	Below Normal	0.013	0.013 (-2.4%)	0.013 (-0.5%)
Fishermans Cut	May	Dry	0.013	0.013 (1.7%)	0.013 (0.1%)
Fishermans Cut	May	Critical	0.013	0.013 (0.0%)	0.013 (0.3%)
Fishermans Cut	June	Wet	0.014	0.014 (-0.2%)	0.014 (-0.7%)
Fishermans Cut	June	Above Normal	0.014	0.014 (0.4%)	0.014 (0.2%)
Fishermans Cut	June	Below Normal	0.013	0.013 (1.3%)	0.013 (0.8%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Fishermans Cut	June	Dry	0.013	0.013 (0.1%)	0.013 (0.5%)
Fishermans Cut	June	Critical	0.013	0.013 (-0.3%)	0.013 (-0.1%)
False River	September	Wet	0.185	0.186 (0.5%)	0.186 (0.6%)
False River	September	Above Normal	0.182	0.183 (0.3%)	0.184 (0.7%)
False River	September	Below Normal	0.186	0.186 (0.0%)	0.186 (0.0%)
False River	September	Dry	0.184	0.183 (0.0%)	0.183 (0.0%)
False River	September	Critical	0.183	0.183 (0.0%)	0.183 (0.0%)
False River	October	Wet	0.184	0.184 (0.0%)	0.184 (0.0%)
False River	October	Above Normal	0.182	0.182 (0.0%)	0.182 (0.0%)
False River	October	Below Normal	0.183	0.183 (0.0%)	0.183 (0.0%)
False River	October	Dry	0.183	0.183 (0.0%)	0.183 (0.0%)
False River	October	Critical	0.182	0.182 (0.0%)	0.182 (0.0%)
False River	November	Wet	0.185	0.185 (0.0%)	0.185 (0.0%)
False River	November	Above Normal	0.184	0.184 (0.0%)	0.184 (0.0%)
False River	November	Below Normal	0.185	0.185 (0.0%)	0.185 (0.0%)
False River	November	Dry	0.184	0.184 (0.0%)	0.184 (0.0%)
False River	November	Critical	0.183	0.183 (0.0%)	0.183 (-0.1%)
False River	December	Wet	0.184	0.184 (0.0%)	0.184 (0.0%)
False River	December	Above Normal	0.186	0.186 (0.0%)	0.186 (0.0%)
False River	December	Below Normal	0.185	0.186 (0.0%)	0.185 (0.0%)
False River	December	Dry	0.186	0.186 (-0.1%)	0.186 (-0.1%)
False River	December	Critical	0.184	0.184 (0.0%)	0.184 (0.0%)
False River	January	Wet	0.179	0.179 (-0.1%)	0.179 (-0.1%)
False River	January	Above Normal	0.183	0.183 (-0.1%)	0.183 (-0.1%)
False River	January	Below Normal	0.183	0.183 (-0.1%)	0.183 (-0.1%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
False River	January	Dry	0.183	0.183 (-0.1%)	0.183 (-0.1%)
False River	January	Critical	0.183	0.183 (-0.2%)	0.183 (-0.2%)
False River	February	Wet	0.178	0.178 (0.0%)	0.178 (0.0%)
False River	February	Above Normal	0.181	0.181 (-0.2%)	0.181 (0.0%)
False River	February	Below Normal	0.182	0.182 (-0.1%)	0.182 (-0.1%)
False River	February	Dry	0.182	0.182 (-0.2%)	0.182 (-0.2%)
False River	February	Critical	0.182	0.182 (-0.1%)	0.182 (-0.1%)
False River	March	Wet	0.176	0.176 (0.0%)	0.176 (0.1%)
False River	March	Above Normal	0.181	0.181 (0.0%)	0.181 (0.1%)
False River	March	Below Normal	0.181	0.181 (0.0%)	0.181 (0.0%)
False River	March	Dry	0.182	0.182 (0.0%)	0.182 (0.0%)
False River	March	Critical	0.181	0.180 (0.0%)	0.180 (0.0%)
False River	April	Wet	0.177	0.177 (0.1%)	0.177 (0.0%)
False River	April	Above Normal	0.178	0.179 (0.1%)	0.178 (0.0%)
False River	April	Below Normal	0.177	0.177 (0.1%)	0.177 (0.0%)
False River	April	Dry	0.180	0.180 (0.0%)	0.180 (0.0%)
False River	April	Critical	0.180	0.180 (0.1%)	0.180 (0.0%)
False River	May	Wet	0.179	0.180 (0.6%)	0.179 (0.2%)
False River	May	Above Normal	0.180	0.181 (0.5%)	0.181 (0.1%)
False River	May	Below Normal	0.180	0.180 (0.3%)	0.180 (0.0%)
False River	May	Dry	0.180	0.181 (0.1%)	0.180 (0.0%)
False River	May	Critical	0.181	0.181 (0.1%)	0.181 (0.0%)
False River	June	Wet	0.181	0.181 (-0.1%)	0.181 (-0.1%)
False River	June	Above Normal	0.183	0.183 (-0.2%)	0.183 (-0.2%)
False River	June	Below Normal	0.183	0.183 (-0.2%)	0.183 (-0.2%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
False River	June	Dry	0.184	0.183 (-0.2%)	0.183 (-0.2%)
False River	June	Critical	0.182	0.182 (0.0%)	0.182 (0.0%)
Georgiana Slough	September	Wet	0.447	0.444 (-0.8%)	0.443 (-0.9%)
Georgiana Slough	September	Above Normal	0.453	0.443 (-2.1%)	0.440 (-2.8%)
Georgiana Slough	September	Below Normal	0.449	0.448 (-0.2%)	0.451 (0.5%)
Georgiana Slough	September	Dry	0.391	0.392 (0.2%)	0.391 (-0.1%)
Georgiana Slough	September	Critical	0.333	0.332 (0.0%)	0.333 (0.0%)
Georgiana Slough	October	Wet	0.392	0.394 (0.5%)	0.393 (0.3%)
Georgiana Slough	October	Above Normal	0.389	0.386 (-0.7%)	0.387 (-0.4%)
Georgiana Slough	October	Below Normal	0.399	0.398 (-0.4%)	0.400 (0.1%)
Georgiana Slough	October	Dry	0.404	0.399 (-1.2%)	0.401 (-0.8%)
Georgiana Slough	October	Critical	0.372	0.374 (0.4%)	0.376 (1.0%)
Georgiana Slough	November	Wet	0.390	0.390 (0.0%)	0.390 (0.0%)
Georgiana Slough	November	Above Normal	0.393	0.392 (-0.1%)	0.393 (0.0%)
Georgiana Slough	November	Below Normal	0.406	0.405 (-0.3%)	0.405 (-0.4%)
Georgiana Slough	November	Dry	0.413	0.413 (0.1%)	0.413 (0.1%)
Georgiana Slough	November	Critical	0.386	0.383 (-0.8%)	0.378 (-1.9%)
Georgiana Slough	December	Wet	0.317	0.318 (0.1%)	0.317 (0.1%)
Georgiana Slough	December	Above Normal	0.385	0.386 (0.1%)	0.385 (0.0%)
Georgiana Slough	December	Below Normal	0.399	0.397 (-0.5%)	0.398 (-0.3%)
Georgiana Slough	December	Dry	0.405	0.406 (0.5%)	0.406 (0.4%)
Georgiana Slough	December	Critical	0.423	0.423 (0.0%)	0.423 (0.0%)
Georgiana Slough	January	Wet	0.298	0.298 (-0.1%)	0.298 (-0.1%)
Georgiana Slough	January	Above Normal	0.308	0.308 (0.0%)	0.308 (0.0%)
Georgiana Slough	January	Below Normal	0.355	0.354 (-0.1%)	0.354 (-0.1%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Georgiana Slough	January	Dry	0.401	0.402 (0.3%)	0.402 (0.3%)
Georgiana Slough	January	Critical	0.397	0.398 (0.1%)	0.396 (-0.3%)
Georgiana Slough	February	Wet	0.286	0.286 (0.0%)	0.286 (0.0%)
Georgiana Slough	February	Above Normal	0.294	0.294 (0.0%)	0.294 (0.0%)
Georgiana Slough	February	Below Normal	0.336	0.338 (0.5%)	0.338 (0.4%)
Georgiana Slough	February	Dry	0.356	0.353 (-0.9%)	0.353 (-0.9%)
Georgiana Slough	February	Critical	0.392	0.391 (-0.4%)	0.391 (-0.3%)
Georgiana Slough	March	Wet	0.289	0.289 (0.0%)	0.289 (0.0%)
Georgiana Slough	March	Above Normal	0.293	0.292 (-0.5%)	0.293 (0.0%)
Georgiana Slough	March	Below Normal	0.320	0.316 (-1.2%)	0.321 (0.1%)
Georgiana Slough	March	Dry	0.362	0.355 (-2.1%)	0.363 (0.0%)
Georgiana Slough	March	Critical	0.420	0.416 (-0.8%)	0.420 (0.0%)
Georgiana Slough	April	Wet	0.305	0.305 (0.1%)	0.305 (0.0%)
Georgiana Slough	April	Above Normal	0.314	0.314 (0.1%)	0.314 (0.0%)
Georgiana Slough	April	Below Normal	0.373	0.373 (0.0%)	0.373 (0.0%)
Georgiana Slough	April	Dry	0.422	0.422 (0.0%)	0.422 (0.0%)
Georgiana Slough	April	Critical	0.447	0.447 (0.0%)	0.447 (0.0%)
Georgiana Slough	May	Wet	0.308	0.309 (0.3%)	0.309 (0.1%)
Georgiana Slough	May	Above Normal	0.342	0.343 (0.3%)	0.343 (0.0%)
Georgiana Slough	May	Below Normal	0.389	0.393 (1.1%)	0.392 (0.8%)
Georgiana Slough	May	Dry	0.435	0.435 (0.1%)	0.435 (0.0%)
Georgiana Slough	May	Critical	0.423	0.424 (0.2%)	0.424 (0.1%)
Georgiana Slough	June	Wet	0.361	0.361 (0.0%)	0.360 (-0.3%)
Georgiana Slough	June	Above Normal	0.390	0.389 (0.0%)	0.388 (-0.4%)
Georgiana Slough	June	Below Normal	0.415	0.414 (-0.2%)	0.413 (-0.5%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Georgiana Slough	June	Dry	0.418	0.413 (-1.4%)	0.412 (-1.6%)
Georgiana Slough	June	Critical	0.358	0.354 (-1.3%)	0.356 (-0.6%)
Head of Old River	September	Wet	0.562	0.568 (1.0%)	0.569 (1.3%)
Head of Old River	September	Above Normal	0.553	0.559 (1.1%)	0.566 (2.5%)
Head of Old River	September	Below Normal	0.558	0.556 (-0.3%)	0.558 (0.0%)
Head of Old River	September	Dry	0.490	0.487 (-0.6%)	0.486 (-0.8%)
Head of Old River	September	Critical	0.393	0.391 (-0.5%)	0.391 (-0.5%)
Head of Old River	October	Wet	0.546	0.546 (-0.1%)	0.546 (-0.1%)
Head of Old River	October	Above Normal	0.529	0.528 (-0.2%)	0.529 (-0.1%)
Head of Old River	October	Below Normal	0.534	0.535 (0.2%)	0.535 (0.3%)
Head of Old River	October	Dry	0.532	0.531 (-0.1%)	0.532 (0.0%)
Head of Old River	October	Critical	0.502	0.504 (0.3%)	0.501 (-0.1%)
Head of Old River	November	Wet	0.568	0.569 (0.1%)	0.569 (0.1%)
Head of Old River	November	Above Normal	0.551	0.550 (-0.2%)	0.550 (-0.1%)
Head of Old River	November	Below Normal	0.552	0.551 (-0.1%)	0.552 (-0.1%)
Head of Old River	November	Dry	0.545	0.545 (0.0%)	0.545 (0.0%)
Head of Old River	November	Critical	0.492	0.495 (0.7%)	0.493 (0.3%)
Head of Old River	December	Wet	0.650	0.649 (-0.1%)	0.649 (-0.1%)
Head of Old River	December	Above Normal	0.680	0.679 (-0.1%)	0.679 (-0.1%)
Head of Old River	December	Below Normal	0.680	0.681 (0.0%)	0.680 (-0.1%)
Head of Old River	December	Dry	0.683	0.680 (-0.4%)	0.680 (-0.4%)
Head of Old River	December	Critical	0.624	0.626 (0.4%)	0.625 (0.2%)
Head of Old River	January	Wet	0.608	0.607 (-0.1%)	0.607 (-0.1%)
Head of Old River	January	Above Normal	0.640	0.639 (-0.2%)	0.639 (-0.2%)
Head of Old River	January	Below Normal	0.660	0.658 (-0.3%)	0.658 (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Head of Old River	January	Dry	0.669	0.667 (-0.2%)	0.667 (-0.3%)
Head of Old River	January	Critical	0.660	0.653 (-1.1%)	0.654 (-0.9%)
Head of Old River	February	Wet	0.577	0.577 (0.0%)	0.577 (0.0%)
Head of Old River	February	Above Normal	0.615	0.615 (-0.1%)	0.615 (-0.1%)
Head of Old River	February	Below Normal	0.626	0.624 (-0.3%)	0.624 (-0.3%)
Head of Old River	February	Dry	0.666	0.662 (-0.7%)	0.661 (-0.7%)
Head of Old River	February	Critical	0.663	0.660 (-0.4%)	0.659 (-0.5%)
Head of Old River	March	Wet	0.566	0.566 (0.1%)	0.566 (0.1%)
Head of Old River	March	Above Normal	0.593	0.594 (0.1%)	0.594 (0.1%)
Head of Old River	March	Below Normal	0.621	0.620 (0.0%)	0.620 (-0.1%)
Head of Old River	March	Dry	0.664	0.663 (-0.2%)	0.663 (-0.2%)
Head of Old River	March	Critical	0.647	0.647 (0.0%)	0.647 (0.0%)
Head of Old River	April	Wet	0.553	0.554 (0.0%)	0.553 (0.0%)
Head of Old River	April	Above Normal	0.562	0.562 (0.0%)	0.562 (0.0%)
Head of Old River	April	Below Normal	0.574	0.574 (0.0%)	0.574 (0.0%)
Head of Old River	April	Dry	0.614	0.614 (0.0%)	0.614 (0.0%)
Head of Old River	April	Critical	0.619	0.621 (0.3%)	0.619 (0.0%)
Head of Old River	May	Wet	0.561	0.566 (0.9%)	0.562 (0.2%)
Head of Old River	May	Above Normal	0.575	0.581 (1.1%)	0.576 (0.2%)
Head of Old River	May	Below Normal	0.587	0.592 (0.8%)	0.587 (0.0%)
Head of Old River	May	Dry	0.619	0.622 (0.5%)	0.619 (0.0%)
Head of Old River	May	Critical	0.600	0.605 (0.8%)	0.601 (0.1%)
Head of Old River	June	Wet	0.534	0.533 (-0.2%)	0.532 (-0.2%)
Head of Old River	June	Above Normal	0.528	0.525 (-0.5%)	0.525 (-0.5%)
Head of Old River	June	Below Normal	0.524	0.521 (-0.7%)	0.520 (-0.8%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Head of Old River	June	Dry	0.501	0.494 (-1.3%)	0.494 (-1.4%)
Head of Old River	June	Critical	0.430	0.427 (-0.7%)	0.428 (-0.5%)
Jersey Point	September	Wet	0.071	0.071 (-0.1%)	0.071 (-0.1%)
Jersey Point	September	Above Normal	0.071	0.072 (0.2%)	0.072 (0.1%)
Jersey Point	September	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	September	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	September	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	October	Wet	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	October	Above Normal	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	October	Below Normal	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	October	Dry	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	October	Critical	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	November	Wet	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	November	Above Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	November	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	November	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	November	Critical	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	December	Wet	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	December	Above Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	December	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	December	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	December	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	January	Wet	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	January	Above Normal	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	January	Below Normal	0.072	0.072 (0.0%)	0.072 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Jersey Point	January	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	January	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	February	Wet	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	February	Above Normal	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	February	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	February	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	February	Critical	0.071	0.071 (-0.1%)	0.071 (-0.1%)
Jersey Point	March	Wet	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	March	Above Normal	0.072	0.072 (0.0%)	0.072 (0.0%)
Jersey Point	March	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	March	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	March	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	April	Wet	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	April	Above Normal	0.071	0.071 (0.2%)	0.071 (0.0%)
Jersey Point	April	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	April	Dry	0.070	0.070 (0.0%)	0.070 (0.0%)
Jersey Point	April	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	May	Wet	0.072	0.072 (0.1%)	0.072 (0.0%)
Jersey Point	May	Above Normal	0.071	0.071 (0.3%)	0.071 (0.0%)
Jersey Point	May	Below Normal	0.071	0.071 (0.1%)	0.071 (0.0%)
Jersey Point	May	Dry	0.071	0.071 (0.1%)	0.071 (0.0%)
Jersey Point	May	Critical	0.071	0.071 (0.1%)	0.071 (0.0%)
Jersey Point	June	Wet	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	June	Above Normal	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	June	Below Normal	0.071	0.071 (0.0%)	0.071 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Jersey Point	June	Dry	0.071	0.071 (0.0%)	0.071 (0.0%)
Jersey Point	June	Critical	0.071	0.071 (0.0%)	0.071 (0.0%)
Mouth of Middle River	September	Wet	0.203	0.208 (2.5%)	0.209 (2.9%)
Mouth of Middle River	September	Above Normal	0.198	0.202 (1.9%)	0.204 (3.2%)
Mouth of Middle River	September	Below Normal	0.205	0.204 (-0.5%)	0.206 (0.0%)
Mouth of Middle River	September	Dry	0.188	0.188 (-0.2%)	0.188 (-0.2%)
Mouth of Middle River	September	Critical	0.177	0.177 (0.0%)	0.177 (0.0%)
Mouth of Middle River	October	Wet	0.194	0.193 (-0.2%)	0.194 (-0.2%)
Mouth of Middle River	October	Above Normal	0.184	0.184 (-0.3%)	0.184 (0.0%)
Mouth of Middle River	October	Below Normal	0.190	0.190 (0.4%)	0.191 (0.5%)
Mouth of Middle River	October	Dry	0.187	0.187 (-0.2%)	0.187 (0.0%)
Mouth of Middle River	October	Critical	0.177	0.178 (0.3%)	0.177 (-0.2%)
Mouth of Middle River	November	Wet	0.203	0.204 (0.2%)	0.204 (0.2%)
Mouth of Middle River	November	Above Normal	0.194	0.193 (-0.1%)	0.194 (0.0%)
Mouth of Middle River	November	Below Normal	0.198	0.198 (-0.1%)	0.198 (-0.1%)
Mouth of Middle River	November	Dry	0.195	0.195 (0.1%)	0.195 (0.1%)
Mouth of Middle River	November	Critical	0.176	0.177 (0.5%)	0.177 (0.2%)
Mouth of Middle River	December	Wet	0.194	0.194 (-0.1%)	0.194 (-0.1%)
Mouth of Middle River	December	Above Normal	0.188	0.188 (-0.1%)	0.188 (0.0%)
Mouth of Middle River	December	Below Normal	0.189	0.189 (0.1%)	0.188 (-0.1%)
Mouth of Middle River	December	Dry	0.187	0.187 (-0.4%)	0.187 (-0.4%)
Mouth of Middle River	December	Critical	0.176	0.177 (0.3%)	0.176 (0.1%)
Mouth of Middle River	January	Wet	0.190	0.189 (-0.2%)	0.189 (-0.2%)
Mouth of Middle River	January	Above Normal	0.186	0.186 (-0.2%)	0.186 (-0.2%)
Mouth of Middle River	January	Below Normal	0.181	0.180 (-0.4%)	0.180 (-0.4%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Mouth of Middle River	January	Dry	0.179	0.179 (-0.4%)	0.178 (-0.4%)
Mouth of Middle River	January	Critical	0.177	0.174 (-1.3%)	0.175 (-1.0%)
Mouth of Middle River	February	Wet	0.192	0.192 (0.0%)	0.192 (0.0%)
Mouth of Middle River	February	Above Normal	0.187	0.185 (-0.7%)	0.186 (-0.3%)
Mouth of Middle River	February	Below Normal	0.185	0.184 (-0.4%)	0.184 (-0.4%)
Mouth of Middle River	February	Dry	0.180	0.178 (-0.9%)	0.178 (-0.9%)
Mouth of Middle River	February	Critical	0.178	0.177 (-0.2%)	0.177 (-0.3%)
Mouth of Middle River	March	Wet	0.186	0.186 (0.2%)	0.186 (0.3%)
Mouth of Middle River	March	Above Normal	0.184	0.185 (0.2%)	0.184 (0.2%)
Mouth of Middle River	March	Below Normal	0.182	0.182 (0.0%)	0.182 (0.0%)
Mouth of Middle River	March	Dry	0.177	0.176 (-0.1%)	0.176 (-0.2%)
Mouth of Middle River	March	Critical	0.173	0.173 (-0.1%)	0.173 (-0.1%)
Mouth of Middle River	April	Wet	0.183	0.184 (0.4%)	0.183 (0.1%)
Mouth of Middle River	April	Above Normal	0.176	0.177 (0.5%)	0.176 (0.0%)
Mouth of Middle River	April	Below Normal	0.168	0.169 (0.4%)	0.168 (0.0%)
Mouth of Middle River	April	Dry	0.166	0.166 (0.1%)	0.166 (0.0%)
Mouth of Middle River	April	Critical	0.167	0.167 (0.1%)	0.167 (0.0%)
Mouth of Middle River	May	Wet	0.185	0.190 (2.5%)	0.186 (0.7%)
Mouth of Middle River	May	Above Normal	0.178	0.180 (1.5%)	0.179 (0.5%)
Mouth of Middle River	May	Below Normal	0.167	0.169 (1.3%)	0.168 (0.2%)
Mouth of Middle River	May	Dry	0.165	0.165 (0.1%)	0.165 (0.0%)
Mouth of Middle River	May	Critical	0.165	0.165 (0.2%)	0.165 (0.0%)
Mouth of Middle River	June	Wet	0.193	0.192 (-0.6%)	0.192 (-0.7%)
Mouth of Middle River	June	Above Normal	0.190	0.188 (-1.1%)	0.188 (-1.2%)
Mouth of Middle River	June	Below Normal	0.187	0.186 (-0.8%)	0.186 (-0.8%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Mouth of Middle River	June	Dry	0.184	0.182 (-1.4%)	0.182 (-1.3%)
Mouth of Middle River	June	Critical	0.174	0.173 (-0.5%)	0.174 (-0.2%)
Mouth of Old River	September	Wet	0.184	0.191 (3.8%)	0.192 (4.4%)
Mouth of Old River	September	Above Normal	0.174	0.181 (3.7%)	0.185 (6.2%)
Mouth of Old River	September	Below Normal	0.180	0.179 (-0.3%)	0.181 (0.5%)
Mouth of Old River	September	Dry	0.155	0.155 (-0.2%)	0.155 (-0.2%)
Mouth of Old River	September	Critical	0.143	0.143 (0.0%)	0.143 (0.0%)
Mouth of Old River	October	Wet	0.162	0.162 (0.0%)	0.162 (-0.1%)
Mouth of Old River	October	Above Normal	0.149	0.148 (-0.3%)	0.148 (0.0%)
Mouth of Old River	October	Below Normal	0.158	0.159 (0.6%)	0.159 (0.8%)
Mouth of Old River	October	Dry	0.154	0.154 (0.0%)	0.155 (0.3%)
Mouth of Old River	October	Critical	0.139	0.140 (0.1%)	0.139 (-0.6%)
Mouth of Old River	November	Wet	0.177	0.177 (0.2%)	0.177 (0.2%)
Mouth of Old River	November	Above Normal	0.159	0.158 (-0.2%)	0.159 (-0.1%)
Mouth of Old River	November	Below Normal	0.167	0.167 (-0.1%)	0.166 (-0.2%)
Mouth of Old River	November	Dry	0.161	0.161 (0.2%)	0.161 (0.2%)
Mouth of Old River	November	Critical	0.138	0.139 (0.9%)	0.138 (0.3%)
Mouth of Old River	December	Wet	0.188	0.188 (-0.1%)	0.188 (-0.1%)
Mouth of Old River	December	Above Normal	0.156	0.156 (0.0%)	0.156 (0.0%)
Mouth of Old River	December	Below Normal	0.154	0.155 (0.2%)	0.154 (-0.1%)
Mouth of Old River	December	Dry	0.152	0.151 (-0.6%)	0.151 (-0.6%)
Mouth of Old River	December	Critical	0.141	0.142 (0.3%)	0.141 (0.1%)
Mouth of Old River	January	Wet	0.208	0.207 (-0.4%)	0.207 (-0.4%)
Mouth of Old River	January	Above Normal	0.179	0.178 (-0.4%)	0.178 (-0.4%)
Mouth of Old River	January	Below Normal	0.151	0.150 (-0.4%)	0.150 (-0.4%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Mouth of Old River	January	Dry	0.144	0.143 (-0.6%)	0.143 (-0.6%)
Mouth of Old River	January	Critical	0.142	0.140 (-1.3%)	0.140 (-1.0%)
Mouth of Old River	February	Wet	0.229	0.229 (0.1%)	0.229 (0.0%)
Mouth of Old River	February	Above Normal	0.188	0.186 (-0.8%)	0.187 (-0.2%)
Mouth of Old River	February	Below Normal	0.166	0.165 (-0.8%)	0.165 (-0.8%)
Mouth of Old River	February	Dry	0.151	0.149 (-1.0%)	0.149 (-1.0%)
Mouth of Old River	February	Critical	0.146	0.145 (-0.4%)	0.145 (-0.6%)
Mouth of Old River	March	Wet	0.202	0.203 (0.3%)	0.203 (0.4%)
Mouth of Old River	March	Above Normal	0.179	0.180 (0.6%)	0.179 (0.3%)
Mouth of Old River	March	Below Normal	0.158	0.158 (0.2%)	0.157 (-0.2%)
Mouth of Old River	March	Dry	0.147	0.147 (0.0%)	0.146 (-0.3%)
Mouth of Old River	March	Critical	0.139	0.139 (0.0%)	0.139 (-0.1%)
Mouth of Old River	April	Wet	0.182	0.182 (0.1%)	0.182 (0.1%)
Mouth of Old River	April	Above Normal	0.151	0.152 (0.7%)	0.151 (0.1%)
Mouth of Old River	April	Below Normal	0.138	0.138 (0.5%)	0.138 (0.0%)
Mouth of Old River	April	Dry	0.132	0.132 (0.0%)	0.132 (0.0%)
Mouth of Old River	April	Critical	0.129	0.129 (0.2%)	0.129 (0.0%)
Mouth of Old River	May	Wet	0.173	0.178 (3.0%)	0.174 (0.9%)
Mouth of Old River	May	Above Normal	0.149	0.153 (2.1%)	0.151 (0.8%)
Mouth of Old River	May	Below Normal	0.136	0.138 (1.5%)	0.136 (0.1%)
Mouth of Old River	May	Dry	0.129	0.130 (0.4%)	0.129 (0.0%)
Mouth of Old River	May	Critical	0.125	0.126 (0.5%)	0.125 (0.0%)
Mouth of Old River	June	Wet	0.174	0.173 (-0.5%)	0.173 (-0.6%)
Mouth of Old River	June	Above Normal	0.160	0.159 (-1.2%)	0.158 (-1.3%)
Mouth of Old River	June	Below Normal	0.157	0.155 (-1.0%)	0.155 (-1.1%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Mouth of Old River	June	Dry	0.152	0.149 (-1.7%)	0.149 (-1.8%)
Mouth of Old River	June	Critical	0.139	0.138 (-0.6%)	0.139 (-0.3%)
Sutter Slough	September	Wet	0.195	0.195 (0.2%)	0.195 (0.2%)
Sutter Slough	September	Above Normal	0.194	0.194 (0.4%)	0.195 (0.5%)
Sutter Slough	September	Below Normal	0.181	0.181 (-0.2%)	0.182 (0.7%)
Sutter Slough	September	Dry	0.154	0.154 (0.4%)	0.154 (0.2%)
Sutter Slough	September	Critical	0.145	0.145 (-0.2%)	0.145 (-0.1%)
Sutter Slough	October	Wet	0.185	0.185 (0.3%)	0.185 (0.1%)
Sutter Slough	October	Above Normal	0.171	0.170 (-0.5%)	0.171 (-0.2%)
Sutter Slough	October	Below Normal	0.177	0.176 (-0.6%)	0.176 (-0.3%)
Sutter Slough	October	Dry	0.176	0.174 (-1.4%)	0.174 (-1.2%)
Sutter Slough	October	Critical	0.160	0.160 (0.3%)	0.161 (1.0%)
Sutter Slough	November	Wet	0.197	0.197 (0.0%)	0.197 (0.0%)
Sutter Slough	November	Above Normal	0.188	0.188 (0.1%)	0.188 (0.1%)
Sutter Slough	November	Below Normal	0.189	0.188 (-0.4%)	0.188 (-0.4%)
Sutter Slough	November	Dry	0.185	0.185 (0.0%)	0.185 (0.1%)
Sutter Slough	November	Critical	0.174	0.173 (-0.8%)	0.172 (-1.2%)
Sutter Slough	December	Wet	0.219	0.219 (0.0%)	0.219 (0.0%)
Sutter Slough	December	Above Normal	0.219	0.219 (-0.1%)	0.219 (-0.1%)
Sutter Slough	December	Below Normal	0.215	0.215 (0.0%)	0.215 (-0.1%)
Sutter Slough	December	Dry	0.216	0.216 (-0.1%)	0.216 (-0.1%)
Sutter Slough	December	Critical	0.213	0.213 (0.3%)	0.213 (0.3%)
Sutter Slough	January	Wet	0.220	0.220 (0.0%)	0.220 (0.0%)
Sutter Slough	January	Above Normal	0.218	0.218 (0.0%)	0.218 (0.0%)
Sutter Slough	January	Below Normal	0.218	0.218 (0.0%)	0.218 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Sutter Slough	January	Dry	0.222	0.222 (0.1%)	0.222 (0.1%)
Sutter Slough	January	Critical	0.210	0.211 (0.4%)	0.210 (0.0%)
Sutter Slough	February	Wet	0.221	0.221 (0.0%)	0.221 (0.0%)
Sutter Slough	February	Above Normal	0.218	0.218 (0.0%)	0.218 (0.0%)
Sutter Slough	February	Below Normal	0.218	0.218 (0.1%)	0.218 (0.1%)
Sutter Slough	February	Dry	0.218	0.217 (-0.2%)	0.217 (-0.2%)
Sutter Slough	February	Critical	0.216	0.218 (0.5%)	0.218 (0.5%)
Sutter Slough	March	Wet	0.220	0.220 (0.0%)	0.220 (0.0%)
Sutter Slough	March	Above Normal	0.219	0.219 (0.0%)	0.219 (0.0%)
Sutter Slough	March	Below Normal	0.217	0.217 (-0.1%)	0.217 (0.0%)
Sutter Slough	March	Dry	0.219	0.219 (-0.2%)	0.219 (0.0%)
Sutter Slough	March	Critical	0.221	0.220 (-0.4%)	0.220 (-0.2%)
Sutter Slough	April	Wet	0.220	0.220 (0.0%)	0.220 (0.0%)
Sutter Slough	April	Above Normal	0.217	0.217 (0.0%)	0.217 (0.0%)
Sutter Slough	April	Below Normal	0.222	0.222 (0.0%)	0.222 (0.0%)
Sutter Slough	April	Dry	0.225	0.225 (-0.1%)	0.225 (0.0%)
Sutter Slough	April	Critical	0.222	0.221 (-0.3%)	0.222 (0.0%)
Sutter Slough	May	Wet	0.220	0.220 (0.0%)	0.220 (0.0%)
Sutter Slough	May	Above Normal	0.219	0.219 (-0.1%)	0.219 (0.0%)
Sutter Slough	May	Below Normal	0.224	0.224 (0.2%)	0.224 (0.2%)
Sutter Slough	May	Dry	0.228	0.228 (0.1%)	0.228 (0.1%)
Sutter Slough	May	Critical	0.203	0.203 (0.2%)	0.203 (0.2%)
Sutter Slough	June	Wet	0.203	0.203 (0.1%)	0.203 (-0.1%)
Sutter Slough	June	Above Normal	0.194	0.194 (0.2%)	0.194 (-0.3%)
Sutter Slough	June	Below Normal	0.180	0.181 (0.0%)	0.180 (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Sutter Slough	June	Dry	0.178	0.176 (-1.2%)	0.176 (-1.4%)
Sutter Slough	June	Critical	0.162	0.161 (-0.5%)	0.162 (0.1%)
Steamboat Slough	September	Wet	0.190	0.194 (2.1%)	0.194 (2.5%)
Steamboat Slough	September	Above Normal	0.185	0.192 (3.6%)	0.195 (5.4%)
Steamboat Slough	September	Below Normal	0.166	0.167 (0.2%)	0.167 (0.5%)
Steamboat Slough	September	Dry	0.164	0.164 (0.0%)	0.164 (0.2%)
Steamboat Slough	September	Critical	0.184	0.183 (-0.1%)	0.183 (-0.1%)
Steamboat Slough	October	Wet	0.190	0.189 (-0.3%)	0.189 (-0.2%)
Steamboat Slough	October	Above Normal	0.180	0.180 (0.2%)	0.180 (0.1%)
Steamboat Slough	October	Below Normal	0.181	0.180 (-0.5%)	0.179 (-0.9%)
Steamboat Slough	October	Dry	0.179	0.179 (-0.1%)	0.179 (-0.3%)
Steamboat Slough	October	Critical	0.183	0.183 (-0.1%)	0.184 (0.5%)
Steamboat Slough	November	Wet	0.199	0.199 (0.1%)	0.199 (0.1%)
Steamboat Slough	November	Above Normal	0.194	0.194 (-0.1%)	0.194 (-0.1%)
Steamboat Slough	November	Below Normal	0.186	0.186 (0.0%)	0.186 (0.0%)
Steamboat Slough	November	Dry	0.179	0.179 (0.0%)	0.179 (0.0%)
Steamboat Slough	November	Critical	0.184	0.183 (-0.4%)	0.184 (-0.1%)
Steamboat Slough	December	Wet	0.250	0.250 (-0.1%)	0.250 (-0.1%)
Steamboat Slough	December	Above Normal	0.218	0.218 (-0.1%)	0.218 (0.0%)
Steamboat Slough	December	Below Normal	0.209	0.210 (0.4%)	0.210 (0.2%)
Steamboat Slough	December	Dry	0.209	0.208 (-0.5%)	0.208 (-0.4%)
Steamboat Slough	December	Critical	0.196	0.197 (0.2%)	0.196 (0.1%)
Steamboat Slough	January	Wet	0.262	0.262 (0.0%)	0.263 (0.0%)
Steamboat Slough	January	Above Normal	0.255	0.255 (0.0%)	0.255 (0.0%)
Steamboat Slough	January	Below Normal	0.228	0.228 (0.1%)	0.228 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Steamboat Slough	January	Dry	0.210	0.209 (-0.4%)	0.209 (-0.4%)
Steamboat Slough	January	Critical	0.205	0.205 (0.1%)	0.205 (0.2%)
Steamboat Slough	February	Wet	0.272	0.272 (0.0%)	0.272 (0.0%)
Steamboat Slough	February	Above Normal	0.261	0.261 (0.0%)	0.261 (0.0%)
Steamboat Slough	February	Below Normal	0.239	0.239 (-0.3%)	0.239 (-0.3%)
Steamboat Slough	February	Dry	0.228	0.229 (0.6%)	0.229 (0.6%)
Steamboat Slough	February	Critical	0.213	0.215 (0.6%)	0.215 (0.5%)
Steamboat Slough	March	Wet	0.266	0.266 (0.0%)	0.266 (0.0%)
Steamboat Slough	March	Above Normal	0.260	0.260 (0.2%)	0.260 (-0.1%)
Steamboat Slough	March	Below Normal	0.240	0.242 (0.6%)	0.240 (0.0%)
Steamboat Slough	March	Dry	0.225	0.227 (1.1%)	0.225 (0.0%)
Steamboat Slough	March	Critical	0.201	0.202 (0.6%)	0.201 (-0.1%)
Steamboat Slough	April	Wet	0.254	0.254 (0.0%)	0.254 (0.0%)
Steamboat Slough	April	Above Normal	0.241	0.241 (0.0%)	0.241 (0.0%)
Steamboat Slough	April	Below Normal	0.217	0.217 (0.0%)	0.217 (0.0%)
Steamboat Slough	April	Dry	0.199	0.198 (-0.2%)	0.198 (0.0%)
Steamboat Slough	April	Critical	0.186	0.186 (-0.1%)	0.186 (-0.1%)
Steamboat Slough	May	Wet	0.248	0.248 (-0.1%)	0.248 (0.0%)
Steamboat Slough	May	Above Normal	0.233	0.233 (0.0%)	0.233 (0.0%)
Steamboat Slough	May	Below Normal	0.214	0.212 (-0.8%)	0.212 (-0.7%)
Steamboat Slough	May	Dry	0.194	0.194 (0.1%)	0.194 (0.1%)
Steamboat Slough	May	Critical	0.187	0.186 (-0.1%)	0.187 (0.0%)
Steamboat Slough	June	Wet	0.216	0.216 (0.1%)	0.216 (0.1%)
Steamboat Slough	June	Above Normal	0.193	0.193 (0.0%)	0.193 (-0.2%)
Steamboat Slough	June	Below Normal	0.174	0.173 (0.0%)	0.174 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Steamboat Slough	June	Dry	0.169	0.169 (-0.2%)	0.169 (-0.2%)
Steamboat Slough	June	Critical	0.178	0.178 (0.2%)	0.178 (0.2%)
Turner Cut	September	Wet	0.175	0.178 (1.9%)	0.179 (2.2%)
Turner Cut	September	Above Normal	0.163	0.165 (1.5%)	0.167 (2.6%)
Turner Cut	September	Below Normal	0.170	0.169 (-0.3%)	0.170 (0.1%)
Turner Cut	September	Dry	0.157	0.157 (-0.3%)	0.157 (-0.3%)
Turner Cut	September	Critical	0.150	0.150 (0.0%)	0.150 (0.0%)
Turner Cut	October	Wet	0.170	0.170 (-0.1%)	0.170 (-0.1%)
Turner Cut	October	Above Normal	0.158	0.157 (-0.2%)	0.157 (-0.1%)
Turner Cut	October	Below Normal	0.167	0.167 (0.2%)	0.167 (0.3%)
Turner Cut	October	Dry	0.163	0.162 (-0.1%)	0.163 (0.0%)
Turner Cut	October	Critical	0.151	0.151 (0.1%)	0.150 (-0.1%)
Turner Cut	November	Wet	0.182	0.182 (0.1%)	0.182 (0.1%)
Turner Cut	November	Above Normal	0.169	0.168 (-0.2%)	0.168 (-0.1%)
Turner Cut	November	Below Normal	0.176	0.176 (0.0%)	0.176 (0.0%)
Turner Cut	November	Dry	0.170	0.170 (0.1%)	0.170 (0.1%)
Turner Cut	November	Critical	0.153	0.154 (0.5%)	0.153 (-0.1%)
Turner Cut	December	Wet	0.173	0.173 (-0.1%)	0.173 (-0.1%)
Turner Cut	December	Above Normal	0.159	0.159 (0.0%)	0.159 (0.0%)
Turner Cut	December	Below Normal	0.159	0.159 (0.1%)	0.159 (-0.1%)
Turner Cut	December	Dry	0.156	0.156 (-0.4%)	0.156 (-0.4%)
Turner Cut	December	Critical	0.149	0.150 (0.2%)	0.149 (0.0%)
Turner Cut	January	Wet	0.174	0.174 (-0.3%)	0.174 (-0.3%)
Turner Cut	January	Above Normal	0.164	0.164 (-0.3%)	0.164 (-0.3%)
Turner Cut	January	Below Normal	0.156	0.155 (-0.3%)	0.155 (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Turner Cut	January	Dry	0.151	0.151 (-0.3%)	0.151 (-0.3%)
Turner Cut	January	Critical	0.151	0.150 (-0.8%)	0.150 (-0.6%)
Turner Cut	February	Wet	0.181	0.181 (0.1%)	0.181 (0.1%)
Turner Cut	February	Above Normal	0.175	0.174 (-0.6%)	0.174 (-0.1%)
Turner Cut	February	Below Normal	0.168	0.168 (-0.4%)	0.168 (-0.4%)
Turner Cut	February	Dry	0.153	0.152 (-0.7%)	0.152 (-0.6%)
Turner Cut	February	Critical	0.152	0.151 (-0.4%)	0.151 (-0.4%)
Turner Cut	March	Wet	0.182	0.183 (0.1%)	0.183 (0.3%)
Turner Cut	March	Above Normal	0.172	0.172 (0.2%)	0.172 (0.2%)
Turner Cut	March	Below Normal	0.164	0.164 (-0.1%)	0.164 (-0.1%)
Turner Cut	March	Dry	0.151	0.151 (-0.2%)	0.151 (-0.2%)
Turner Cut	March	Critical	0.147	0.147 (-0.1%)	0.147 (-0.1%)
Turner Cut	April	Wet	0.187	0.187 (0.1%)	0.187 (0.1%)
Turner Cut	April	Above Normal	0.172	0.173 (0.4%)	0.172 (0.0%)
Turner Cut	April	Below Normal	0.158	0.159 (0.3%)	0.158 (0.0%)
Turner Cut	April	Dry	0.146	0.146 (0.1%)	0.146 (0.0%)
Turner Cut	April	Critical	0.143	0.143 (0.1%)	0.143 (0.0%)
Turner Cut	May	Wet	0.183	0.186 (2.0%)	0.184 (0.6%)
Turner Cut	May	Above Normal	0.167	0.169 (1.4%)	0.168 (0.6%)
Turner Cut	May	Below Normal	0.153	0.155 (1.3%)	0.153 (0.2%)
Turner Cut	May	Dry	0.143	0.144 (0.2%)	0.143 (0.0%)
Turner Cut	May	Critical	0.139	0.140 (0.3%)	0.139 (0.0%)
Turner Cut	June	Wet	0.189	0.189 (-0.4%)	0.189 (-0.4%)
Turner Cut	June	Above Normal	0.172	0.170 (-0.9%)	0.170 (-0.9%)
Turner Cut	June	Below Normal	0.165	0.163 (-0.8%)	0.163 (-0.8%)

Junction	Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Turner Cut	June	Dry	0.157	0.155 (-1.1%)	0.155 (-1.1%)
Turner Cut	June	Critical	0.147	0.147 (-0.4%)	0.147 (-0.2%)

5.1.2.1.3. Conclusions on Delta Hydrodynamics and Junction Routing

Although DSM2-HYDRO modeling for the Sacramento River showed negligible changes in velocity between Baseline Conditions and both Proposed Project scenarios at Freeport and Walnut Grove, CalSim 3 modeling of SWP south Delta exports obtained from subsequent coordination with DWR indicates that there will be increases to mean monthly exports (2-87% increase) and decreases in mean monthly OMR flows (29-1,435% decrease) in all water year types during the months of April and May for the Proposed Project 9A_V2A scenario (see Appendix C – CalSim Modeling Results; Table C- 19, Table C- 20, Table C- 31, and Table C- 32). For the 9A_V2A scenario, median monthly SWP south Delta exports appear higher in April of wet years and May of all water year types (see Appendix C – CalSim Modeling Results; Figure C- 3) and median monthly OMR flows appear lower in April of above normal and critical water years and May of all water year types (see Appendix C – CalSim Modeling Results; Figure C- 7). April is an important Delta migration month for both juvenile CHNWR and CHNSR, with CHNSR migration extending through the Delta in May. Changes in exports and negative OMR flows of this magnitude will have a negative impact on juvenile CHNWR and CHNSR by increasing entrainment into the CVP and SWP export facilities. OMR flows modeled in CalSim 3 appear to be more negative under the Proposed Project 9A_V2A scenario in May of all water year types, and more negative in April of dry, below normal, and above normal water years compared to Baseline Conditions and the Proposed Project ITP_Spring scenario (see Appendix C – CalSim Modeling Results; Figure C- 7).

Impacts of increased exports and more negative OMR flows on salmonid routing are greatest at the head of Old River, which is the junction analyzed closest to the CVP and SWP export facilities (SST 2017). Increases in reverse flows near the export facilities is likely to increase salvage, which is supported by the Salvage-Density Method results that show increases in modeled loss of genetically-identified natural-origin CHNWR and CHNSR at the SWP export facilities during April and May (see Section 5.2.1.3 – Salvage-Density Method; Tables 25 and 29). Mean monthly OMR flow values are more negative in April and May of most water year types for the ITP_Spring scenario compared to Baseline Conditions ranging from a decrease of 0% to 46% (see Appendix C – CalSim Modeling Results; Table C- 31 and Table C- 32), but would likely not have as pronounced impacts on routing of CHNWR and CHNSR as the Proposed Project 9A_V2A scenario.

5.1.3. Effects of South Delta Export Operations on Juvenile Chinook Salmon Through-Delta Survival

DWR used both the STARS model (based on Perry et al. 2018) and ECO-PTM (based on Wang 2019) in the ITP Application (DWR 2023f) to evaluate potential differences in through-Delta survival of outmigrating Chinook Salmon smolts from the Sacramento River Basin between Baseline Conditions and the two Proposed Project scenarios (ITP_Spring and 9A_V2A). For the three scenarios, modeling outputs from CalSim 3, and subsequently DSM2, were used as inputs to the STARS model and ECO-PTM. See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon for additional information on each modeling scenario. Modeling results discussed below are based on information CDFW obtained from DWR's ITP Application (DWR 2023f) and subsequent coordination with DWR.

Survival estimates generated by the STARS model and ECO-PTM are not intended to predict future outcomes or current conditions. Instead, the STARS model and ECO-PTM are simulation tools that compare the effects of different water management options to smolt migration survival, with accompanying estimates of uncertainty. There is an assumption of stationarity of basic relationships within these two models to enable comparison of scenarios for the current analysis. As with all other methods found in the ITP Application (DWR 2023f), it is possible that underlying relationships (e.g., flow-survival) used to inform the STARS model and ECO-PTM could change in the future. It may be necessary to re-examine the relationships as new information becomes available.

The results of the STARS model and ECO-PTM should be interpreted with caution and should only be considered relevant, with caveats, for natural CHNWR and CHNSR that have reared upstream and are rapidly transiting through the Delta as smolts, and hatchery CHNWR and CHNSR released upstream of the Delta. The STARS model and ECO-PTM do not evaluate routing and through-Delta survival for rearing (pre-smolt) natural CHNWR and CHNSR, nor do they incorporate Project-related effects on the behavior and life history diversity displayed by the majority of these populations which spend extended periods in the Delta (see Appendix D – Juvenile Size Distribution in Delta Monitoring and Salvage). Further, the statistical model of Perry et al. (2018; STARS) provides limited analysis of through-Delta survival as it considers the effects of Freeport flows and DCC operations but does not include south Delta exports. Similarly, ECO-PTM is mainly calibrated for the north Delta from Freeport to Chipps Island (Wang 2019). Thus, the modeling results presented below are insensitive to any differences in SWP exports between Baseline Conditions and the two scenarios modeled for the Proposed Project.

Given the importance in DCC operations in both models, it is important to note that the CalSim 3 model assumes DCC gates are closed in October and November when Sacramento River flow at Wilkins Slough is greater than 7,500 cfs, which acts as a flow surrogate for an increase in the presence of juvenile Chinook Salmon within the vicinity of the DCC gates. Implementation of DCC gate actions is based on water quality criteria as well as fish presence as determined by the Knights Landing catch index or Sacramento catch index, which are calculated based on Knights Landing RST, Sacramento River beach seines, and Sacramento River trawl monitoring data (NMFS 2019a). Fish presence at these monitoring sites does not always align with the surrogate flow trigger used in CalSim 3 modeling and, depending on Sacramento River conditions, catch efficiency at the monitoring sites can be low and result in low fish detection. Additionally, at high Sacramento River flows, monitoring is often suspended due to safety concerns. Thus, the flow surrogate for DCC gate operations modeled in CalSim 3 may artificially increase the amount of time CalSim 3 assumes the DCC gates are closed, and as a result, may assume reduced impacts on CHNWR and CHNSR seen in the STARS and ECO-PTM modeling outputs. It is likely that impacts on CHNWR and CHNSR will be greater during implementation of the Project compared to what is observed in the modeling results because DCC gates may be open more frequently with real-time operations based on fish presence rather than the modeling flow surrogate.

5.1.3.1. Survival, Travel Time, and Routing Simulation Analysis (STARS)

The STARS model, based on Perry et al. (2018), is a stochastic, individual-based simulation model designed to predict survival of a cohort of juvenile Chinook Salmon that experience variable daily river flows as they migrate through the Delta from the Sacramento River. Detailed methods for the STARS model are presented in Perry et al. (2020). Modeling results herein are based on information CDFW obtained from DWR's ITP Application (DWR 2023f) and subsequent coordination with DWR.

Although the STARS analysis considered through-Delta survival, travel time, and routing, the discussion herein focuses on differences in through-Delta survival because the survival calculations integrate flow-survival relationships, travel time, and routing of fish into different parts of the Delta with varying survival rates. Run-specific analyses are not conducted using the STARS model, rather, a daily analysis of juvenile Chinook Salmon entry into the Delta was conducted for each month of the year. STARS modeling results were provided for two efficiency scenarios for reducing juvenile Chinook Salmon entry into the Georgiana Slough via the Georgiana Slough Salmonid Migratory Barrier (referred to as BAFF in the following tables; 50% and 67% efficiency). Modeling of the BAFF operation was dynamic in STARS with the BAFF turned on during times when DCC gates are closed between November 16 and December 31, turned on full-time January 1 through April 30, and turned off for the remainder of the year. In the following tables, May through October modeled results do not include BAFF operations for Baseline Conditions or Proposed Project scenarios. In implementation, DWR will operate the BAFF annually as early as November 1, but no later than November 16, with operations from November 1 through November 30 tied to DCC gate operations (i.e., when DCC gates are closed for fishery protection purposes, BAFF will be operated). DWR will operate the BAFF continuously from December 1 through April 30 and coordinate with CDFW annually on the need to operate the BAFF into May in consideration of juvenile CHNWR and CHNSR presence in the Delta. Percent difference between Baseline Conditions and Proposed Project scenarios was calculated as the difference between survival estimates from Baseline Conditions and Proposed Project scenarios divided by Baseline Conditions.

Changes in mean through-Delta survival between Baseline Conditions and the two Proposed Project scenarios ranged from a decrease of about 2% to an increase of about 6% in any month or water year type (Tables 3-14). The greatest differences in survival between Baseline Conditions and Proposed Project scenarios during months that juvenile CHNWR and CHNSR are expected to be present in the Delta appear in October of below normal and dry water years (1.1-1.4% decrease; Table 3), October of critical water years for the ITP_Spring scenario (1.9% increase; Table 3), November of critical water years (1.3-2.3% decrease; Table 4), and March of dry water years (1.2-1.4% increase; Table 8). Decreases in survival seen in October of below normal and dry water years and November of critical water years reflect potential decreases in Delta inflow during those months due to a higher proportion of Sacramento River flow entering the DCC; however, the underlying causes of these changes in flow are unclear (see Section 5.1.2.1 – Delta Hydrodynamic Assessment and Junction Routing Analysis). Early migrating juvenile CHNWR and yearling CHNSR present in the Delta in October and November would experience conditions reflected in the STARS modeling that reduce through-Delta survival. Increased through-Delta survival seen in March of dry water years for the 9A_V2A scenario is likely a result of the 50 TAF Delta inflow block of water in March under Condition of Approval 8.12.2 Spring Delta Outflow Implementation Via the Healthy Rivers and Landscapes Program (see Section 6.1.3; Condition of Approval 8.12).

Larger differences in survival are seen in June of dry water years (1.5-1.7% decrease; Table 11), August of above normal and dry years (0.7-1.5% decrease; Table 13), and September of wet and above normal water years (2.3-5.9% increase; Table 14); however, June, August, and September are not peak migration months for either juvenile CHNWR or CHNSR, and juveniles may not be present at all depending on the run and life history type (i.e., YOY or yearling). Juvenile CHNWR are not present in the Delta during June and juvenile CHNSR are not present during August or September (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). Remaining months and water year types showed negligible differences between Baseline Conditions and the two Proposed Project scenarios (Tables 5-7, 9, 10, and 12). Changes in survival between the two Proposed Project scenarios compared to Baseline Conditions were generally similar. Operation of the BAFF between November and April did not appear to substantially improve through-Delta survival when comparing the 50% efficiency scenario to the 67% efficiency scenario. STARS modeling results showed some minor differences, mostly increases, in through-Delta survival under the greater BAFF efficiency scenario.

Table 3. Mean October Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.36	0.36 (0.2%)	0.36 (0.2%)
Above Normal	0.32	0.32 (-0.1%)	0.32 (0.0%)
Below Normal	0.33	0.32 (-1.4%)	0.32 (-1.2%)
Dry	0.32	0.32 (-1.2%)	0.32 (-1.1%)
Critical	0.30	0.31 (0.5%)	0.31 (1.9%)

Table 4. Mean November Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.43	0.43 (0.1%)	0.43 (0.2%)	0.43	0.43 (0.1%)	0.43 (0.2%)
Above Normal	0.40	0.40 (-0.1%)	0.40 (-0.2%)	0.41	0.41 (0.0%)	0.41 (0.0%)
Below Normal	0.38	0.38 (-0.5%)	0.38 (-0.6%)	0.39	0.38 (-0.5%)	0.38 (-0.6%)
Dry	0.36	0.36 (0.1%)	0.36 (0.2%)	0.36	0.36 (0.1%)	0.37 (0.2%)
Critical	0.34	0.34 (-1.3%)	0.34 (-2.2%)	0.35	0.35 (-1.5%)	0.34 (-2.3%)

Table 5. Mean December Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.60	0.60 (0.0%)	0.60 (0.0%)	0.61	0.61 (-0.1%)	0.61 (0.0%)
Above Normal	0.51	0.51 (0.0%)	0.51 (-0.1%)	0.53	0.52 (-0.1%)	0.52 (-0.1%)
Below Normal	0.48	0.49 (0.4%)	0.48 (0.0%)	0.50	0.50 (0.4%)	0.50 (0.1%)
Dry	0.48	0.48 (-0.4%)	0.48 (-0.3%)	0.50	0.49 (-0.4%)	0.50 (-0.4%)
Critical	0.45	0.45 (0.3%)	0.45 (0.1%)	0.46	0.47 (0.2%)	0.46 (0.1%)

Table 6. Mean January Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.63	0.63 (0.0%)	0.63 (0.1%)	0.64	0.64 (0.1%)	0.64 (0.1%)
Above Normal	0.61	0.61 (0.0%)	0.61 (0.0%)	0.62	0.62 (0.0%)	0.62 (0.0%)
Below Normal	0.53	0.53 (0.0%)	0.53 (0.0%)	0.55	0.55 (0.0%)	0.55 (0.0%)
Dry	0.49	0.49 (-0.3%)	0.49 (-0.3%)	0.50	0.50 (-0.3%)	0.50 (-0.4%)
Critical	0.46	0.46 (0.2%)	0.46 (0.0%)	0.48	0.48 (0.1%)	0.48 (0.0%)

Table 7. Mean February Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.66	0.66 (0.0%)	0.66 (0.0%)	0.67	0.67 (0.0%)	0.67 (0.0%)
Above Normal	0.63	0.62 (-0.1%)	0.62 (-0.1%)	0.64	0.64 (0.0%)	0.64 (0.0%)
Below Normal	0.56	0.56 (-0.3%)	0.56 (-0.2%)	0.58	0.57 (-0.3%)	0.57 (-0.2%)
Dry	0.53	0.53 (0.4%)	0.53 (0.4%)	0.54	0.55 (0.3%)	0.55 (0.4%)
Critical	0.49	0.49 (0.8%)	0.49 (0.8%)	0.50	0.51 (0.8%)	0.51 (0.6%)

Table 8. Mean March Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.64	0.64 (0.0%)	0.64 (0.0%)	0.65	0.65 (0.1%)	0.65 (0.0%)
Above Normal	0.63	0.63 (0.3%)	0.63 (-0.1%)	0.64	0.64 (0.3%)	0.64 (-0.1%)
Below Normal	0.57	0.57 (0.7%)	0.57 (-0.1%)	0.58	0.58 (0.7%)	0.58 (-0.1%)
Dry	0.52	0.53 (1.4%)	0.52 (0.1%)	0.53	0.54 (1.2%)	0.53 (0.0%)
Critical	0.46	0.47 (0.5%)	0.46 (-0.2%)	0.48	0.48 (0.4%)	0.48 (-0.2%)

Table 9. Mean April Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.61	0.61 (0.0%)	0.61 (0.0%)	0.62	0.62 (0.0%)	0.62 (0.0%)
Above Normal	0.56	0.56 (0.0%)	0.56 (0.0%)	0.58	0.58 (0.1%)	0.58 (-0.1%)
Below Normal	0.50	0.50 (-0.1%)	0.50 (0.0%)	0.51	0.51 (0.0%)	0.52 (0.1%)
Dry	0.46	0.46 (-0.4%)	0.46 (0.0%)	0.47	0.47 (-0.4%)	0.47 (0.0%)
Critical	0.43	0.43 (-0.2%)	0.43 (0.0%)	0.44	0.44 (-0.1%)	0.44 (0.0%)

Table 10. Mean May Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.56	0.56 (0.0%)	0.56 (0.0%)
Above Normal	0.50	0.50 (0.1%)	0.50 (0.0%)
Below Normal	0.45	0.45 (-0.6%)	0.45 (-0.6%)
Dry	0.40	0.41 (0.3%)	0.41 (0.2%)
Critical	0.36	0.36 (0.1%)	0.36 (0.1%)

Table 11. Mean June Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.45	0.45 (0.1%)	0.45 (-0.1%)
Above Normal	0.39	0.39 (-0.1%)	0.39 (-0.6%)
Below Normal	0.33	0.33 (-0.2%)	0.33 (-0.6%)
Dry	0.32	0.32 (-1.5%)	0.31 (-1.7%)
Critical	0.28	0.28 (-0.7%)	0.28 (-0.3%)

Table 12. Mean July Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.37	0.37 (-0.1%)	0.37 (-0.1%)
Above Normal	0.38	0.38 (-0.4%)	0.38 (-0.4%)
Below Normal	0.38	0.38 (-0.4%)	0.38 (-0.5%)
Dry	0.36	0.36 (0.0%)	0.36 (0.0%)
Critical	0.28	0.28 (-0.3%)	0.28 (-0.1%)

Table 13. Mean August Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.35	0.35 (-0.1%)	0.35 (0.0%)
Above Normal	0.36	0.36 (-1.3%)	0.36 (-1.5%)
Below Normal	0.35	0.35 (-0.5%)	0.35 (-0.3%)
Dry	0.30	0.30 (-0.7%)	0.30 (-1.0%)
Critical	0.26	0.25 (-0.9%)	0.25 (-0.7%)

Table 14. Mean September Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions STARS modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	0.37	0.38 (2.3%)	0.38 (2.7%)
Above Normal	0.36	0.38 (4.0%)	0.38 (5.9%)
Below Normal	0.32	0.32 (-0.1%)	0.33 (0.8%)
Dry	0.28	0.28 (0.2%)	0.28 (0.1%)
Critical	0.26	0.26 (0.1%)	0.26 (0.1%)

Inherent limitations of the STARS model introduce some level of uncertainty in the results and could be responsible for muting potential impacts of the Project and contributing to a lack of differences in survival between Proposed Project scenarios and Baseline Conditions. Perry et al. (2018) relies predominantly on data from acoustic-tagging studies of large (>140 millimeters [mm]) hatchery-origin CHNLFR smolts; therefore, conclusions should be applied cautiously to pre-smolt migrants. Juvenile salmon less than 80 mm are more likely to rear in the Delta for extended periods of time rather than emigrate quickly from the Delta (Moyle 2002) and will not be represented well by the STARS model. Natural-origin juvenile CHNWR can spend between 40 and 110 days in the Delta before entering the ocean (del Rosario et al. 2013). Phillis et al. (2018) found that a substantial proportion of returning adult CHNWR collected as LSNFH reared as juveniles in non-natal habitat including upper Sacramento River tributaries, the Feather River, American River, and Delta. These life history nuances are not captured in salmon routing and survival models like the STARS model and ECO-PTM that utilize acoustically-tagged hatchery smolts, which migrate quickly into and through the Delta.

Perry et al. (2018) also does not account for water temperature impacts on through-Delta survival that may occur beginning in April when water temperatures start to increase in the Delta. Hance et al. (2021) found that juvenile CHNWR survival decreases with reduced flow and increased water temperatures and found the strongest correlation with daily water temperature and survival after March 1 in the upper Delta between Knights Landing and Sacramento. Singer et al. (2020) documented similar results between Sacramento and Hood, with reduced survival of CHNFR and CHNSR smolts as water temperatures in April increased. Finally, Perry et al. (2018) is currently limited in that it cannot account for impacts associated with south Delta export operations or entrainment because it only includes Freeport inflow on the Sacramento River and DCC gate operations as covariates of through-Delta survival and interior Delta routing probability. Because the STARS model does not account for south Delta operations, any positive or negative impacts to survival from changes in Project exports may not be reflected in STARS survival estimates.

5.1.3.2. Ecological Particle Tracking Model (ECO-PTM)

ECO-PTM is an individual-based juvenile Chinook Salmon migration model that uses random-walk particle tracking with fish-like behavior incorporated in the particles. Acoustic telemetry data from various studies on late-fall Chinook Salmon (Perry et al. 2018) were used to develop fish behavior parameters. Detailed methods for ECO-PTM can be found in Wang (2019). Modeling results herein are based on information CDFW obtained from DWR’s ITP Application (DWR 2023f) and subsequent coordination with DWR.

Although ECO-PTM considered junction routing and through-Delta survival, the discussion herein focuses on differences in through-Delta survival because the survival calculations integrate flow-survival relationships, travel time, and routing of fish into different parts of the Delta with varying survival rates. Daily cumulative survival estimates were produced and averaged by month and water year type. ECO-PTM results were provided for three different scenarios for the Georgiana Slough Salmonid Migratory Barrier (referred to as BAFF in the following tables). The BAFF could not be modeled dynamically with DCC gates as done in the STARS model; therefore, three separate modeling exercises were completed that assumed 1) the BAFF was not operating at all (0% efficiency); 2) the BAFF was operating from November through April at an efficiency of 50%; and 3) the BAFF was operating from November through April at an efficiency of 67%. As stated in Section 5.1.3.1, DWR will operate the BAFF annually as early as

November 1, but no later than November 16, with operations from November 1 through November 30 tied to DCC gate operations (i.e., when DCC gates are closed for fishery protection purposes, BAFF will be operated). DWR will operate the BAFF continuously from December 1 through April 30 and coordinate with CDFW annually on the need to operate the BAFF into May in consideration of juvenile CHNWR and CHNSR presence in the Delta. ECO-PTM results were also summarized differently for water year type determination from the STARS model and other modeling results presented in this Effects Analysis. For ECO-PTM, water year type was determined by month, which applies the previous year's water year type for October through January, the forecasted water year type for February through April, and the final assigned water year type for May through September. DWR did not provide ECO-PTM modeling results for July and August. For all other modeling results presented in this Effects Analysis, water year type was determined based on the 50% exceedance forecast in May of the Sacramento Valley "40-30-30" water year hydrologic classification index (i.e., May Bulletin 120; DWR 2024a). Percent difference between Baseline Conditions and Proposed Project scenarios was calculated as the difference between survival estimates from Baseline Conditions and Proposed Project scenarios divided by Baseline Conditions.

Changes in mean through-Delta survival between Baseline Conditions and the two Proposed Project scenarios ranged from a decrease of about 3% to an increase of about 5% in any month or water year type analyzed (Tables 15-24). The greatest differences in survival between Baseline Conditions and Proposed Project scenarios during months that juvenile CHNWR and CHNSR are expected to be present in the Delta appear in October of below normal water years for the ITP_Spring scenario (1.5% increase; Table 15), February of critical water years (1.1-1.3% increase; Table 19), March of below normal and dry water years for the 9A_V2A scenario (1.3-1.6% increase; Table 20), and May of below normal water years (1.2-1.6% decrease; Table 22). Increased through-Delta survival seen in March of below normal and dry water years for the 9A_V2A scenario are likely a result of the 50 TAF Delta inflow block of water in March under Condition of Approval 8.12.2 – Spring Delta Outflow Via the Healthy Rivers and Landscapes Program (see Section 6.1.3; Condition of Approval 8.12).

Larger differences in survival are seen in June of dry water years (2.2-2.7% decrease; Table 23) and September of wet and above normal water years (2.5-5.1% increase; Table 24); however, June and September are not peak migration months for either juvenile CHNWR or CHNSR, and juveniles may not be present at all depending on the run and life history type (i.e., YOY or yearling). Juvenile CHNWR are not present in the Delta during June and juvenile CHNSR are not present during September (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). Other months and water year types showed negligible differences between Baseline Conditions and Proposed Project scenarios. Survival was slightly higher in scenarios with the BAFF operating compared with the scenarios without the BAFF operating. ECO-PTM modeled results showed slight increases in through-Delta survival under the 67% BAFF efficiency scenario compared to the 50% efficiency scenario during months when the BAFF is expected to be operating (November-April).

Table 15. Mean October Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%
Wet	0.40	0.40 (0.0%)	0.40 (-0.2%)
Above Normal	0.37	0.37 (-0.2%)	0.37 (-0.3%)
Below Normal	0.35	0.35 (0.6%)	0.35 (1.5%)
Dry	0.33	0.33 (-0.5%)	0.33 (-0.5%)
Critical	0.32	0.32 (0.0%)	0.32 (-0.2%)

Table 16. Mean November Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.41	0.41 (0.2%)	0.41 (0.2%)	0.43	0.43 (0.2%)	0.43 (0.1%)	0.44	0.44 (0.2%)	0.44 (0.3%)
Above Normal	0.40	0.40 (0.2%)	0.40 (-0.1%)	0.41	0.41 (0.0%)	0.41 (0.0%)	0.42	0.42 (0.5%)	0.42 (0.3%)
Below Normal	0.37	0.37 (-0.2%)	0.37 (-0.3%)	0.39	0.39 (-0.1%)	0.38 (-0.4%)	0.39	0.39 (-0.2%)	0.39 (-0.3%)
Dry	0.38	0.38 (0.0%)	0.38 (-0.4%)	0.39	0.39 (0.1%)	0.39 (-0.4%)	0.40	0.40 (0.1%)	0.40 (-0.4%)
Critical	0.33	0.33 (-0.4%)	0.33 (-0.1%)	0.35	0.35 (-0.3%)	0.35 (0.1%)	0.35	0.35 (-0.5%)	0.35 (0.0%)

Table 17. Mean December Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.47	0.47 (-0.2%)	0.47 (-0.3%)	0.49	0.49 (-0.2%)	0.49 (-0.2%)	0.50	0.49 (-0.2%)	0.49 (-0.3%)
Above Normal	0.44	0.45 (0.7%)	0.45 (0.5%)	0.47	0.47 (0.4%)	0.47 (-0.1%)	0.47	0.48 (0.6%)	0.47 (0.1%)
Below Normal	0.47	0.47 (0.2%)	0.47 (0.1%)	0.49	0.49 (0.1%)	0.49 (0.1%)	0.49	0.50 (0.1%)	0.50 (0.1%)
Dry	0.45	0.44 (-0.2%)	0.44 (-0.2%)	0.46	0.46 (-0.1%)	0.46 (-0.2%)	0.47	0.47 (-0.1%)	0.47 (-0.2%)
Critical	0.39	0.39 (0.0%)	0.39 (0.0%)	0.41	0.41 (-0.2%)	0.41 (0.0%)	0.41	0.41 (-0.6%)	0.41 (-0.1%)

Table 18. Mean January Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.48	0.48 (-0.1%)	0.48 (0.0%)	0.50	0.50 (-0.2%)	0.50 (-0.2%)	0.51	0.51 (-0.3%)	0.51 (-0.2%)
Above Normal	0.46	0.46 (0.0%)	0.46 (0.0%)	0.49	0.49 (0.1%)	0.48 (-0.2%)	0.49	0.49 (0.2%)	0.49 (-0.2%)
Below Normal	0.50	0.50 (0.0%)	0.50 (0.0%)	0.52	0.52 (0.0%)	0.52 (0.1%)	0.52	0.52 (0.1%)	0.52 (0.2%)
Dry	0.47	0.47 (-0.1%)	0.47 (0.0%)	0.49	0.49 (-0.2%)	0.49 (-0.2%)	0.49	0.49 (-0.4%)	0.49 (-0.4%)
Critical	0.45	0.45 (0.1%)	0.45 (0.2%)	0.47	0.47 (0.0%)	0.46 (-0.2%)	0.47	0.47 (-0.2%)	0.47 (-0.1%)

Table 19. Mean February Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.59	0.59 (0.1%)	0.59 (0.0%)	0.60	0.60 (0.1%)	0.60 (0.1%)	0.61	0.61 (-0.1%)	0.61 (-0.1%)
Above Normal	0.55	0.55 (-0.1%)	0.55 (-0.1%)	0.57	0.57 (-0.1%)	0.57 (-0.1%)	0.57	0.57 (-0.2%)	0.57 (0.0%)
Below Normal	0.49	0.49 (-0.6%)	0.49 (-0.1%)	0.51	0.51 (-0.3%)	0.51 (-0.3%)	0.52	0.52 (-0.5%)	0.52 (-0.3%)
Dry	0.46	0.46 (0.6%)	0.46 (0.7%)	0.48	0.48 (0.3%)	0.48 (0.5%)	0.49	0.49 (0.2%)	0.49 (0.5%)
Critical	0.43	0.43 (1.2%)	0.43 (1.1%)	0.45	0.46 (1.1%)	0.46 (0.9%)	0.46	0.46 (1.3%)	0.46 (1.1%)

Table 20. Mean March Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.57	0.57 (0.0%)	0.57 (0.0%)	0.59	0.59 (-0.2%)	0.59 (-0.1%)	0.59	0.59 (0.0%)	0.59 (-0.1%)
Above Normal	0.54	0.55 (0.5%)	0.54 (-0.2%)	0.56	0.57 (0.4%)	0.56 (-0.3%)	0.57	0.57 (0.4%)	0.57 (0.0%)
Below Normal	0.47	0.47 (1.3%)	0.47 (0.0%)	0.49	0.49 (1.3%)	0.49 (0.2%)	0.50	0.50 (1.4%)	0.50 (0.1%)
Dry	0.43	0.44 (1.6%)	0.43 (0.0%)	0.46	0.46 (1.6%)	0.46 (0.0%)	0.47	0.47 (1.3%)	0.46 (-0.2%)
Critical	0.40	0.40 (0.0%)	0.40 (-0.2%)	0.42	0.42 (-0.3%)	0.42 (-0.5%)	0.43	0.43 (-0.2%)	0.43 (-0.4%)

Table 21. Mean April Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%	Baseline Conditions BAFF 50%	9A_V2A BAFF 50%	ITP_Spring BAFF 50%	Baseline Conditions BAFF 67%	9A_V2A BAFF 67%	ITP_Spring BAFF 67%
Wet	0.51	0.51 (0.0%)	0.51 (-0.1%)	0.53	0.53 (0.1%)	0.53 (0.1%)	0.54	0.54 (0.2%)	0.54 (0.1%)
Above Normal	0.49	0.49 (0.1%)	0.49 (0.0%)	0.51	0.51 (0.2%)	0.51 (0.1%)	0.52	0.52 (0.0%)	0.52 (-0.1%)
Below Normal	0.38	0.38 (0.4%)	0.38 (0.4%)	0.40	0.40 (0.5%)	0.40 (0.8%)	0.41	0.41 (0.3%)	0.41 (0.6%)
Dry	0.38	0.37 (-0.9%)	0.38 (-0.1%)	0.40	0.40 (-0.7%)	0.40 (0.0%)	0.41	0.40 (-0.9%)	0.41 (-0.2%)
Critical	0.35	0.35 (-0.1%)	0.35 (0.0%)	0.37	0.37 (-0.1%)	0.37 (-0.1%)	0.38	0.37 (-0.2%)	0.37 (-0.4%)

Table 22. Mean May Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%
Wet	0.50	0.50 (-0.2%)	0.50 (0.1%)
Above Normal	0.43	0.43 (-0.3%)	0.43 (0.0%)
Below Normal	0.38	0.37 (-1.6%)	0.37 (-1.2%)
Dry	0.32	0.33 (0.4%)	0.33 (0.5%)
Critical	0.29	0.29 (1.1%)	0.29 (0.7%)

Table 23. Mean June Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%
Wet	0.41	0.41 (0.0%)	0.41 (0.0%)
Above Normal	0.35	0.35 (0.1%)	0.35 (-0.6%)
Below Normal	0.29	0.29 (-0.5%)	0.29 (-0.6%)
Dry	0.29	0.28 (-2.2%)	0.28 (-2.7%)
Critical	0.26	0.26 (-0.2%)	0.26 (0.4%)

Table 24. Mean September Chinook Salmon smolt survival through the Delta under the Proposed Project and Baseline Conditions ECO-PTM modeling scenarios grouped by water year type and Georgiana Slough Salmonid Migratory Barrier (BAFF) efficiency assumption. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions BAFF 0%	9A_V2A BAFF 0%	ITP_Spring BAFF 0%
Wet	0.40	0.41 (2.5%)	0.41 (2.7%)
Above Normal	0.41	0.42 (3.4%)	0.43 (5.1%)
Below Normal	0.37	0.37 (-0.4%)	0.37 (0.6%)
Dry	0.33	0.33 (0.3%)	0.33 (0.1%)
Critical	0.32	0.32 (0.2%)	0.32 (0.3%)

Inherent limitations of ECO-PTM introduce some level of uncertainty in the results and could be responsible for muting potential impacts of the Project and contributing to a lack of differences in survival between Proposed Project scenarios and Baseline Conditions. Similar to the STARS model, ECO-PTM relies on data from acoustic-tagging studies of large (>140 mm) hatchery-origin CHNLFR smolts to calibrate simulations of routing, travel time, and survival of juvenile salmon at key Delta junctions; therefore, results should be applied cautiously to pre-smolt migrants. Juvenile salmon less than 80 mm are more likely to rear in the Delta for extended periods of time rather than emigrate quickly from the Delta (Moyle 2002) and will not be represented well by ECO-PTM, similar to STARS modeling. Additionally, any non-natal rearing behavior, as has been observed for CHNWR (Phillis et al. 2018), is not captured by ECO-PTM.

ECO-PTM has the advantage of a 15-minute timestep (Wang 2019), as opposed to the daily timestep utilized in the STARS model (Perry et al. 2018), and accounts for complex Delta hydrodynamics by using fine-scale DSM2-HYDRO (Wang 2019). However, ECO-PTM is only calibrated for the north Delta from Freeport on the Sacramento River to Chipps Island; therefore, it does not account for impacts associated with south Delta entrainment (Wang 2019). As a result, ECO-PTM through-Delta survival results likely underestimate potential impacts associated with changes in Project exports, similar to south Delta limitations within the STARS model.

5.1.3.3. Conclusions on Through-Delta Survival

The STARS and ECO-PTM modeling used by DWR to evaluate Project-related impacts on through-Delta survival of juvenile CHNWR and CHNSR generally resulted in minimal changes between Baseline Conditions and Proposed Project scenarios. Results from the STARS model and ECO-PTM both showed minor changes across all months and water year types. However, STARS and ECO-PTM changes in survival for certain months and water year types did not always substantiate one another. For example, decreases in survival during October of below normal and dry water years and November of critical water years for Proposed Project scenarios was apparent in STARS modeling results but not in ECO-PTM results. The results from STARS align with DSM2-HYDRO that shows an increased proportion of flow entering the DCC during the same months and water year types. In contrast, ECO-PTM results showed an increase in survival for the ITP_Spring scenario during October of below normal water years. This type of discrepancy demonstrates the uncertainty associated with modeled through-Delta survival estimates.

Model assumptions limit analysis of the full scope of Project-related impacts that may be experienced by juvenile CHNWR and CHNSR within the Delta. Due to the inability of the STARS model and ECO-PTM to estimate rearing pre-smolt survival as well as incorporate south Delta export effects, changes in survival between Baseline Conditions and the Proposed Project scenarios are likely underestimated. Additionally, the STARS model and ECO-PTM are limited to evaluating through-Delta survival and do not allow for a comprehensive assessment of population-level impacts of the Proposed Project on CHNWR and CHNSR.

5.1.4. Effects of Georgiana Slough Salmonid Migratory Barrier on Routing and Survival

Condition of Approval 8.11.1 requires DWR to continue to annually install and operate the Georgiana Slough Salmonid Migratory Barrier Project through the duration of the 2024 SWP ITP to deter outmigrating juvenile CHNWR and CHNSR from entering the interior Delta (see Section 6.1.1 – Operation of Georgiana Slough Salmonid Migratory Barrier). Juvenile CHNWR and CHNSR that enter the interior Delta through Georgiana Slough may experience migration delays and further entrainment into the CVP and SWP export facilities, causing an increase in juvenile mortality (Perry et al. 2010). The installation of the Georgiana Slough Salmonid Migratory Barrier, which is comprised of a BAFF system spanning the majority of the river channel, provides an important deterrent at the Sacramento River-Georgiana Slough junction and is expected to provide a higher probability of juvenile survival to Chipps Island for emigrating CHNWR and CHNSR. While the barrier serves as a minimization measure for long-term operations of the Project, the barrier could have additional impacts to CHNWR and CHNSR that are currently not well studied.

DWR will operate the barrier annually no later than November 16 through April 30, and potentially into May, which coincides with adult CHNWR (November through August) and CHNSR (January through September) presence in the Delta (DWR 2022c; see Appendix A – Winter-run and Spring-run Chinook Salmon Temporary Occurrence in the Delta). Migrating adults that enter Georgiana Slough from the south may experience increased migration timing during upstream spawning migration when encountering the barrier, causing an increased risk of pre-spawn mortality. Documentation for the previous BAFF installation notes that the design for the barrier may allow for the passage of larger sensitive species, like adult Chinook Salmon, with a clearance of at least 1.5-2 ft between the barrier frame and the stream channel bottom (DWR 2015c). In November 2023, DWR installed the BAFF with a clearance as low as 3-4 ft in some places to reduce impacts on sturgeon (Shahid Anwar, personal communication, 1/2024). However, there is a gap in understanding barrier impacts on adult CHNWR and CHNSR; therefore, DWR will conduct pilot investigations to evaluate upstream passage of adult CHNWR and CHNSR to ensure the barrier does not obstruct upstream migration. Pilot investigations include CDFW involvement and approval to ensure the Georgiana Slough Salmonid Migratory Barrier provides benefits to CHNWR and CHNSR and will not be detrimental to the continued management and recovery of CHNWR and CHNSR.

Although the intent of the Georgiana Slough Salmonid Migratory Barrier is to improve overall juvenile CHNWR and CHNSR through-Delta survival, operation of the barrier may increase juvenile salmon vulnerability to predation through creation of enhanced predatory fish habitat adjacent to the in-water barrier components. Preliminary studies tagged predatory fish species and tracked their locations adjacent to the BAFF and found that they inhabit the sides of the river (DWR 2012, 2015a). While this appears to be opposite behavior of smolt juvenile Chinook Salmon that were tracked migrating down the center of the channel, different life stages utilize different parts of the river channel and previous studies have shown that fry are found in the margins of the river (Brandes and McLain 2001; McLain and Gonzalo 2009), and thus could potentially encounter predators. Flows are an important factor for considering travel time through the Delta and probability of encountering a predator. Decreased flows increase travel time (Perry et al. 2010) and change environmental conditions, such as decreased turbidity and increased temperatures, which favor predators. It is unknown if the Georgiana Slough Salmonid Migratory Barrier attracts a greater number of predators to the site, though it is possible that the barrier also acts as a deterrent to predators (DWR 2012). In pilot studies, the BAFF was found to deter predators when operating and there was no indication that the structure provided holding habitat for predatory fishes. Over time, it is possible that certain species of predatory fishes could become conditioned to the barrier (DWR 2015a).

It is possible that the Georgiana Slough Salmonid Migratory Barrier could cause delays in migration of adult Chinook Salmon. The operational window of the BAFF, from November through April, overlaps with the upstream migration period for CHNWR and, to a minor degree, CHNSR. Adult Chinook Salmon can migrate up Georgiana Slough; however, typically they migrate up the Sacramento River mainstem. If adult Chinook Salmon do encounter the BAFF, they may be able to navigate under the structure or around it in the open water between the barrier and the shore (DWR 2024c).

Despite the potential for some increased vulnerability of juveniles to predation and increased migration timing for adults, the operation of the Georgiana Slough Salmonid Migratory Barrier is expected overall to minimize Project take of CHNWR and CHNSR, with benefits of the migratory barrier outweighing potential negative impacts.

5.2. Effects of South Delta Export Operations on Entrainment of Chinook Salmon

Take of juvenile and adult CHNWR and CHNSR in the form of impacts related to entrainment and salvage will occur as a result of Project-related effects on Delta hydrodynamics. Entrainment is the incidental removal of species in the water diverted by the Project from the Delta and Estuary (Castillo et al. 2012). Entrainment as a result of Project operations draws in and/or attracts fish and other organisms into water diversion intakes or areas with reduced habitat quality, ultimately resulting in migratory delays, reduced fitness, or mortality. In the Delta, entrainment occurs primarily in the south Delta at the SWP export facilities (including CCF and the Skinner Fish Protective Facility) and the CVP export facilities (Tracy Fish Collection Facility), as well as other smaller water diversion intakes. At the SWP export facilities, CDFW considers take of Chinook Salmon to occur upon entrance into CCF via the radial gates, regardless of the fate of each fish. Altered hydrodynamics resulting from south Delta exports at CVP and SWP export facilities can also cause fish to become entrained away from their migration route and into terminal areas such as the south Delta (NMFS 2009; Kimmerer 2008; Grimaldo et al. 2009), which may provide less suitable rearing habitat and higher threats of predation. Juvenile and adult CHNWR and CHNSR occurring in the Project Area are susceptible to entrainment into the south Delta. Entrainment of other organisms, such as primary and secondary producers (i.e., prey items for CHNWR and CHNSR), is largely unaccounted for and the magnitude of Project impacts on prey items to CHNWR and CHNSR is not well understood.

At the SWP export facilities, fish enter CCF through water diversion from Old River. CCF is located near the town of Byron in the south Delta and consists of an approximately 2,500 acre artificially flooded embayment that serves as a storage reservoir for the SWP (Clark et al. 2009). During high tide cycles, when the water elevation in Old River exceeds that of the CCF, up to five radial gates, located on the southeast corner of CCF, open to divert water from the Delta into CCF. Daily operations of the radial gates depend on scheduled water exports, tides, and storage availability with CCF. The Banks Pumping Plant pumps water diverted from CCF via the intake channel near the Skinner Fish Protective Facility into the California Aqueduct. Fish entering the CCF must travel approximately 3.4 km to reach the Skinner Fish Protective Facility. The Skinner Fish Protective Facility was designed to protect fish greater than 20 mm (0.04 inches) in length or width from entrainment into the Banks Pumping Plant by diverting them into holding tanks where they can be salvaged and returned to the Delta. Water is drawn to the Skinner Fish Protective Facility from CCF via the intake canal and past a floating trash boom. The trash boom is designed to intercept floating debris and guide it to an onshore trash conveyor. Water and fish then flow through a trash rack, equipped with an automated cleaner. Openings into the trash rack exclude fish greater than 51 mm (2 inches) in length or width from entering the Skinner Fish Protective Facility (CDFG 1981). Fish that move through the trash rack enter a series of louvers arranged in a “V” pattern and are behaviorally guided to salvage holding tanks where they remain until sacrificed or released back into the Delta. All LFS, DS, and Wakasagi (*Hypomesus nipponensis*) observed in salvage are sacrificed for secondary identification purposes. Additionally, all adipose fin-clipped Chinook Salmon observed in salvage are sacrificed for CWT extraction. All adipose fin-unclipped Chinook Salmon observed in salvage are released outside of the south Delta unless they are subjected to accidental mortality (Kyle Griffiths, personal communication, 9/2024).

At the CVP export facilities, water is drawn into the Tracy Fish Collection Facility from the Old River. The Tracy Fish Collection Facility was designed to protect fish greater than 20 mm (0.04 inches) in length or width from entrainment into the Delta-Mendota Intake by diverting fish into salvage holding tanks where they can be salvaged and returned to the Delta. Upon entry to the Tracy Fish Collection Facility, fish encounter a floating trash deflector boom, much like the trash boom located at the entrance to the Skinner Fish Protective Facility. Water and fish then flow through a trash rack with openings averaging 57 mm (2.25 inches) and equipped with an automated cleaner (Reyes et al. 2018). Fish that move through the trash rack enter the primary channel followed by a series of louvers that behaviorally guide fish into the salvage holding tanks for processing.

Salvage describes the process of catching and collecting a portion of the entrained fish and transporting them to release locations outside of the interior and south Delta (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon). It is hypothesized that survival is higher for fish that undergo the salvage process and are released outside of the south Delta than for fish volitionally migrating through the south Delta. Studies have suggested that once juvenile salmon enter the south Delta, survival can be higher for fish captured in the Tracy Fish Collection Facility and rereleased more seaward (Buchanan et al. 2013; Windell et al. 2017). However, little information exists to support this hypothesis and data on post-release survival of salvaged fish is scarce. The suggestion that survival is higher through the salvage process is questionable and highlights the extremely low survival rate of juvenile Chinook Salmon in the south Delta, which is hypothesized to result from poor rearing conditions (such as low refuge habitat and food availability) and high predation risk (Windell et al. 2017). Furthermore, only a subset of salvaged fish is quantified during the salvage process, and an even smaller subset of these fish survive the salvage process. Mortality rates prior to salvage can be high due to predation or poor water quality conditions, and handling can cause stress and injuries that reduces both short and long-term survival.

Handling and transporting adult and juvenile salmonids increase stress-related impairment and mortality (Raquel 1989; Teffer et al. 2017; Cook 2015, 2018a, 2018b). Handling can lead to air exposure and hypoxia from crowding, which can cause swimming impairment in salmonids post-release (Donaldson et al. 2011; Hinch et al. 2019). This impairment makes salvaged juvenile and adult salmonids highly vulnerable to predation. Handling can also cause direct injuries and the removal of the protective epidermal mucus, which increases an individual’s susceptibility to fungal and bacterial infections (Dash et al. 2018; Reverter et al. 2018). Trucking juveniles from the salvage facilities in combination with Delta water operations may also contribute to adult straying (Keefer and Caudill 2014; Windell et al. 2017).

Longer travel times and lower survival of juvenile Chinook Salmon have been documented in the interior Delta compared to the north Delta (Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2010; Windell et al. 2017). Survival probabilities have been negatively associated with water exports, suggesting that water exports affect migration by increasing the risk of entrainment into the CVP and SWP export facilities and prolonging outmigration timing; however, many more years of data would be needed to quantify the export effect (Newman and Brandes 2010; Windell et al. 2017). The development of the Winter-Run Chinook Salmon Machine Learning (WRCML) Model, a predictive model that can be used to identify when salvage of LAD natural-origin CHNWR may occur at the CVP and SWP facilities, has provided more insight into the relationship between exports and the probability of CHNWR absence in salvage (Gaeta et al. in prep.). Specifically, in the WRCML Model the exports feature is not one of the most important features contributing to model outcomes when compared to other features like water temperature at Sherwood Harbor, the juvenile natural-origin CHNWR passage estimate at RBDD, day of year, and juvenile natural-origin CHNWR catch at Sherwood Harbor. It may be the case that exports, along with other model features relevant to State and federal natural resource management, are important to the routing of juvenile CHNWR during specific times of year or under certain conditions but they are not as influential in predicting juvenile CHNWR presence in salvage as features related to CHNWR presence in the Delta. In other words, no amount of exports will impact entrainment when CHNWR are not present in the Delta. The WRCML Model incorporates interaction effects between biological factors and abiotic factors, e.g., exports (Gaeta et al. in prep.).

The SST (2017) documented that when juvenile Chinook Salmon are present in the Delta, higher numbers of juveniles salvaged are associated with more negative OMR flows. Loss at the CVP and SWP export facilities increases sharply at OMR flows more negative than -5,000 cfs (NMFS 2009). Creating less negative daily OMR flows is expected to reduce entrainment of CHNWR and CHNSR into the interior Delta and may increase CHNWR and CHNSR through-Delta survival by reducing their emigration time through the Delta (see Section 5.2.1 – Entrainment of Juvenile Chinook Salmon; Perry et al. 2016). The SST (2017) found that salvage at both the CVP and SWP export facilities was determined either directly by the volume of combined exports or by local hydrodynamic conditions strongly influenced by exports (e.g., OMR flow); therefore, entrainment risk of CHNWR and CHNSR attributable to Project operations is best assessed by evaluating patterns of CHNWR and CHNSR salvage at the Skinner Fish Protective Facility and Tracy Fish Collection Facility as combined salvage. Currently, combined salvage from both facilities provides the best means to effectively extrapolate the effects of south Delta SWP export operations on entrainment of CHNWR and CHNSR into the interior and south Delta (Smith 2019).

Since south Delta SWP operations began in the late 1960s, the SWP has coordinated operations with the CVP to maintain Delta water quality and a formal Coordinated Operations Agreement has been in place since 1986, and amended in 2018, to ensure each project retains its portion of the shared water for export and bears its share of the obligation to protect beneficial uses (Reclamation and DWR 2018; DWR and Reclamation 1995; Arthur et al. 1996). Some facilities were developed for joint use, such as San Luis Reservoir, O'Neill Forebay, and more than 100 miles of the California Aqueduct and related pumping facilities (DWR and Reclamation 1995). Such coordination is increasingly necessary over time to achieve multiple, mandatory water quality objectives (e.g., D-1641) and ESA and CESA-listed species protections (e.g., 2019 NMFS BO, 2019 USFWS BO, 2024 SWP ITP) while optimizing water supply south of the Delta (Arthur et al. 1996).

Minimization of Project entrainment effects on CHNWR and CHNSR are discussed in Section 6.2 – Minimization of Project Effects on Entrainment of Chinook Salmon of this Effects Analysis and include the implementation of Conditions of Approval required by the 2024 SWP ITP.

5.2.1. Entrainment of Juvenile Chinook Salmon

5.2.1.1. Effects of South Delta Export Operations on Juvenile Chinook Salmon

Human modification of the Delta has resulted in a channel network that no longer operates across predictable gradients for native fish and provides unnatural cues and routes for migration (SFEI-ASC 2014; Windell et al. 2017). Migration corridors and rearing habitats near water diversions increase the risk of entrainment-related mortality for juvenile Chinook Salmon (Windell et al. 2017). Juvenile salmon entrained into the south Delta experience a diminished ability to navigate out towards the ocean due to confusing navigational cues from altered hydrology, changes in channel network configuration and water quality gradients, and impairments to sensory systems from contaminants (Windell et al. 2017). Export effects in the south Delta are expected to reduce the probability that juvenile Chinook Salmon in the south Delta will successfully migrate out past Chipps Island through entrainment mortality at the CVP and SWP export facilities, or changes to migration rates or routes that increase residence time of juvenile Chinook Salmon in the south Delta, which can increase exposure time to agents of mortality such as predators, contaminants, and impaired water quality parameters (see Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon; NMFS 2019a). Net OMR flows provide a surrogate indicator of the influence the south Delta exports have on hydrodynamics in the south Delta. The Project's export effects on OMR flows vary as a result of multiple factors including inflow, tides, and the amount of water being exported. Depending on the extent of these hydrodynamic changes, CHNWR and CHNSR residence time in the interior and south Delta may change, which may increase or decrease CHNWR and CHNSR exposure to predation or other localized stressors (NMFS 2019a). The largest effect of exports on Delta hydrology is seen in Old River (SST 2017), and effects likely lessen with distance from the CVP and SWP export facilities (Cavallo et al. 2015). As indicated above, higher numbers of juvenile Chinook Salmon are salvaged during periods of more negative OMR flows (SST 2017). Kimmerer (2008) found similar patterns of high salvage of hatchery Chinook Salmon from the Sacramento River associated with increasing export levels. However, exports may play less of a role in entraining juvenile Chinook Salmon when outflow from the San Joaquin River is high. During wet water year types, CVP and SWP exporting at full capacity may still yield positive OMR flows if San Joaquin River flows are high enough to offset the hydrodynamic effect of exports (NMFS 2019a).

Although juvenile CHNWR and CHNSR do exhibit some swimming behavior in the Delta, traditional particle tracking modeling (PTM) of neutrally buoyant particles can provide some indication of how the CVP and SWP export operations and changes in OMR impact junction routing and entrainment risk into the interior and south Delta. Based on PTM simulation of particles injected at the confluence of the Mokelumne River and the San Joaquin River conducted to support the 2009 NMFS BO, the risk of particle entrainment nearly doubles from 10 to 20% as net OMR flows decrease from -2,500 cfs to -3,500 cfs, and quadruples to 40% at -5,000 cfs (NMFS 2009). At OMR flows more negative than -5,000 cfs, the risk of particle entrainment increases at an even greater rate, reaching approximately 90% at -7,000 cfs. PTM simulations show the risk of entrainment increases considerably with increasing CVP and SWP exports, as represented by net OMR flows (NMFS 2009). Thus, the risk of juvenile CHNWR and CHNSR entrainment into the south Delta channels is increased when OMR flows become more negative (NMFS 2009). Recent PTM simulations obtained from DWR's ITP Application (DWR 2023f) and subsequent coordination with DWR show similar correlations between OMR flows and particle fates for both neutrally buoyant and surface-oriented particles. Less negative OMR flows result in greater proportions of particles exiting the Delta past Chipps Island and lower proportions of particles entrained at the CVP and SWP export facilities (see Attachment 5, Appendix A to the 2024 SWP ITP). However, correlations may be less strong than those originally described in the 2009 NMFS BO due to changes in south Delta CVP and SWP operations and OMR Management following the 2009 NMFS BO. Data utilized in PTM analyses included in the 2009 NMFS BO were collected prior to implementation of modern OMR Management suggesting that instances of negative OMR flows were likely more frequent and greater in magnitude compared to data collected once OMR Management was implemented following the 2009 NMFS BO.

CHNWR and CHNSR that are exposed to the hydrodynamic changes in the waterways immediately adjacent to the CVP and SWP export facilities are expected to have reduced migratory success. Increased negative flows immediately adjacent to the intakes of CCF decrease the probability of juvenile CHNWR and CHNSR being able to alter course and successfully exit the Delta, although the magnitude of this effect is currently unknown due to a lack of data on fine-scale fish movement behavior and survival in reaches under export effects. This is particularly important for CHNSR that originate in the San Joaquin River Basin and enter Old River. These fish migrate downstream in either the Old River, Middle River, or Grant Line/Fabian-Bell channels. All three channels have considerable exposure to the effects of exports. The Old River and Grant Line/Fabian-Bell channels pass directly in front of or in very close proximity to the intakes for the CVP and SWP export facilities. A large proportion of fish moving through these channels are expected to be entrained into either the Tracy Fish Collection Facility or Skinner Fish Protective Facility, where high levels of mortality are expected. The Middle River joins with the man-made Victoria Canal/North Canal, a large, dredged channel directly leading to the CVP and SWP export facilities, and net flows move towards the export facility intakes under most conditions (NMFS 2019a).

During times of increased SWP south Delta exports, as observed in Table C- 19 and Table C- 20 for Proposed Project operations in April and May, increased CCF inflows are required to deliver sufficient volumes of water to Banks Pumping Plant. Water elevation in CCF is drawn down to a greater extent with increased pumping rates during times when CCF radial gates are closed. When the gates reopen following the peak of high tide, there will be a greater difference in hydrostatic pressure between the Old River corridor and water elevation in CCF, resulting in higher velocity of flows entering the CCF. Increased velocities through the radial gates may entrain more CHNWR and CHNSR into CCF (NMFS 2009). Only one out of four or five juvenile salmonids are estimated to survive their transit through CCF to Skinner Fish Protective Facility mainly due to high levels of predation within CCF (NMFS 2009). CHNWR and CHNSR present in the OMR corridor and their distributaries downstream of the CVP and SWP export facilities also experience negative impacts on migration and routing due to increased net flows towards the export facilities. Increased CVP and SWP exports mute the ebbing tide signal that cues fish to move out of the OMR corridor and back into the main migratory corridor of the San Joaquin River and instead routes fish farther south into waters that are more heavily influenced by the effects of reverse OMR flows due to exports. Entrainment into the CVP and SWP export facilities is a risk for juvenile CHNWR and CHNSR originating in the Sacramento River Basin as well as CHNSR originating in the San Joaquin River Basin and migrating downstream through the Delta (NMFS 2019a).

5.2.1.2. Historical Loss of Juvenile Chinook Salmon

"Loss" is a term used to refer to the estimated number of fish that experience mortality within the CVP and SWP export facilities as they go through the salvage process and is estimated based on the number of salvaged fish (fish observed within the salvage facilities) and other factors related to facility efficiency and mortality associated with fish handling. Loss is calculated for each run of Chinook Salmon that is observed at the salvage facilities. Chinook Salmon are identified as natural-origin or hatchery-origin based on the presence or absence of an adipose fin ("unclipped" versus "clipped"). CWTs in all clipped fish are processed to determine run. The run of unclipped fish is initially determined by the Delta Model LAD criteria (USFWS 1997) and then confirmed through genetic analysis of fin clips taken during the salvage process. Genetic analysis of all unclipped (natural-origin) older juvenile Chinook Salmon[3] was conducted in season to inform OMR Management between water years 2016 and 2019, and then continued in water years 2022 and 2023 to support Minor Amendments 6 and 8 of the 2020 SWP ITP (CDFW 2023a, 2023b). Ongoing efforts to perform genetic analyses on older juvenile Chinook Salmon have led to the development of a genetic CHNWR database that was available for use in this Effects Analysis (DWR et al. 2023).

The salvage process for the SWP starts with fish entrainment into CCF and proceeds with fish moving through CCF until they enter the Skinner Fish Protective Facility where they are collected in holding tanks. A screened subsample of fish that reach the salvage tanks are collected approximately every two hours and the total fish salvaged per sampling period is calculated by expanding the number of fish salvaged by the fraction of time that diversions were sampled. Fish loss for each sampling period is calculated based on the standard loss equation for Chinook Salmon (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Daily salvage and loss are the cumulative sum of loss for each sampling period that occurred in that day (NMFS 2019a). After this stage, fish are transferred to tanker trucks and driven to release sites in the western Delta and released back into the Sacramento or San Joaquin rivers. At the CVP, the fish salvage process starts with fish encountering the trash rack on Old River in front of the primary channel, and then progressing through the salvage process at the Tracy Fish Collection Facility until the salvaged fish are ultimately released at the release sites, similar to the process at the Skinner Fish Protective Facility (NMFS 2019a). Data collected on juvenile Chinook Salmon at both the Skinner Fish Protective Facility and the Tracy Fish Collection Facility during the salvage process are combined at the end of each day. Data are then used by both DWR and Reclamation to determine the total daily loss of each run of juvenile Chinook Salmon. Combined loss of juvenile Chinook Salmon can help inform the total entrainment and loss that is occurring in the south Delta due to operations at CVP and SWP export facilities.

Each step in the salvage process is associated with a different rate of mortality. CCF has a high mortality rate of juvenile Chinook Salmon due to predation by fish and birds (Clark et al. 2009). Loss occurring in CCF is termed "pre-screen loss" and assumed to be 75% at the SWP facility, while pre-screen loss at the CVP facility occurs between the trash racks and primary channel and is assumed to be only 15% (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Pre-screen loss at CCF only accounts for predation mortality and does not include potential lethal impacts from aquatic weed and algal bloom maintenance

[3] Older juvenile Chinook Salmon is defined as any Chinook Salmon measured above the minimum length for CHNWR, according to the Delta Model LAD criteria (USFWS 1997) used to assign individuals to run.

in CCF (see Section 5.3 – Effects of Maintenance at Clifton Court Forebay on Chinook Salmon). Juvenile Chinook Salmon also experience mortality at the louvers, termed "screening (louver) efficiency," where fish are screened from entering Banks Pumping Plant at SWP or C.W. Bill Jones Pumping Plant (Jones Pumping Plant) at CVP. Screening (louver) efficiency is dependent upon the size of the fish as well as the water velocity through the louver (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Fish that are salvaged at the Skinner Fish Protective Facility and the Tracy Fish Collection Facility may also experience loss during the handling, transport, and release process. The loss equation assumes that fish 100 mm and smaller experience a 2% mortality rate, while fish greater than 100 mm experience a mortality rate of 0% during handling, transport, and release (see Attachment 8 to the 2024 SWP ITP; CDFW 2018).

Mortality rates used in the loss equation have not been updated since 2003, and more recent studies have shown higher rates of loss during the salvage process. For example, Wunderlich (2015) reported pre-screen loss as high as 81.14% at SWP. Additionally, the loss equation does not consider the condition and survival of fish post-release (see Section 6.2.12 – Alternative Loss Estimation Pilot Study; Condition of Approval 7.9.1). The salvage process, including handling, transport, and release, can result in increased stress, dermal injury, increased risk for disease contraction, disorientation following release, predation during transport and at release sites, and delayed mortality. Handling and transport stress induced mortality is difficult to document in juvenile Chinook Salmon, as these fish are typically unable to be monitored post-release. Raquel (1989) examined the effects of handling and trucking of fish collected at the Skinner Fish Protective Facility and the Tracy Fish Collection Facility. At the Skinner Fish Protective Facility, low levels of immediate mortality of juvenile Chinook Salmon were observed with over 98% survival during the study period. However, Raquel (1989) notes low levels of immediate mortality were biased low because they do not account for undocumented mortality following release. At the Tracy Fish Collection Facility, 57% of juvenile Chinook Salmon salvaged and transported died shortly after release. In addition to mortality, collection and transportation can also cause interrupted olfactory imprinting of juvenile salmon during migration, which can lead to increased adult straying rates (Keefer and Caudill 2014).

The estimated loss at the CVP and SWP salvage facilities does not fully represent take of listed species under the CESA. Specifically, CDFW considers take of juvenile Chinook Salmon to occur when they enter the radial gates at CCF, regardless of whether they survive the salvage and release process. Additionally, no fish salvage occurs during planned maintenance outages at the Skinner Fish Protective Facility, CCF, and Banks Pumping Plant, and any fish remaining in CCF may perish and not be accounted for in salvage. These maintenance outages can occur multiple times a year including during the period of juvenile outmigration for CHNWR and CHNSR.

OMR Management measures under the 2024 SWP ITP are based on genetic identification of CHNWR and CHNSR observed in salvage; however, the following sections include analyses of LAD CHNWR and CHNSR due to the limited availability of the CHNWR and CHNSR genetic salvage data (see CDFW 2024b for more information).

5.2.1.2.1. Historical Loss of Winter-run Chinook Salmon

Entrainment primarily affects migrating salmonids during their juvenile life stages although adult salmonids have been documented in salvage at both the CVP and SWP export facilities (see Section 5.2.2 – Entrainment of Adult Chinook Salmon). Salvage data of Chinook Salmon collected at the CVP and SWP export facilities from water years 1993 through 2022 were summarized from the CDFW Bay-Delta

Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018) to evaluate historical loss of LAD hatchery-origin and natural-origin CHNWR. The Delta Model LAD criteria (USFWS 1997) were used to identify juvenile LAD CHNWR at the CVP and SWP export facilities. As described in Section 5.2.1.2 above, natural-origin and hatchery-origin CHNWR were classified based on the presence or absence of an adipose fin ("unclipped" versus "clipped") as documented in the salvage database. Clipped CHNWR were characterized as hatchery-origin and unclipped CHNWR were characterized as natural-origin. Although the presence or absence of a CWT would be a more precise way to verify a hatchery-origin designation, data limitations precluded the use of CWTs to determine CHNWR origin for this evaluation.

Loss was also evaluated for genetically-identified natural-origin CHNWR. The genetically-identified natural-origin CHNWR database for water years 2010 through 2022 was consolidated by DWR, Reclamation, and CDFW (DWR et al. 2023). A collaborative quality assurance/quality control (QA/QC) process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds (see Section 6.2.7; Condition of Approval 8.4.4) for OMR Management. However, there are caveats to the genetic database for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss for both the genetic and LAD database is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on data sources and limitations see CDFW (2024b).

Figure 7 shows the annual historical loss of juvenile LAD natural-origin and hatchery-origin CHNWR combined for water years 1993 to 2022. Annual loss of juvenile LAD CHNWR was very low in 1997 (634 fish), then gradually increased and peaked in water years 2003 and 2004 (29,564 fish and 27,097 fish, respectively), followed by a sharp decline in 2005 (5,337 fish). After water year 2005, loss was relatively steady until declining substantially after water year 2011, reaching a low of 320 fish in 2015. Since water year 2015, loss increased to a small peak in 2019 (2,301 fish) and then decreased again in 2020 to an all-time low (291 fish). Loss of LAD CHNWR was relatively low in water years 2021 (338 fish) and 2022 (466 fish), as well. The years with lowest loss were water years 2014, 2015, 2020, 2021, and 2022. In water years 2014 and 2020, there was more natural-origin CHNWR loss compared to hatchery-origin loss. In contrast, water years 2015, 2021, and 2022 saw a greater amount of hatchery-origin CHNWR loss than natural-origin loss. Hatchery-origin and natural-origin JPEs were incorporated into Figure 7 for comparative purposes and suggest that when JPE numbers are low, LAD CHNWR detection in salvage may be limited. However, when JPE numbers are higher this does not necessarily indicate there will be high LAD CHNWR observations in salvage. CDFW did not conduct an analysis to test for a relationship between LAD CHNWR annual loss and JPE numbers in this Effects Analysis. Loss of genetically identified natural-origin CHNWR tends to increase with JPE since 2010. However, this relationship is not significant, likely due to high variability in both JPE and loss as the species continues to decline, as well as low sample size (i.e., 13 years).

Loss at the CVP and SWP export facilities is typically lower in drier years compared to wetter years. Water year 2020 was classified as dry and water years 2021 and 2022 were classified as critical, which matches the pattern of loss during these years. This contrast is likely due to declines in juvenile CHNWR through-Delta survival from poorer river conditions in drier years, resulting in fewer fish detected in monitoring or observed in salvage in those years. LAD CHNWR loss for water years 2021 and 2022 also corresponds with low natural-origin CHNWR JPE values (see Section 4.1.2 – Population Status and Trends; Figure 3). Natural-origin CHNWR egg-to-fry survival was only 2.6% and 2.2% in water years 2021 and 2022, respectively (WR PWT 2022, 2023). In addition to low historical egg-to-fry survival, the decline in LAD CHNWR loss observed since 2009 may also be attributed to the implementation of the 2009 NMFS Biological Opinion that included RPA Action IV.2.3 designed to minimize entrainment and loss of CHNWR by restricting OMR flows to be less negative when a daily loss density trigger was exceeded (NMFS 2009). It is also worth noting that Harvey and Stroble (2013) found that about 41% of LAD natural-origin CHNWR observed in salvage in migration years[4] 2004 and 2006 to 2010 were genetically identified as non-CHNWR, which indicates that LAD run identification can inflate natural-origin CHNWR loss when there are potentially lower numbers of CHNWR in the system or in the population.

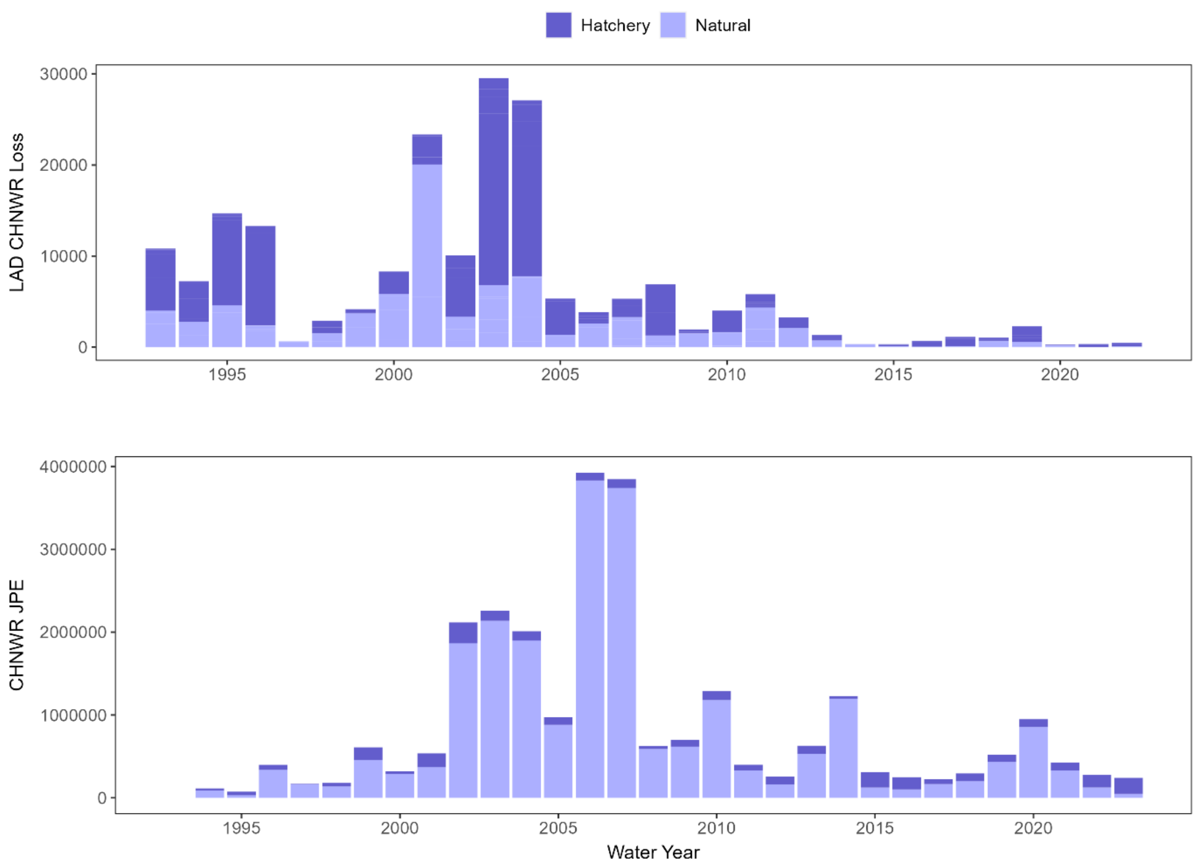

Figure 7. Juvenile LAD natural-origin and hatchery-origin CHNWR annual loss at the CVP and SWP export facilities for water years 1993-2022 (top) and CHNWR hatchery-origin and natural-origin JPEs for water years 1993-2022 (bottom; corresponding to brood years 1992-2021).

Historically, juvenile LAD natural-origin and hatchery-origin CHNWR have been observed in salvage from December through June, with most loss occurring between December and April (Figures 8-14). However,

[4] Migration year is defined by Harvey and Stroble (2013) as September of the previous year through August of the specified year. For example, migration year 2010 would span from September 2009 through August 2010.

loss has historically been highest in January through March. Migrating juvenile CHNWR typically finish exiting the Delta in late May (del Rosario et al. 2013); therefore, loss of juvenile LAD CHNWR in May and, even more so, in June have generally been very low. Loss of juvenile LAD natural-origin and hatchery-origin CHNWR in May only occurred in 10 of the 26 water years analyzed, while loss of juvenile LAD CHNWR during June only occurred in water year 2003 and included only natural-origin fish.

It is important to note that hatchery-origin CHNWR releases from LSNFH do not occur in December and the earliest releases historically have not occurred until late January. All LAD hatchery-origin CHNWR observed in salvage in December and most LAD hatchery-origin CHNWR observed in salvage in January are not true CHNWR and are likely hatchery-origin CHNLFR released from CNFH that were classified incorrectly as CHNWR using the Delta Model LAD criteria (USFWS 1997). See CDFW (2024b) for more details on designation of hatchery-origin and natural-origin Chinook Salmon observed in salvage.

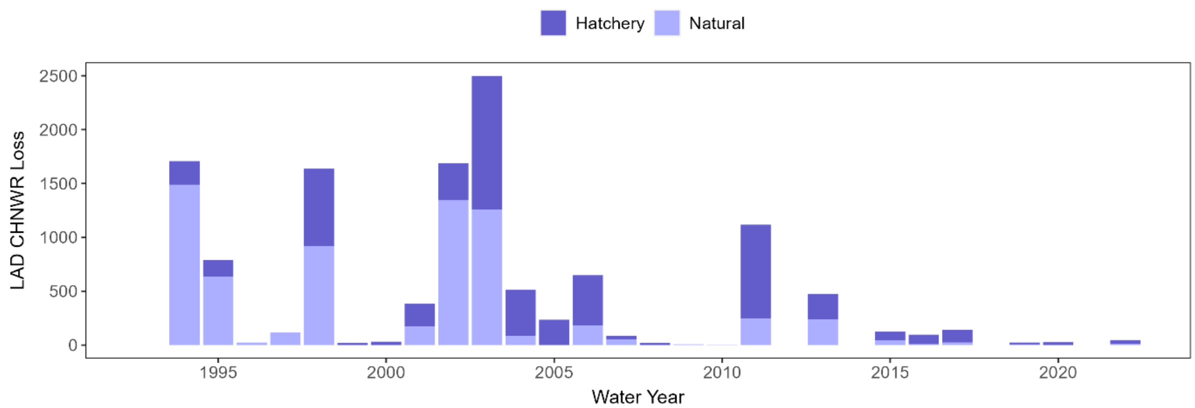

Figure 8. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in December at the CVP and SWP export facilities for water years 1993-2022.

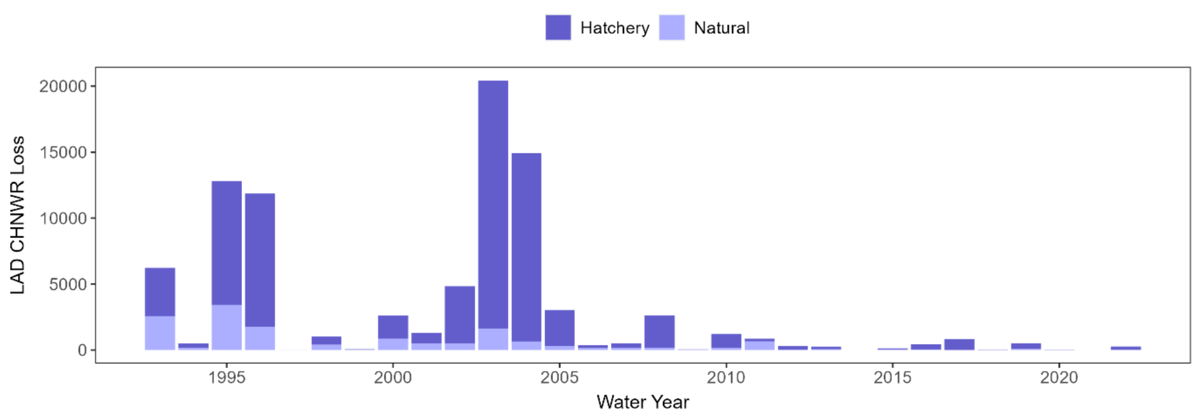

Figure 9. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in January at the CVP and SWP export facilities for water years 1993-2022.

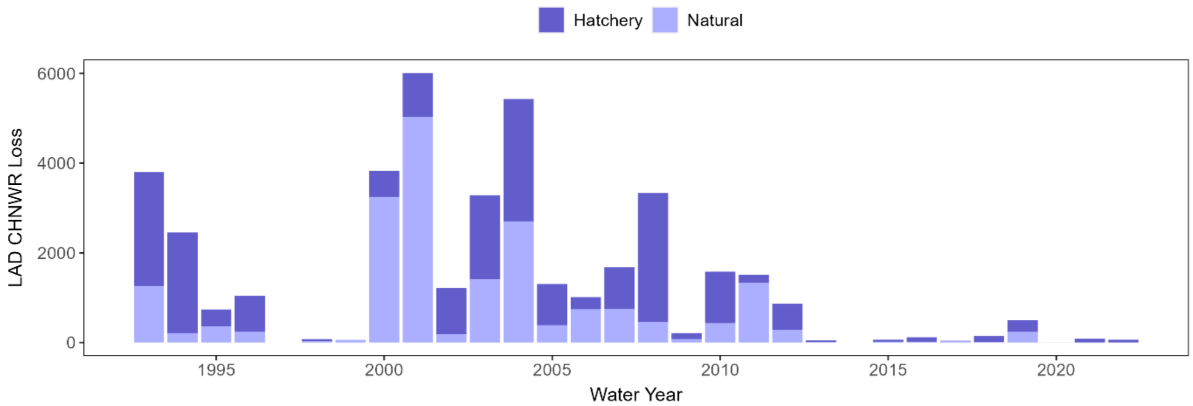

Figure 10. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in February at the CVP and SWP export facilities for water years 1993-2022.

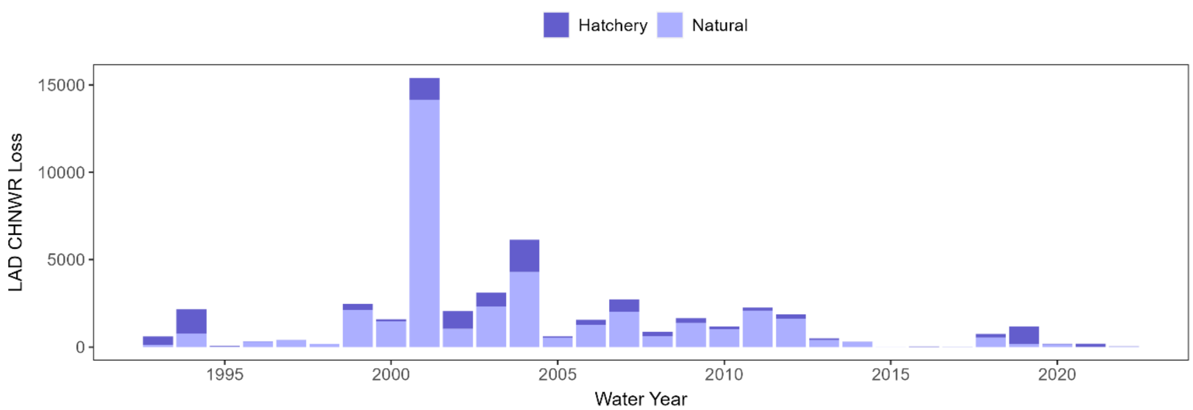

Figure 11. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in March at the CVP and SWP export facilities for water years 1993-2022.

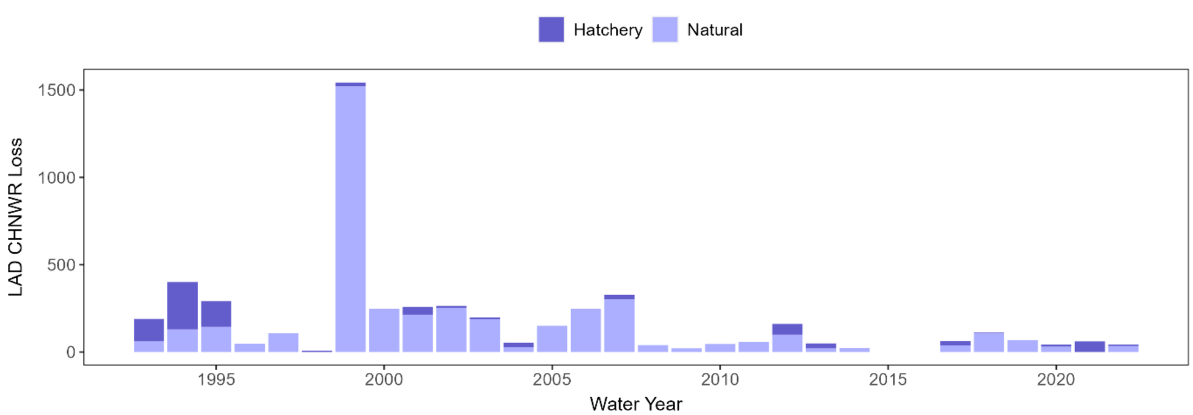

Figure 12. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in April at the CVP and SWP export facilities for water years 1993-2022.

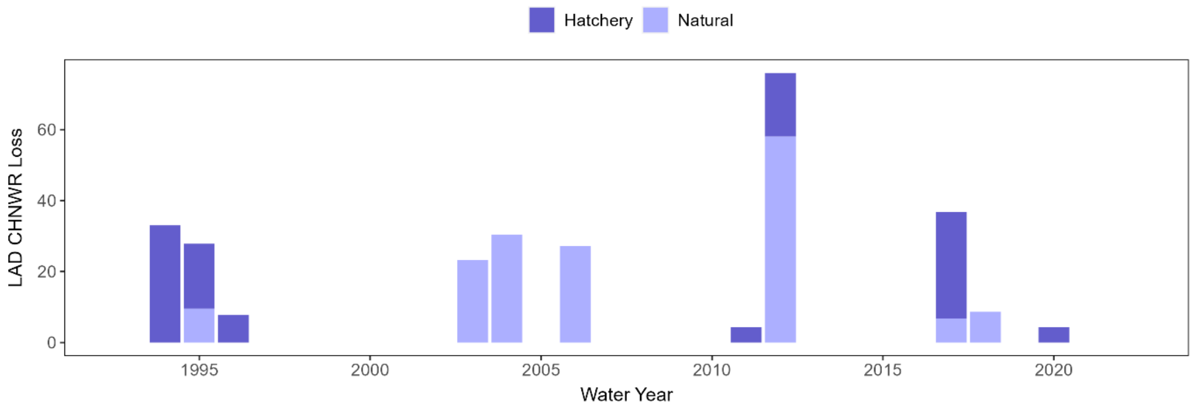

Figure 13. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in May at the CVP and SWP export facilities for water years 1993-2022.

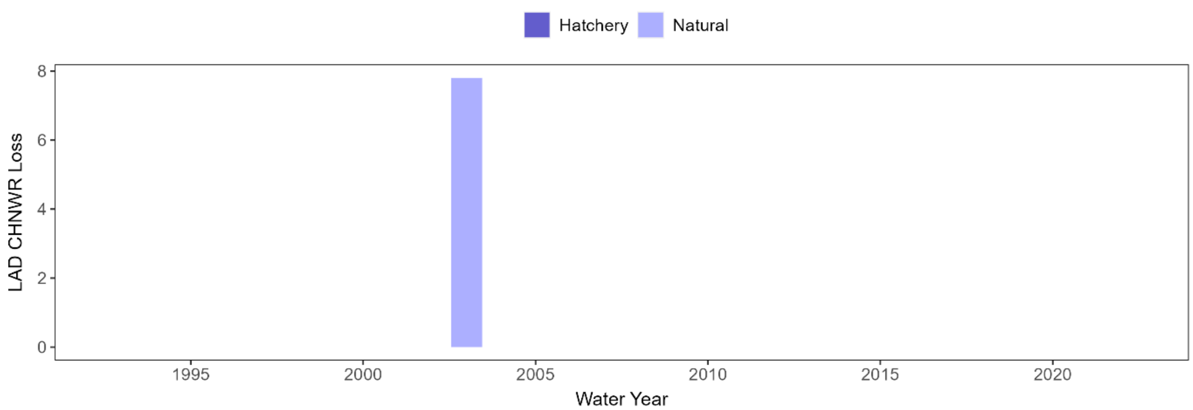

Figure 14. Juvenile LAD natural-origin and hatchery-origin CHNWR monthly loss in June at the CVP and SWP export facilities for water years 1993-2022.

Genetically-identified natural-origin CHNWR are more rare in salvage compared to LAD CHNWR because LAD CHNWR can include other run types of Chinook Salmon that fall into the LAD CHNWR size category. Figure 15 shows the annual historical loss of juvenile genetically-identified natural-origin CHNWR for water years 2010 to 2022. Zero loss of genetically-identified natural-origin CHNWR occurred in water years 2015, 2017, and 2022. Very low loss occurred in water year 2021 (4 fish) from one salvage event in March. Loss was also low in water years 2014 and 2016 with loss occurring on ten days in water year 2014 (48 fish) and only two days in water year 2016 (11 fish). The highest amount of loss occurred in water year 2011 (1,470 fish), which is consistent with the highest recorded loss of LAD CHNWR between water years 2010 and 2022 (Figure 7).

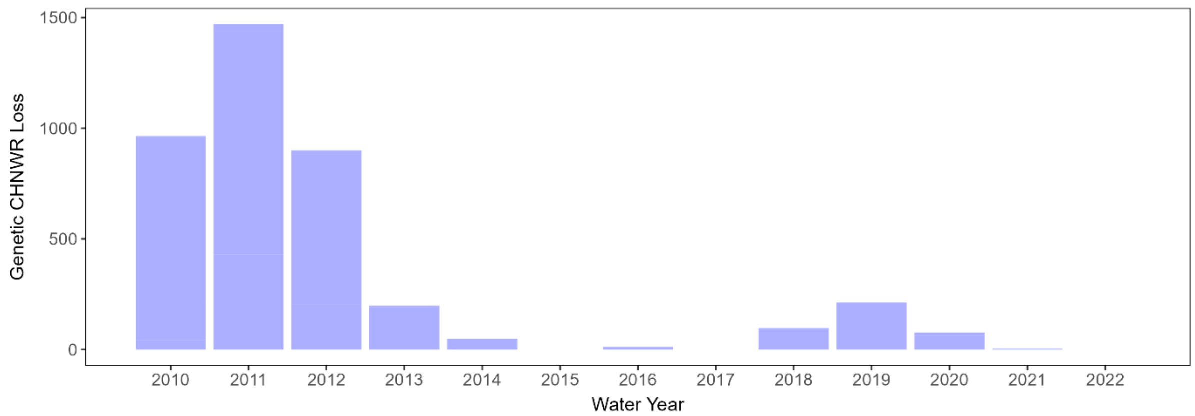

Figure 15. Juvenile genetically-identified natural-origin CHNWR annual loss at the CVP and SWP export facilities for water years 2010-2022.

Historically, loss of genetically-identified natural-origin CHNWR has occurred between December and April, with the highest loss observed in March (Figures 16-20). Loss occurred in December in water years 2010, 2011, and 2013 but has not occurred in recent years. Loss has occurred more frequently in March compared to other months (9 out of 13 water years) and the highest amount of monthly loss occurred in March of water year 2011 (1,010 fish). In more recent water years (2018-2020), loss has occurred more frequently in April, albeit in small numbers (between 9 and 39 fish).

To minimize future entrainment and take of CHNWR under the 2024 SWP ITP, CDFW requires minimization in the form of Conditions of Approval (see Section 6 – Minimization of Take and Impacts of the Taking on Winter- and Spring-run Chinook Salmon).

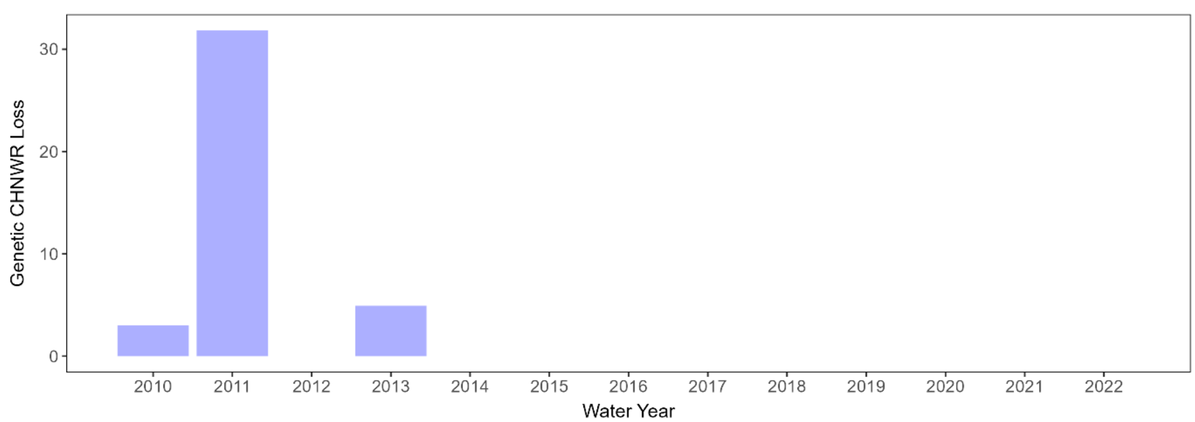

Figure 16. Juvenile genetically-identified natural-origin CHNWR monthly loss in December at the CVP and SWP export facilities for water years 2010-2022.

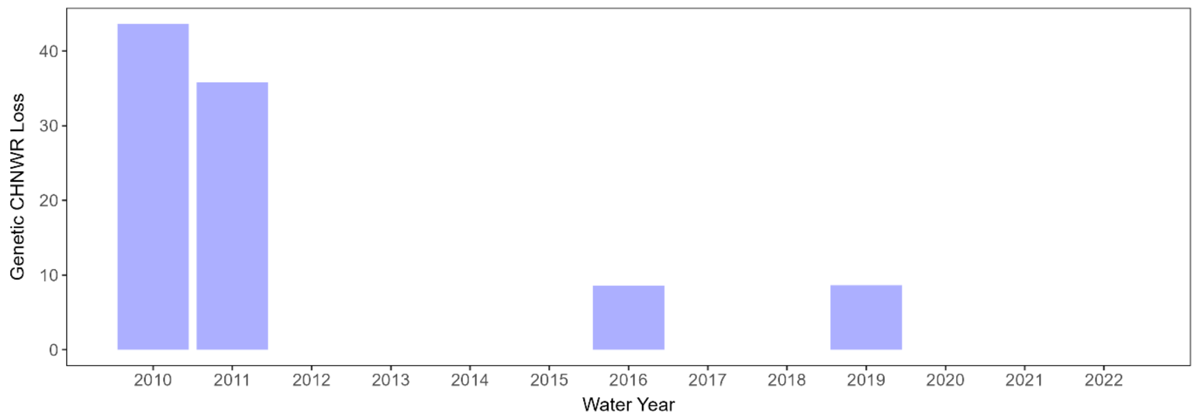

Figure 17. Juvenile genetically-identified natural-origin CHNWR monthly loss in January at the CVP and SWP export facilities for water years 2010-2022.

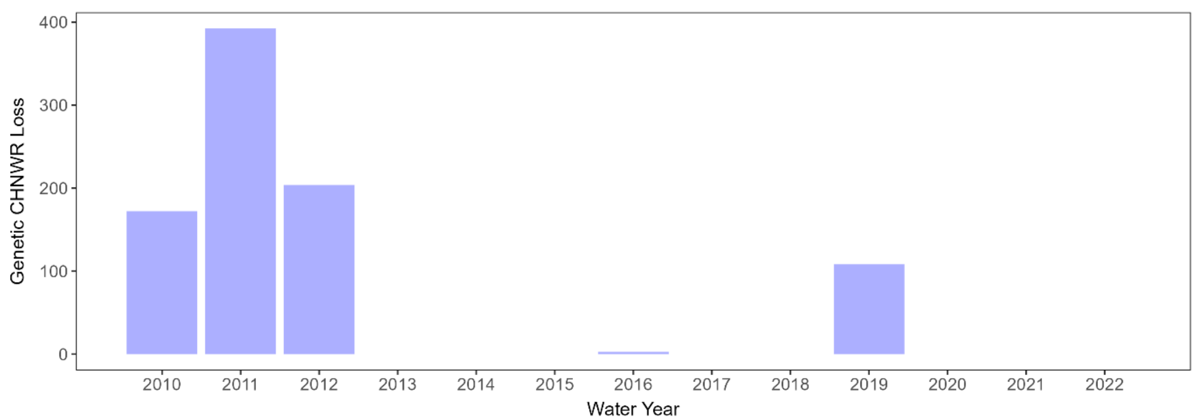

Figure 18. Juvenile genetically-identified natural-origin CHNWR monthly loss in February at the CVP and SWP export facilities for water years 2010-2022.

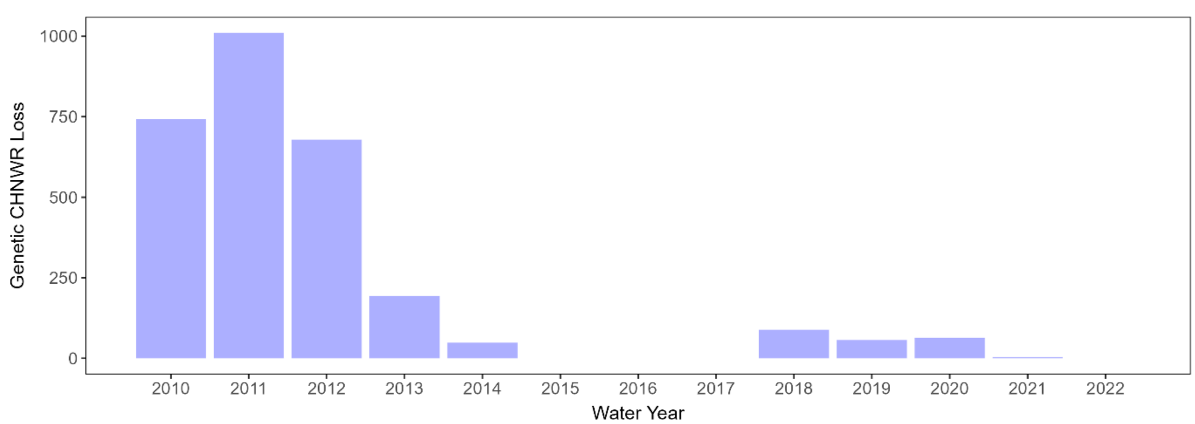

Figure 19. Juvenile genetically-identified natural-origin CHNWR monthly loss in March at the CVP and SWP export facilities for water years 2010-2022.

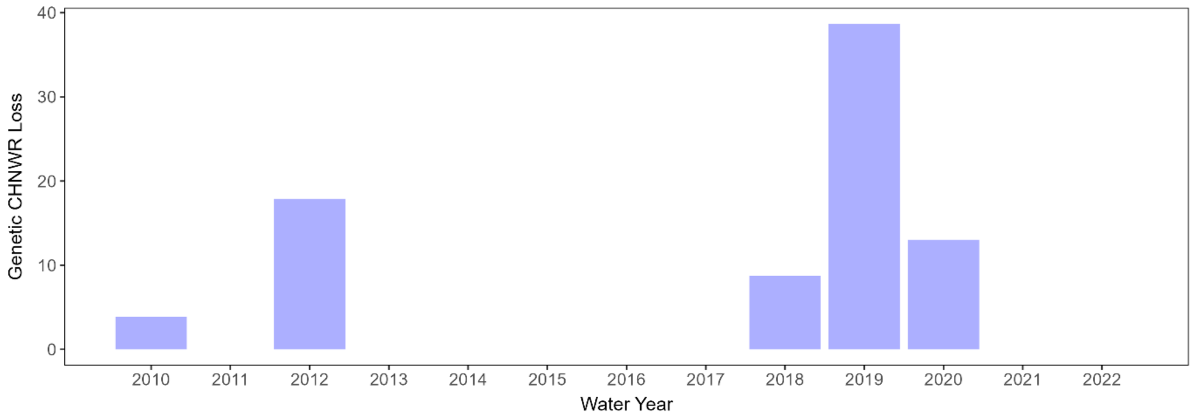

Figure 20. Juvenile genetically-identified natural-origin CHNWR monthly loss in April at the CVP and SWP export facilities for water years 2010-2022.

5.2.1.2.2. Historical Loss of Spring-run Chinook Salmon

Entrainment primarily affects migrating salmonids during their juvenile life stages although adult salmonids have been documented in salvage at both the SWP and CVP export facilities (see Section 5.2.2 – Entrainment of Adult Chinook Salmon). Salvage data of Chinook Salmon collected at the CVP and SWP export facilities from water years 1993 through 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018) to evaluate historical loss of LAD hatchery-origin and natural-origin CHNSR. The Delta Model LAD criteria (USFWS 1997) were used to identify juvenile LAD CHNSR at the CVP and SWP export facilities. As described in Section 5.2.1.2 above, natural-origin and hatchery-origin CHNSR were classified based on the presence or absence of an adipose fin (“unclipped” versus “clipped”) as documented in the salvage database. Clipped CHNSR were characterized as hatchery-origin and unclipped CHNSR were characterized as natural-origin. Although the presence or absence of a CWT would be a more precise way to verify a hatchery-origin designation, data limitations precluded the use of CWTs to determine CHNSR origin for this evaluation.

Loss was also evaluated for genetically-identified natural-origin CHNSR. Loss data for genetically-identified natural-origin CHNSR was available for water years 2017 through 2022 and was consolidated by DWR and CDFW (DWR and CDFW 2023b). Water year 2019 observed loss for both the genetic and LAD database is potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on data sources and limitations see CDFW (2024b).

Figure 21 shows the annual historical loss of juvenile LAD natural-origin and hatchery-origin CHNSR combined for water years 1993 to 2022. Annual loss of juvenile LAD CHNSR peaked in water year 1999 (128,173 fish), followed by a sharp decline in water year 2001 (41,395 fish), and continued a negative trend with very low numbers during drought years 2012 to 2016 (2,684 fish in 2012, 2,511 fish in 2013, 356 fish in 2014, 77 fish in 2015, and 858 fish in 2016). Peaks in LAD CHNSR loss are observed in wet water years 2011 and 2017 (53,297 fish and 73,799 fish, respectively). Greater combined CVP and SWP exports in these water years (2011: 6.68 MAF; 2017: 6.46 MAF) as compared to the 15-year rolling averages (2011 rolling average: 5.45 MAF; 2017 rolling average: 4.87 MAF; Delta Stewardship Council 2024) may have resulted in more negative OMR flows early in the year before high flows moved through the Delta, which could explain higher rates of loss because these hydrologic conditions are expected to increase entrainment and salvage of juvenile Chinook Salmon and reduce survival in some reaches in the interior Delta (SST 2017). Loss of LAD CHNSR has continued to decline each year since water year 2017 for a low of 669 fish in water year 2022. Low numbers of adult CHNSR and poor quality in-stream rearing conditions in tributaries during drought years are likely contributing factors to the low numbers of CHNSR observed in salvage (see Section 4.2.2 – Population Status and Trends). It is not possible to determine if the declines in loss are due to lower proportions of CHNSR being entrained or due to population declines, though development of a CHNSR JPE and life cycle model should provide further insight on this issue (see Section 6.1.4; Conditions of Approval 7.9.3 and 7.9.4). The years with lowest loss were water years 2014, 2015, 2016, 2021, and 2022. In water years 2014, 2015, and 2022 there was more natural-origin LAD CHNSR loss compared to hatchery-origin loss. Water years 2014 and 2015 had hatchery-origin loss of less than ten fish. In contrast, water years 2016 and 2021 saw a greater amount of hatchery-origin CHNSR loss than natural-origin loss. For water years 2014 and 2022, CDFW released part of the FRFH CHNSR production in the San Pablo Bay due to poor in-river conditions (RMPC 2024). Additionally, in water year 2022, all constant fractional marking for FRFH CHNSR was reduced to 50% (CDFW 2022b). The reduced number of in-river CHNSR hatchery releases as well as the lower proportion of constant fractional marking may have contributed to the higher proportion of unclipped LAD CHNSR loss in water years 2014 and 2022.

The Delta Model LAD criteria (USFWS 1997) used to calculate loss of LAD CHNSR have been shown to be less accurate for juvenile CHNSR compared to other runs of juvenile Chinook Salmon (see Section 4.4 – Importance of Life History Diversity for Chinook Salmon). Harvey and Stroble (2013) found that 95% of the LAD CHNSR sized fish observed in salvage at the CVP and SWP export facilities in migration years 2004 and 2006 to 2010 were genetically CHNFR. Therefore, loss of CHNSR at the CVP and SWP export facilities is likely much lower than what is represented in Figures 22 through 29. However, YOY CHNSR can also be misidentified as CHNFR using the Delta Model LAD criteria and, thus, are not included in LAD CHNSR loss numbers (see Section 6.2.8; Condition of Approval 8.4.5). It is unknown to what degree these two factors contribute to uncertainty in historical LAD CHNSR loss numbers.

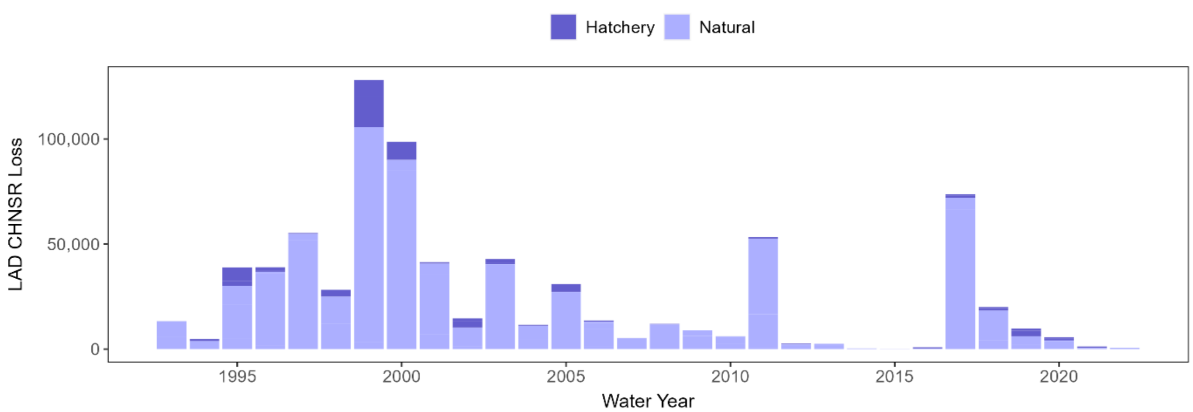

Figure 21. Juvenile LAD natural-origin and hatchery-origin CHNSR annual loss at the CVP and SWP export facilities for water years 1993-2022.

Historically, juvenile LAD hatchery-origin and natural-origin CHNSR have been observed in salvage from January through June, with peak loss occurring from March through May (Figures 23-28). Salvage of juvenile LAD CHNSR observed outside of these months has been rare; however, loss of natural-origin juvenile CHNSR was observed on October 15, 1997 (Figure 22) and September 26, 2000 (Figure 29). Both fish observed in these instances were classified as yearling CHNSR due to their large sizes (285 mm and 240 mm, respectively). Loss in January has been very low and only observed in four out of 30 water years analyzed (2002-2004 and 2011). All historical LAD CHNSR loss in January has been natural-origin CHNSR (Figure 23). Loss of LAD hatchery-origin and natural-origin CHNSR in June was also very low; however, there were three water years analyzed with loss surpassing 5,000 fish (1995, 2011, and 2017; Figure 28). It is important to note that hatchery-origin CHNSR releases from FRFH do not occur in February and the earliest releases historically have not occurred until early March. Some LAD hatchery-origin CHNSR observed in salvage in February may not be true CHNSR and could be hatchery-origin CHNWR released from LSNFH that were classified incorrectly as CHNSR using the Delta Model LAD criteria (USFWS 1997). Alternatively, these LAD hatchery-origin CHNSR could also be yearling hatchery-origin CHNSR that delayed their outmigration. See CDFW (2024b) for more details on designation of hatchery-origin and natural-origin Chinook Salmon captured in salvage.

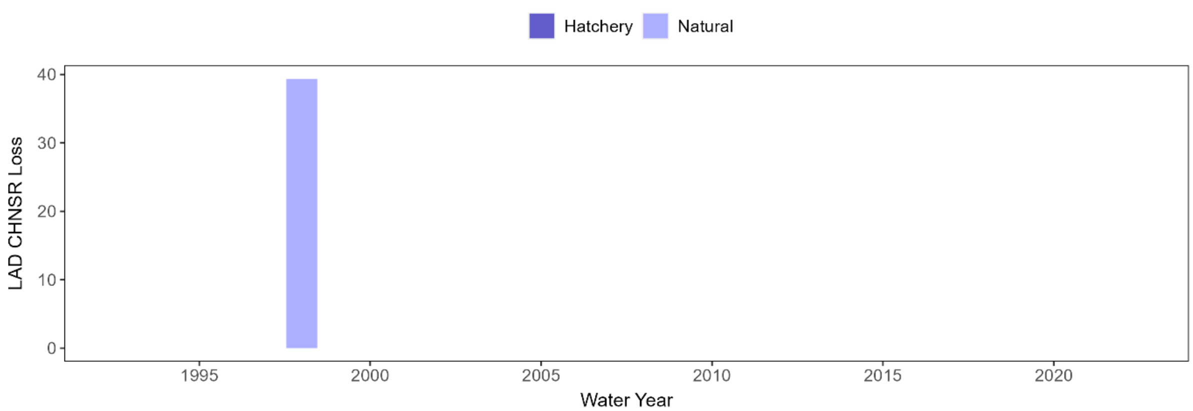

Figure 22. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in October at the CVP and SWP export facilities for water years 1993-2022.

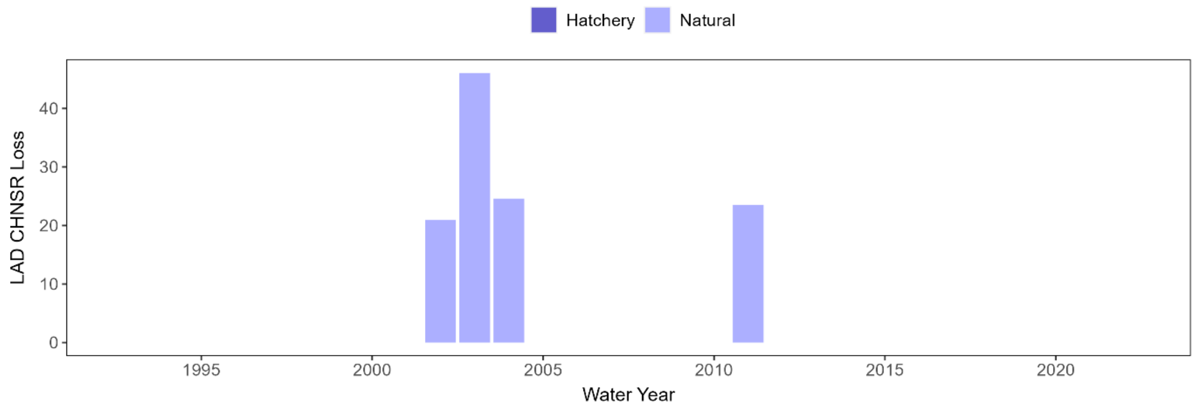

Figure 23. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in January at the CVP and SWP export facilities for water years 1993-2022.

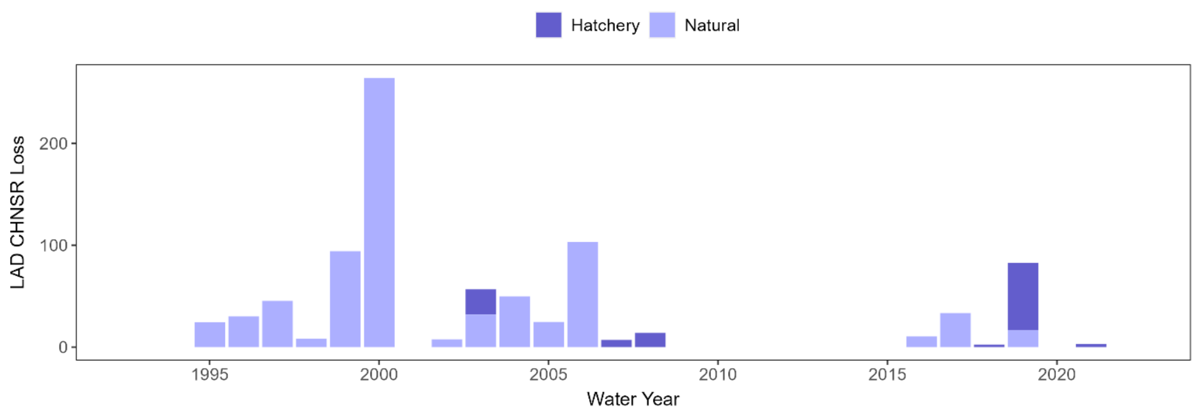

Figure 24. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in February at the CVP and SWP export facilities for water years 1993-2022.

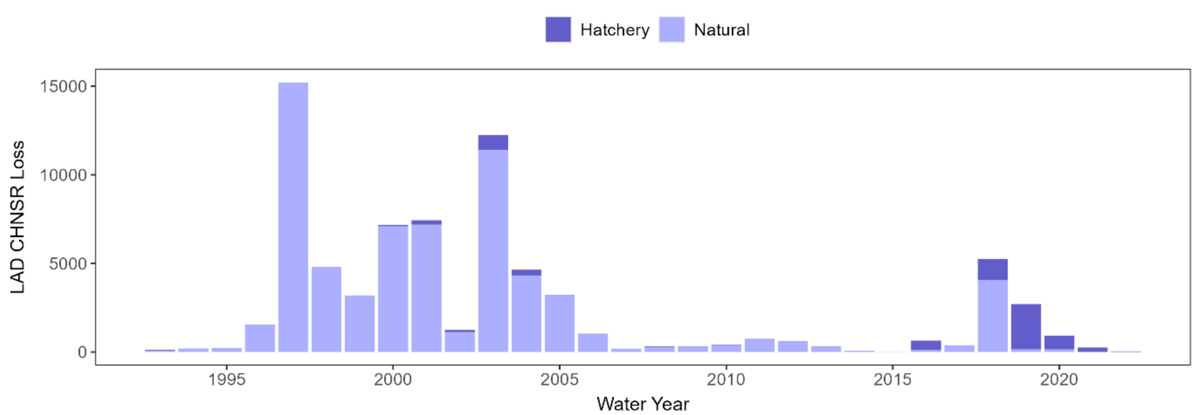

Figure 25. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in March at the CVP and SWP export facilities for water years 1993-2022.

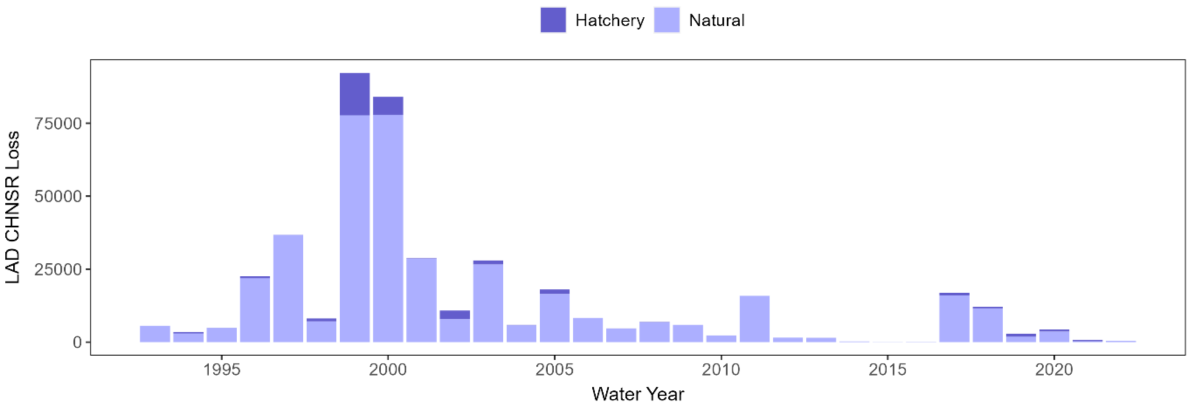

Figure 26. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in April at the CVP and SWP export facilities for water years 1993-2022.

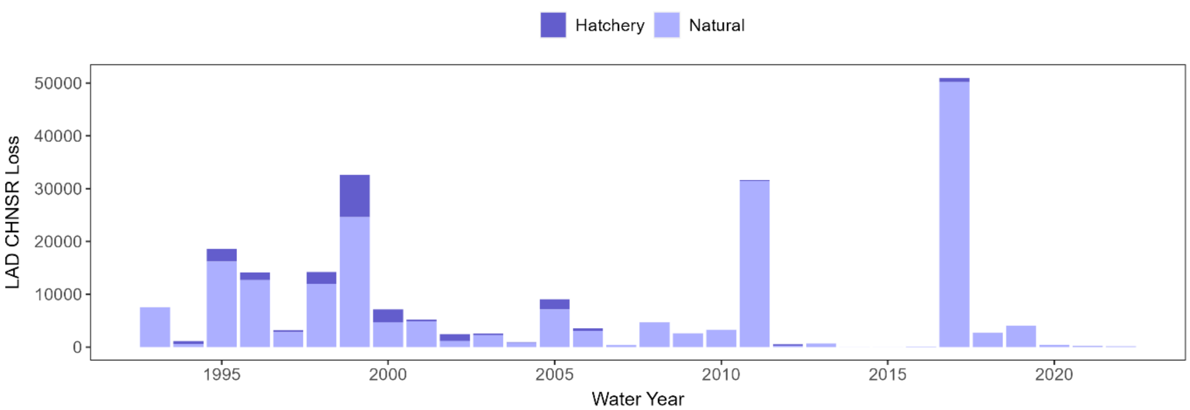

Figure 27. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in May at the CVP and SWP export facilities for water years 1993-2022.

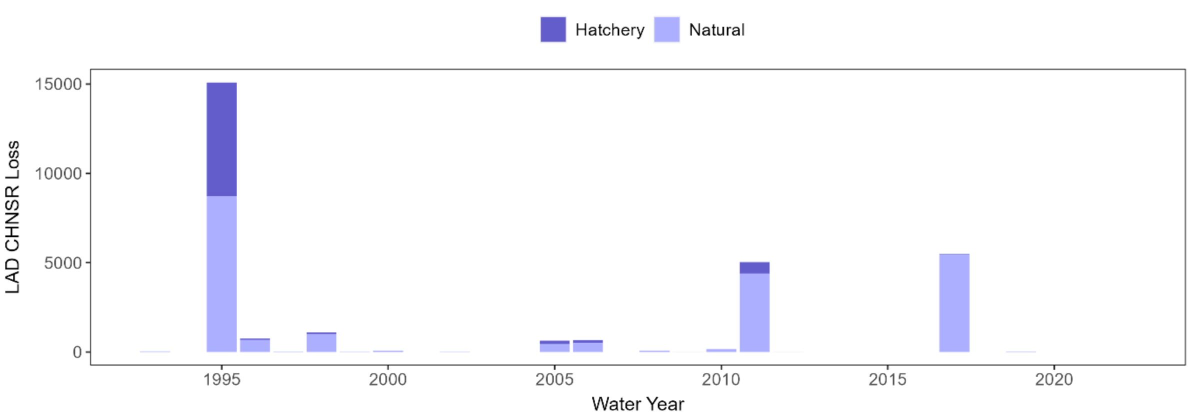

Figure 28. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in June at the CVP and SWP export facilities for water years 1993-2022.

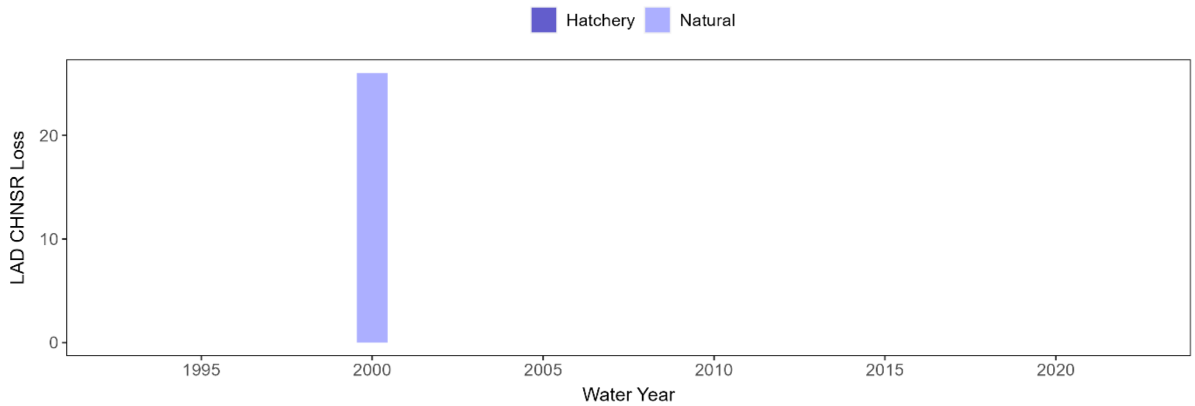

Figure 29. Juvenile LAD natural-origin and hatchery-origin CHNSR monthly loss in September at the CVP and SWP export facilities for water years 1993-2022.

Genetically-identified natural-origin CHNSR loss data can provide estimates of natural-origin CHNSR loss to compare with LAD CHNSR loss; however, genetic data were not available for water years 1993 to 2016 for comparative purposes. Total loss of genetically-identified natural-origin CHNSR is much lower than that of LAD CHNSR. As mentioned above, LAD CHNSR loss can include other run types of Chinook Salmon that fall into the CHNSR LAD size category. Figure 30 shows the annual historical loss of juvenile genetically-identified natural-origin CHNSR for water years 2017 to 2022. Loss of genetically-identified natural-origin CHNSR occurred in all years, though water years 2017 and 2018 had much higher loss (292 fish and 209 fish, respectively) compared to more recent years. The relatively high loss of genetically-identified natural-origin CHNSR in water year 2017 mirrors that of LAD CHNSR. Very low loss occurred in water year 2021 (4 fish) from one salvage event in May.

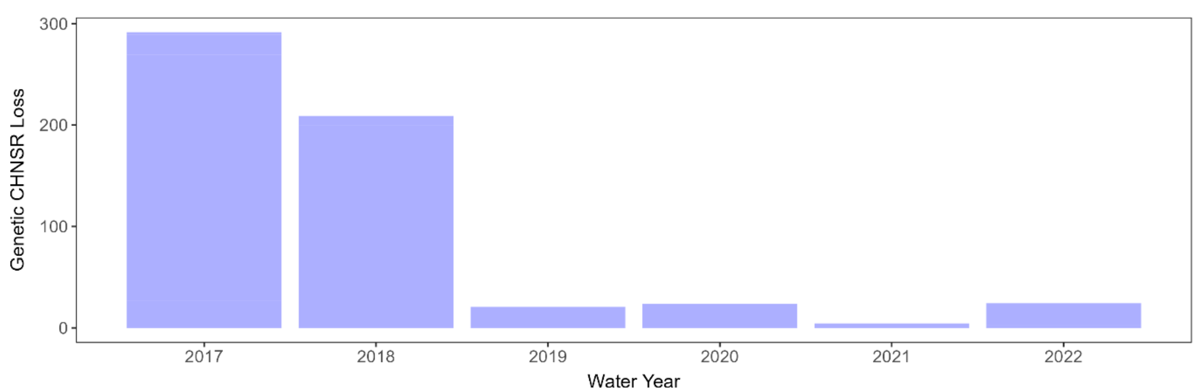

Figure 30. Juvenile genetically-identified natural-origin CHNSR annual loss at the CVP and SWP export facilities for water years 2017-2022.

Historically, loss of genetically-identified natural-origin CHNSR has occurred between January and July, with the highest loss observed in April and May (Figures 31-37). Water year 2017 was the only year when loss was observed in February, June, and July. For genetically-identified natural-origin CHNSR, juvenile CHNSR include both YOY and yearling size classes, whereby the yearling size class includes fish sized greater than the maximum Delta Model LAD criteria (USFWS 1997) for CHNSR. Most genetically-identified natural-origin CHNSR were of YOY size; however, one yearling was observed in salvage in January 2022 for a total loss of 2.60 fish (Figure 31). It is important to note that, although not included in this analysis, salvage of three yearling-sized genetically-identified natural-origin CHNSR was observed in December of water year 2023, which confirms the presence of yearling natural-origin CHNSR in the Delta during December (DWR 2023d).

To minimize future entrainment and take of CHNSR under the 2024 SWP ITP, CDFW requires minimization in the form of Conditions of Approval (see Section 6 – Minimization of Take and Impacts of the Taking on Winter- and Spring-run Chinook Salmon).

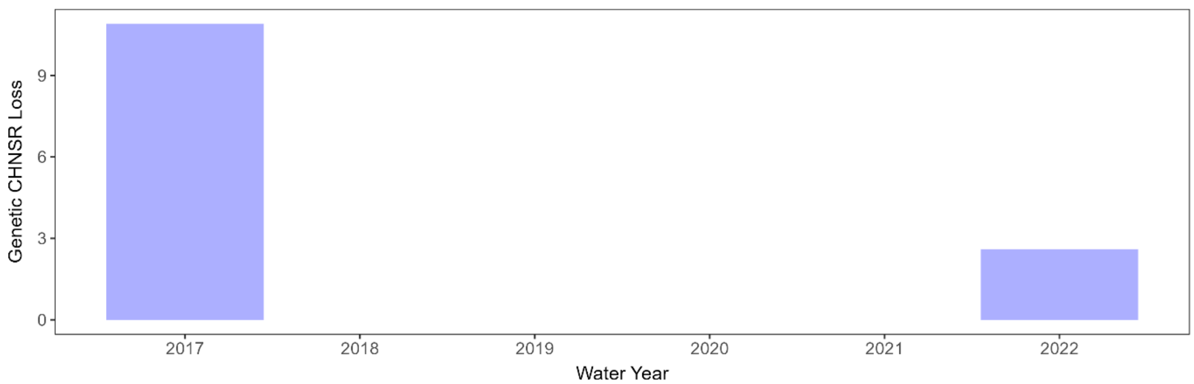

Figure 31. Juvenile genetically-identified natural-origin CHNSR monthly loss in January at the CVP and SWP export facilities for water years 2017-2022.

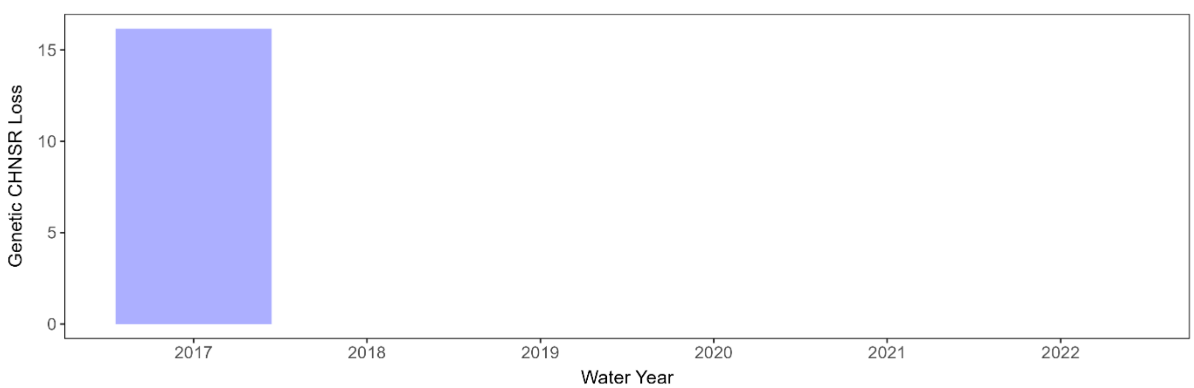

Figure 32. Juvenile genetically-identified natural-origin CHNSR monthly loss in February at the CVP and SWP export facilities for water years 2017-2022.

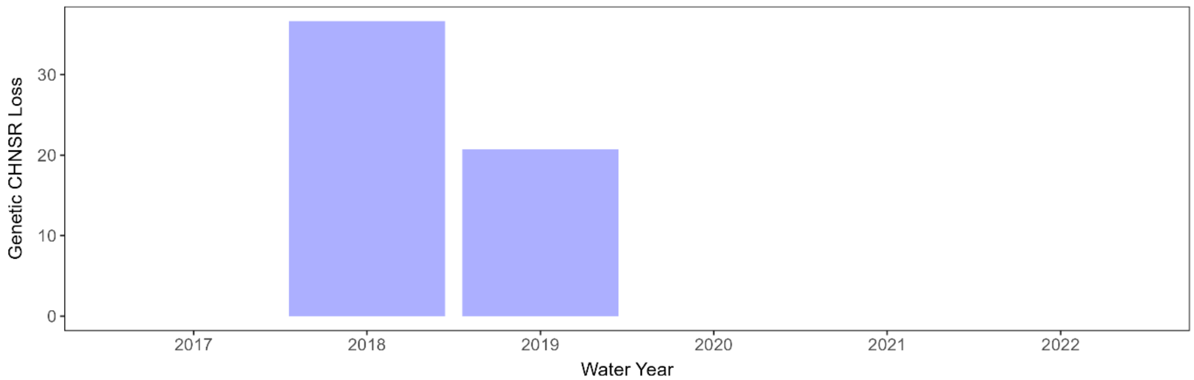

Figure 33. Juvenile genetically-identified natural-origin CHNSR monthly loss in March at the CVP and SWP export facilities for water years 2017-2022.

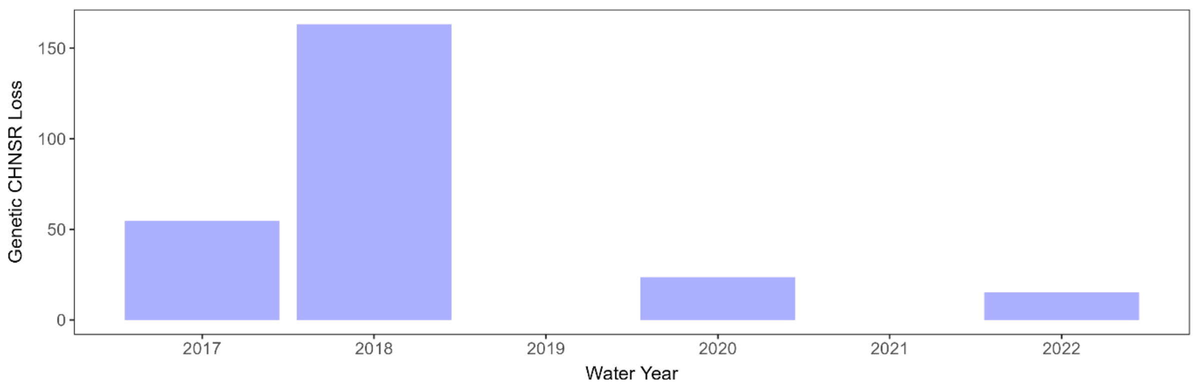

Figure 34. Juvenile genetically-identified natural-origin CHNSR monthly loss in April at the CVP and SWP export facilities for water years 2017-2022.

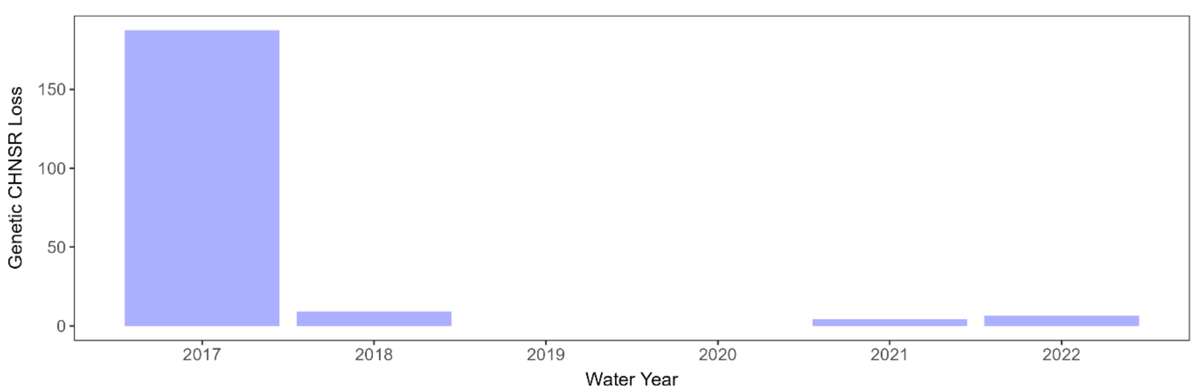

Figure 35. Juvenile genetically-identified natural-origin CHNSR monthly loss in May at the CVP and SWP export facilities for water years 2017-2022.

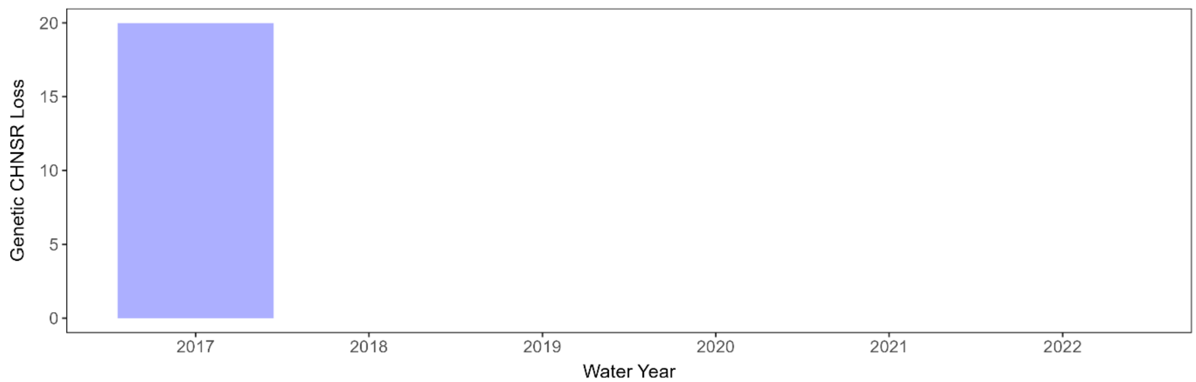

Figure 36. Juvenile genetically-identified natural-origin CHNSR monthly loss in June at the CVP and SWP export facilities for water years 2017-2022.

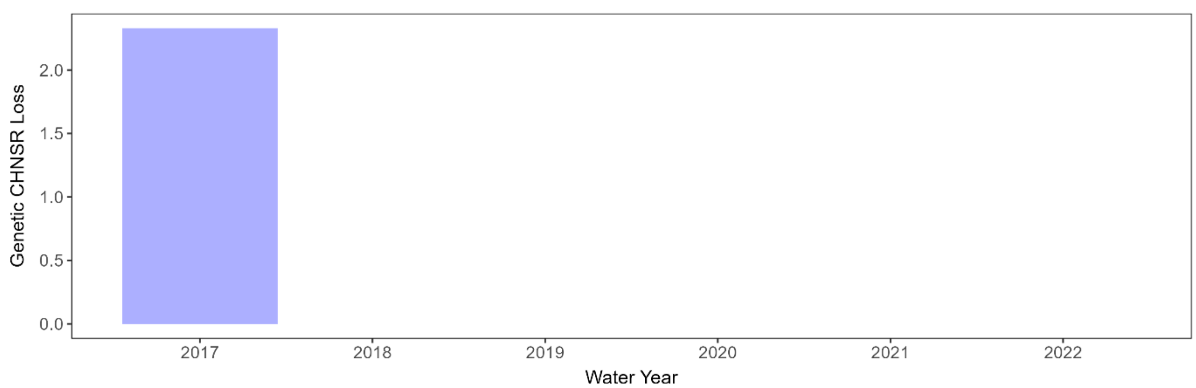

Figure 37. Juvenile genetically-identified natural-origin CHNSR monthly loss in July at the CVP and SWP export facilities for water years 2017-2022.

5.2.1.3. Salvage-Density Method

DWR used the Salvage-Density Method in the ITP Application (DWR 2023f) to evaluate potential differences in entrainment loss of natural-origin CHNWR and CHNSR at the CVP and SWP export facilities between Baseline Conditions and the two Proposed Project scenarios (ITP_Spring and 9A_V2A). For the three scenarios, modeling outputs from CalSim 3, and subsequently DSM2, were used as inputs to the Salvage-Density Method. See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon for additional information on modeling of Baseline Conditions and Proposed Project scenarios in CalSim 3. Modeling results discussed below are based on information CDFW obtained through subsequent coordination with DWR.

Historical juvenile loss of both genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR and CHNSR observed at the CVP and SWP export facilities were used to calculate a daily loss density (DWR 2023f, Appendix D). Salvage data were available for genetically-identified natural-origin CHNWR for water years 2010 to 2022 and for CHNSR for water years 2017 to 2022. Salvage data were available for hatchery-origin CWT tagged CHNWR and CHNSR for water years 2010 to 2022. Loss was calculated from the salvage data using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018), divided by the amount of water exported at the CVP and SWP export facilities (TAF) to determine the density (fish per TAF of water exported), and then multiplied by the CalSim 3 modeled exports for all three scenarios. Percent difference between Baseline Conditions and Proposed Project scenarios was calculated as the difference between loss estimates from Baseline Conditions and Proposed Project scenarios divided by Baseline Conditions. Differences were calculated by month and water year type. There were no above normal water years from 2010 to 2022, so the monthly pattern for wet water years was used and only percent differences were reported (Tables 2532). Instances of zero loss modeled under Baseline Conditions equated to 0% difference in loss for the Proposed Project scenarios. Tables 2532 report modeled results and percent differences as rounded to the nearest whole number, as provided by DWR.

5.2.1.3.1. Salvage Density Results for Winter-run Chinook Salmon

SWP Export Facilities:

Percent changes in mean monthly loss of genetically-identified natural-origin CHNWR loss at the SWP export facilities between Baseline Conditions and the 9A_V2A scenario ranged from a 7% decrease to a 64% increase in any month or water year type (Table 25; absolute change ranges from a decrease by 11 fish to an increase by 11 fish, above normal water years excluded given no modeled loss value). Under the ITP_Spring scenario, percent changes in mean monthly loss of genetically-identified natural-origin CHNWR from Baseline Conditions ranged from a 5% decrease to a 9% increase in any month or water year type (absolute change ranges from a decrease in 11 fish to an increase in 19 fish, above normal water years excluded given no modeled loss value). The greatest percent decreases in genetically-identified natural-origin CHNWR loss between Baseline Conditions and Proposed Project scenarios appear in February of above normal and below normal water year types with February of above normal water years under the 9A_V2A scenario having the greatest percent decrease in loss (7% decrease; absolute change not available). Lesser percent decreases in loss as well as some minor percent increases appear in December, January, and March, depending on water year type. Percent increases in loss of genetically-identified natural-origin CHNWR are larger than percent decreases in loss shown for both Proposed Project scenarios. The 9A_V2A scenario shows percent increases in loss between 21% and 36% for above normal, below normal, and critical water years in April; however absolute change for below normal and critical water years is no greater than one modeled fish. The highest percent increases in loss of genetically-identified natural-origin CHNWR from the 9A_V2A scenario are shown in May for wet (48% increase; absolute change less than 1 fish) and above normal (64% increase; absolute change not available) water years (Table 25). In comparison, the ITP_Spring scenario shows a small percent increase in loss in April for wet (2% increase; absolute change of 1 fish) and below normal (1% increase; absolute change less than 1 fish) water years with all other water year types showing zero percent change in modeled loss. For May, the ITP_Spring scenario shows percent increases in modeled genetically-identified natural-origin CHNWR loss for wet (9% increase; absolute change less than 1 fish) and above normal (5% increase; absolute change not available) water years, though smaller in magnitude than the 9A_V2A percent increases. It is important to note that there have been no May observations of genetically-identified natural-origin CHNWR in salvage for water years 2010 to 2022.

Other months and water year types showed minor changes or zero percent change in loss of genetically-identified natural-origin CHNWR lost at the SWP export facilities between Baseline Conditions and Proposed Project scenarios; zero percent change was observed for the months of June through September, when juvenile CHNWR are expected absent or present in very low numbers in the south Delta, as well as October and November.

The greatest absolute change in genetically-identified natural-origin CHNWR loss between Baseline Conditions and Proposed Project scenarios appears in March of wet and below normal water years. The 9A_V2A scenario shows an absolute increase in loss of 11 modeled fish in March of wet water years and an absolute decrease in loss of 11 modeled fish in March of below normal water years. The ITP_Spring scenario shows an absolute increase in loss of 19 modeled fish in March of wet water years and an absolute decrease in loss of 11 modeled fish in March of below normal water years.

Table 25. Mean monthly loss of genetically-identified natural-origin CHNWR juveniles at the SWP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	4	4 (-1%)	4 (-1%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	7	7 (-2%)	7 (-2%)
January	Above Normal	N/A	(-2%)	(-2%)
January	Below Normal	10	9 (-4%)	9 (-3%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	197	199 (1%)	198 (1%)
February	Above Normal	N/A	(-7%)	(-1%)
February	Below Normal	134	127 (-5%)	127 (-5%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	539	550 (2%)	558 (4%)
March	Above Normal	N/A	(3%)	(3%)
March	Below Normal	424	413 (-3%)	413 (-2%)
March	Dry	95	94 (-2%)	94 (-2%)
March	Critical	4	4 (0%)	4 (0%)
April	Wet	58	59 (2%)	59 (2%)
April	Above Normal	N/A	(36%)	(0%)
April	Below Normal	4	5 (24%)	4 (1%)
April	Dry	7	8 (5%)	7 (0%)
April	Critical	6	7 (21%)	6 (0%)
May	Wet	1[a]	1 (48%)	1 (9%)
May	Above Normal	N/A	(64%)	(5%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

[a] There have been zero genetically-identified natural-origin CHNWR observed in salvage in May of water years 2010 and 2022.

Modeled loss of CWT-confirmed hatchery-origin CHNWR at the SWP export facilities was typically zero for Baseline Conditions and both Proposed Project scenarios across all months and water year types (Table 26). Both Proposed Project scenarios show slight decreases in modeled percent loss during February of critical water years (5% decrease; absolute change less than 1 fish) and March in below normal (2-3% decrease; absolute change less than 1 fish) and dry (2% decrease; absolute change less than 1 fish) water years. The greatest potential percent increase in loss is seen under the 9A_V2A scenario in April of below normal water years (24% increase), although this change is based on an absolute change of less than one modeled fish. The ITP_Spring scenario also shows a slight percent increase in loss of CWT-confirmed hatchery-origin CHNWR in April of below normal water years (1% increase), although this change is also based on an absolute change of less than one modeled fish.

Table 26. Mean monthly loss of CWT-confirmed hatchery-origin CHNWR juveniles at the SWP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	0	0 (0%)	0 (0%)
January	Above Normal	N/A	(0%)	(0%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	0	0 (0%)	0 (0%)
February	Above Normal	N/A	(0%)	(0%)
February	Below Normal	0	0 (0%)	0 (0%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	2	2 (-5%)	2 (-5%)
March	Wet	0	0 (0%)	0 (0%)
March	Above Normal	N/A	(0%)	(0%)
March	Below Normal	18	18 (-3%)	18 (-2%)
March	Dry	4	4 (-2%)	4 (-2%)
March	Critical	0	0 (0%)	0 (0%)
April	Wet	0	0 (0%)	0 (0%)
April	Above Normal	N/A	(0%)	(0%)
April	Below Normal	2	2 (24%)	2 (1%)
April	Dry	0	0 (0%)	0 (0%)
April	Critical	0	0 (0%)	0 (0%)
May	Wet	0	0 (0%)	0 (0%)
May	Above Normal	N/A	(0%)	(0%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

CVP Export Facilities:

Percent changes in mean monthly loss of genetically-identified natural-origin CHNWR at the CVP export facilities between Baseline Conditions and the 9A_V2A scenario ranged from a 6% decrease to a 2% increase in any month or water year type (Table 27; absolute change ranges from a decrease by 2 fish to an increase by less than 1 fish, above normal water years excluded given no modeled loss value). Under the ITP_Spring scenario, percent changes in mean monthly loss of genetically-identified natural-origin CHNWR from Baseline Conditions ranged from a 4% decrease to a 2% increase in any month or water year type (absolute change ranges from a decrease by 2 fish to an increase by less than 1 fish, above normal water years excluded given no modeled loss value). The greatest percent decreases in genetically-identified natural-origin CHNWR loss between Baseline Conditions and Proposed Project scenarios occur in January of critical water years (6% decrease) and February of below normal water years (5% decrease) under the 9A_V2A scenario; however absolute change for both months and water year types is no greater than one modeled fish. Both Proposed Project scenarios show the greatest percent increases in loss during March of above normal water years (2% increase; absolute change not available). Smaller percent decreases in loss as well as some minor percent increases appear in December through April, depending on water year type. Other months and water year types showed minor changes or zero percent change between Baseline Conditions and Proposed Project scenarios. No percent change in loss of genetically-identified natural-origin CHNWR at the CVP export facilities was modeled for the months of May through November, consistent with zero historical loss between May and November.

The greatest absolute change in genetically-identified natural-origin CHNWR loss between Baseline Conditions and Proposed Project scenarios appears in March of below normal water years. The 9A_V2A scenario shows an absolute decrease in loss of two modeled fish in March of below normal water years. The ITP_Spring scenario shows an absolute decrease in loss of two modeled fish in March of below normal water years.

Table 27. Mean monthly loss of genetically-identified natural-origin CHNWR juveniles lost at the CVP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	4	4 (-1%)	4 (-1%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	1	1 (-1%)	1 (-1%)
December	Dry	2	2 (-1%)	2 (-1%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	4	4 (-2%)	4 (-2%)
January	Above Normal	N/A	(-2%)	(-2%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	1	1 (-6%)	1 (-1%)
February	Wet	20	20 (-1%)	20 (0%)
February	Above Normal	N/A	(-1%)	(-1%)
February	Below Normal	35	34 (-5%)	34 (-4%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	51	51 (0%)	51 (0%)
March	Above Normal	N/A	(2%)	(2%)
March	Below Normal	94	92 (-2%)	92 (-2%)
March	Dry	40	39 (-2%)	39 (-2%)
March	Critical	10	10 (-1%)	10 (-1%)
April	Wet	1	1 (0%)	1 (0%)
April	Above Normal	N/A	(1%)	(1%)
April	Below Normal	2	2 (0%)	2 (0%)
April	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
April	Critical	0	0 (0%)	0 (0%)
May	Wet	0	0 (0%)	0 (0%)
May	Above Normal	N/A	(0%)	(0%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

Modeled loss of CWT-confirmed hatchery-origin CHNWR at the CVP export facilities was typically zero for Baseline Conditions and both Proposed Project scenarios across all months and water year types (Table 28). Both Proposed Project scenarios show slight decreases in modeled percent loss during February of below normal water years (4-5% decrease) and March of below normal (2% decrease) and critical (1% decrease) water years, although these changes are based on absolute changes of less than one modeled fish. The greatest potential percent decrease in loss is observed under scenario 9A_V2A in February of below normal water years (5% decrease; absolute change less than 1 fish). The ITP_Spring scenario also shows a slight decrease in loss in February of below normal water years (4% decrease; absolute change less than 1 fish). There were no modeled increases in loss of CWT-confirmed hatchery-origin CHNWR at the CVP export facilities for any month or water year type.

Table 28. Mean monthly loss of CWT-confirmed hatchery-origin CHNWR juveniles lost at the CVP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	0	0 (0%)	0 (0%)
January	Above Normal	N/A	(0%)	(0%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	0	0 (0%)	0 (0%)
February	Above Normal	N/A	(0%)	(0%)
February	Below Normal	4	4 (-5%)	4 (-4%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	0	0 (0%)	0 (0%)
March	Above Normal	N/A	(0%)	(0%)
March	Below Normal	13	13 (-2%)	13 (-2%)
March	Dry	0	0 (0%)	0 (0%)
March	Critical	2	2 (-1%)	2 (-1%)
April	Wet	0	0 (0%)	0 (0%)
April	Above Normal	N/A	(0%)	(0%)
April	Below Normal	0	0 (0%)	0 (0%)
April	Dry	0	0 (0%)	0 (0%)
April	Critical	0	0 (0%)	0 (0%)
May	Wet	0	0 (0%)	0 (0%)
May	Above Normal	N/A	(0%)	(0%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

5.2.1.3.2. Salvage Density Results for Spring-run Chinook Salmon

SWP Export Facilities:

Percent changes in mean monthly loss of genetically-identified natural-origin CHNSR at the SWP export facilities between Baseline Conditions and the 9A_V2A scenario ranged from a 7% decrease to a 64% increase in any month or water year type (Table 29; absolute change ranges from a decrease by 1 fish to an increase by 24 fish, above normal water years excluded given no modeled loss value). Under the ITP_Spring scenario, percent changes in mean monthly loss of genetically-identified natural-origin CHNSR from Baseline Conditions ranged from a 2% decrease to a 9% increase in any month or water year type (absolute change ranges from a decrease by 1 fish to an increase by 4 fish, above normal water years excluded given no modeled loss value). The greatest percent decreases in genetically-identified natural-origin CHNSR loss between Baseline Conditions and Proposed Project scenarios appear in February of above normal water years and March of below normal water years with February of above normal water years in the 9A_V2A scenario showing the greatest percent decrease in loss (7% decrease; absolute change not available). Lesser percent decreases in loss as well as some minor percent increases appear in January and March, depending on water year type, as well as February of wet water years. Percent increases in loss of genetically-identified natural-origin CHNSR are larger than any percent decreases in loss shown for both Proposed Project scenarios. The 9A_V2A scenario shows percent increases in April loss of 24% for below normal (absolute change of 7 fish) and 21% for critical (absolute change of 1 fish) water years. The highest percent increases in loss from the 9A_V2A scenario are shown in May of wet (48% increase; absolute change of 24 fish), above normal (64% increase; absolute change not available), and critical (41% increase; absolute change of 1 fish) water years. For comparison, the ITP_Spring scenario shows a small percent increase in loss in April for below normal (1% increase; absolute change of 1 fish) water years with all other water year types in April showing zero percent change in modeled loss. For May, the ITP_Spring scenario shows increases in loss for wet (9% increase; absolute change of 4 fish), above normal (5% increase; absolute change not available), and critical (3% increase; absolute change less than 1 fish) water years, though smaller in magnitude than the 9A_V2A percent increases. Other months and water year types showed minor changes or zero percent change in loss of genetically-identified natural-origin CHNSR lost at the SWP facilities between Baseline Conditions and Proposed Project scenarios; zero percent change was observed in June through December.

Table 29. Mean monthly loss of genetically-identified natural-origin CHNSR juveniles at the SWP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	2	2 (-2%)	2 (-2%)
January	Above Normal	N/A	(-2%)	(-2%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	5	5 (1%)	5 (1%)
February	Above Normal	N/A	(-7%)	(-1%)
February	Below Normal	0	0 (0%)	0 (0%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	9	9 (2%)	9 (4%)
March	Above Normal	N/A	(3%)	(3%)
March	Below Normal	23	22 (-3%)	22 (-2%)
March	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
March	Critical	0	0 (0%)	0 (0%)
April	Wet	0	0 (0%)	0 (0%)
April	Above Normal	N/A	(0%)	(0%)
April	Below Normal	30	37 (24%)	31 (1%)
April	Dry	23	24 (5%)	23 (0%)
April	Critical	6	7 (21%)	6 (0%)
May	Wet	51	75 (48%)	55 (9%)
May	Above Normal	N/A	(64%)	(5%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)
May	Critical	4	5 (41%)	4 (3%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

The greatest percent increases in modeled loss of CWT-confirmed hatchery-origin CHNSR at the SWP export facilities appear in April of below normal (24% increase) and dry (5% increase) water years under the 9A_V2A scenario (Table 30), although these changes are based on an absolute change of less than one modeled fish. The ITP_Spring scenario also shows a small percent change in loss during April of below normal water years (1% increase), which also reflects an absolute change of less than one modeled fish. All other months and water year types showed zero percent change in CWT-confirmed hatchery-origin CHNSR loss at the SWP export facilities for both Proposed Project scenarios.

Table 30. Mean monthly loss of CWT-confirmed hatchery-origin CHNSR juveniles at the SWP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	0	0 (0%)	0 (0%)
January	Above Normal	N/A	(0%)	(0%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	0	0 (0%)	0 (0%)
February	Above Normal	N/A	(0%)	(0%)
February	Below Normal	0	0 (0%)	0 (0%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	0	0 (0%)	0 (0%)
March	Above Normal	N/A	(0%)	(0%)
March	Below Normal	0	0 (0%)	0 (0%)
March	Dry	0	0 (0%)	0 (0%)
March	Critical	0	0 (0%)	0 (0%)
April	Wet	0	0 (0%)	0 (0%)
April	Above Normal	N/A	(0%)	(0%)
April	Below Normal	1	1 (24%)	1 (1%)
April	Dry	1	1 (5%)	1 (0%)
April	Critical	0	0 (0%)	0 (0%)
May	Wet	0	0 (0%)	0 (0%)
May	Above Normal	N/A	(0%)	(0%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

<u>CVP Export Facilities</u>:

Percent changes in mean monthly loss of genetically-identified natural-origin CHNSR at the CVP export facilities between Baseline Conditions and the 9A_V2A scenario ranged from a 8% decrease to a 7% increase in any month or water year type (Table 31; absolute change ranges from a decrease by 1 fish to an increase by 1 fish, above normal water years excluded given no modeled loss value). Under the ITP_Spring scenario, percent changes in mean monthly loss of genetically-identified natural-origin CHNSR from Baseline Conditions ranged from a 7% decrease to a 7% increase in any month or water year type (absolute change ranges from a decrease by 1 fish to an increase by 1 fish, above normal water years excluded given no modeled loss value). The greatest percent decrease in genetically-identified natural-origin CHNSR loss between Baseline Conditions and Proposed Project scenarios appears in June of above normal water years under the 9A_V2A scenario (8% decrease; absolute change not available). There is also a small percent decrease in loss shown under the 9A_V2A scenario in April of critical water years (1% decrease; absolute change less than 1 fish). The greatest percent increase in loss is observed under both Proposed Project scenarios in May of above normal water years (7% increase; absolute change not available). Smaller percent decreases in loss are seen in January, March, and April in some water year types, and small percent increases in loss appear in March, April, and July of above normal water years and May of wet water years for both Proposed Project scenarios. Other months and water year types showed minor changes or zero percent change in loss of genetically-identified natural-origin CHNSR lost at the CVP export facilities between Baseline Conditions and Proposed Project scenarios; zero percent change was observed in February and August through December.

Table 31. Mean monthly loss of genetically-identified natural-origin CHNSR juveniles at the CVP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	1	1 (-2%)	1 (-2%)
January	Above Normal	N/A	(-2%)	(-2%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	1	1 (-6%)	1 (-1%)
February	Wet	0	0 (0%)	0 (0%)
February	Above Normal	N/A	(0%)	(0%)
February	Below Normal	0	0 (0%)	0 (0%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	8	8 (0%)	8 (0%)
March	Above Normal	N/A	(2%)	(2%)
March	Below Normal	3	3 (-2%)	3 (-2%)
March	Dry	0	0 (0%)	0 (0%)
March	Critical	0	0 (0%)	0 (0%)
April	Wet	24	24 (0%)	24 (0%)
April	Above Normal	N/A	(1%)	(1%)
April	Below Normal	4	4 (0%)	4 (0%)
April	Dry	4	4 (0%)	4 (0%)
April	Critical	4	4 (-1%)	4 (0%)
May	Wet	13	14 (3%)	14 (4%)
May	Above Normal	N/A	(7%)	(7%)
May	Below Normal	5	5 (0%)	5 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	3	3 (0%)	3 (0%)
June	Wet	10	9 (-4%)	9 (-4%)
June	Above Normal	N/A	(-8%)	(-7%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	1	1 (0%)	1 (0%)
July	Above Normal	N/A	(4%)	(5%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

Modeled loss of CWT-confirmed hatchery-origin CHNSR at the CVP export facilities was zero for Baseline Conditions across all months and water year types (Table 32). No percent changes in loss were modeled under the two Proposed Project scenarios. Loss of CWT-confirmed hatchery-origin CHNSR has occurred historically at the CVP export facilities, though it was not captured in modeled loss under Baseline Conditions likely due to the low value.

Table 32. Mean monthly loss of CWT-confirmed hatchery-origin CHNSR juveniles at the CVP export facilities under the Proposed Project and Baseline Conditions Salvage-Density Method modeling scenarios grouped by month and water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
October	Wet	0	0 (0%)	0 (0%)
October	Above Normal	N/A	(0%)	(0%)
October	Below Normal	0	0 (0%)	0 (0%)
October	Dry	0	0 (0%)	0 (0%)
October	Critical	0	0 (0%)	0 (0%)
November	Wet	0	0 (0%)	0 (0%)
November	Above Normal	N/A	(0%)	(0%)
November	Below Normal	0	0 (0%)	0 (0%)
November	Dry	0	0 (0%)	0 (0%)
November	Critical	0	0 (0%)	0 (0%)
December	Wet	0	0 (0%)	0 (0%)
December	Above Normal	N/A	(0%)	(0%)
December	Below Normal	0	0 (0%)	0 (0%)
December	Dry	0	0 (0%)	0 (0%)
December	Critical	0	0 (0%)	0 (0%)
January	Wet	0	0 (0%)	0 (0%)
January	Above Normal	N/A	(0%)	(0%)
January	Below Normal	0	0 (0%)	0 (0%)
January	Dry	0	0 (0%)	0 (0%)
January	Critical	0	0 (0%)	0 (0%)
February	Wet	0	0 (0%)	0 (0%)
February	Above Normal	N/A	(0%)	(0%)
February	Below Normal	0	0 (0%)	0 (0%)
February	Dry	0	0 (0%)	0 (0%)
February	Critical	0	0 (0%)	0 (0%)
March	Wet	0	0 (0%)	0 (0%)
March	Above Normal	N/A	(0%)	(0%)
March	Below Normal	0	0 (0%)	0 (0%)
March	Dry	0	0 (0%)	0 (0%)
March	Critical	0	0 (0%)	0 (0%)
April	Wet	0	0 (0%)	0 (0%)
April	Above Normal	N/A	(0%)	(0%)
April	Below Normal	0	0 (0%)	0 (0%)
April	Dry	0	0 (0%)	0 (0%)
April	Critical	0	0 (0%)	0 (0%)
May	Wet	0	0 (0%)	0 (0%)
May	Above Normal	N/A	(0%)	(0%)
May	Below Normal	0	0 (0%)	0 (0%)
May	Dry	0	0 (0%)	0 (0%)

Month	Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
May	Critical	0	0 (0%)	0 (0%)
June	Wet	0	0 (0%)	0 (0%)
June	Above Normal	N/A	(0%)	(0%)
June	Below Normal	0	0 (0%)	0 (0%)
June	Dry	0	0 (0%)	0 (0%)
June	Critical	0	0 (0%)	0 (0%)
July	Wet	0	0 (0%)	0 (0%)
July	Above Normal	N/A	(0%)	(0%)
July	Below Normal	0	0 (0%)	0 (0%)
July	Dry	0	0 (0%)	0 (0%)
July	Critical	0	0 (0%)	0 (0%)
August	Wet	0	0 (0%)	0 (0%)
August	Above Normal	N/A	(0%)	(0%)
August	Below Normal	0	0 (0%)	0 (0%)
August	Dry	0	0 (0%)	0 (0%)
August	Critical	0	0 (0%)	0 (0%)
September	Wet	0	0 (0%)	0 (0%)
September	Above Normal	N/A	(0%)	(0%)
September	Below Normal	0	0 (0%)	0 (0%)
September	Dry	0	0 (0%)	0 (0%)
September	Critical	0	0 (0%)	0 (0%)

5.2.1.3.3. Salvage-Density Method Discussion

The Salvage-Density Method provides an entrainment index that reflects south Delta export pumping weighted by the seasonal pattern of CHNWR and CHNSR abundance in the Delta, as reflected by historical genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR and CHNSR loss at the CVP and SWP export facilities. Estimated entrainment losses do not provide accurate predictions of future entrainment loss under the two Proposed Project scenarios, but instead provide a coarse assessment of potential differences between Baseline Conditions and the Proposed Project. Datasets used for Salvage-Density modeling may not be entirely representative of fish presence and distribution due to the rarity of smaller-sized fish captured in salvage. Genetically-identified natural origin fry- and parr-sized CHNWR and CHNSR (25-60 mm) are not commonly sampled (see Appendix D – Juvenile Size Distribution in Delta Monitoring and Salvage). In addition, hatchery-origin Chinook Salmon tagged with CWTs are larger, highly migratory, and exhibit faster transit times through the Delta (approximately seven days; SST 2017), which may decrease the likelihood of being entrained and salvaged as a result of the Project. Conclusions regarding changes in salvage and loss of CHNWR and CHNSR that may result under the Proposed Project scenarios compared to Baseline Conditions should be approached with caution as it is not reasonable to make assumptions about trends based on such a limited dataset.

Percent differences in entrainment loss at the CVP and SWP export facilities between Baseline Conditions and the two Proposed Project scenarios were generally consistent when comparing genetically-identified natural-origin CHNWR and CHNSR with some notable differences. For example, loss of genetically-identified natural-origin CHNWR at the SWP export facilities was estimated to be 36% greater under the 9A_V2A scenario in April of above normal water years but 0% greater for genetically-identified natural-origin CHNSR (absolute loss not available for above normal water years). This is because there was zero historical loss of genetically-identified natural-origin CHNSR in April of wet years[5] within the 2017 to 2022 dataset (Table 29), whereas CHNWR loss did occur in wet years within the 2010 to 2022 dataset (Table 25). Loss of genetically-identified natural-origin CHNSR was estimated to be 41% (absolute change of 1 fish) and 3% (absolute change of less than 1 fish) greater under the 9A_V2A and ITP_Spring scenarios, respectively, in May of critical water years at the SWP export facilities. There was zero historical loss of genetically-identified natural-origin CHNWR in May between 2010 and 2022 regardless of water year type; however, there were percent change increases in modeled SWP loss of genetically-identified natural-origin CHNWR in May of wet and above normal water years for both Proposed Project scenarios, although these changes were based on an absolute change of less than one modeled fish. Smaller variances in percent differences between genetically-identified natural-origin CHNWR and CHNSR loss under the Proposed Project scenarios are seen in other months and water year types at both CVP and SWP export facilities due to differences in the timing of historical loss. The largest percent increases in modeled loss of genetically-identified natural-origin CHNWR and CHNSR appear in April and May under the 9A_V2A scenario at the SWP export facilities for multiple water year types. Percent increases in modeled loss of genetically-identified natural-origin CHNWR and CHNSR at the SWP export facilities under the ITP_Spring scenario were lower than under the 9A_V2A scenario in April and May, which may reflect Spring Delta Outflow Implementation measures (see Section 6.1.3; Condition of Approval 8.12). Under Condition of Approval 8.12.1, Spring Delta Outflow Via Export Curtailments, implementation in April and May for Baseline Conditions is consistent with the measure applied under the ITP_Spring scenario (see Appendix C – CalSim Modeling Results). The largest absolute changes in modeled loss of genetically-identified natural-origin CHNWR appear in March of below normal and wet water years under both the Proposed Project scenarios at the SWP export facilities. For the 9A_V2A scenario, the absolute change in loss ranges from a decrease in 11 modeled fish in March of below normal water years to an increase in 11 modeled fish in March of wet water years. A similar relationship exists for the ITP_Spring scenario with an absolute decrease in 11 modeled fish in March of below normal water years to an increase in 19 modeled fish in March of wet water years. The largest absolute changes in modeled loss of genetically-identified natural-origin CHNSR appear in May of wet water years under both the Proposed Project scenarios at the SWP export facilities. The absolute change in loss under the 9A_V2A and ITP_Spring scenarios increases by 24 fish and 4 fish, respectively in May of wet water years.

Estimated loss of CWT-confirmed hatchery-origin CHNWR and CHNSR showed similar trends to genetically-identified natural-origin CHNWR and CHNSR between the two Proposed Project scenarios and Baseline Conditions at the CVP and SWP export facilities. The greatest percent increases in CWT-confirmed hatchery-origin CHNWR and CHNSR loss are shown in April of below normal water years under the 9A_V2A scenario at the SWP export facilities (Tables 26 and 30). The only CWT-confirmed CHNWR salvage that occurred in April was at the SWP export facilities, so no loss of CWT-confirmed CHNWR was modeled to occur in April at the CVP export facilities (Table 28). The largest percent

[5] Note that there were no above normal water years from 2017-2022, so the monthly CHNSR loss pattern for wet water years was applied for above normal water years and only percent difference was reported.

decreases in CWT-confirmed hatchery-origin CHNWR are seen in February of critical water years at the SWP export facilities and February of below normal water years at the CVP export facilities. Delta outflow modeling shows an increase in flows during February of these two water year types, which could be contributing to decreases in CHNWR loss (see Section 5.1.2.1 – Delta Hydrodynamic Assessment and Junction Routing Analysis). Absolute changes in modeled loss of CWT-confirmed hatchery-origin CHNWR and CHNSR show very little change or zero change between Baseline Conditions and the two Proposed Project scenarios.

Percent decreases in loss of genetically-identified natural-origin CHNWR and CHNSR and CWT-confirmed hatchery-origin CHNWR shown in March under the 9A_V2A scenario in below normal and/or dry years likely reflect the 50 TAF Delta inflow block of water under Condition of Approval 8.12.2, which deploys in dry, below normal, and above normal water years (see Section 6.1.3; Condition of Approval 8.12). Condition of Approval 8.12.2 also includes SWP south Delta export curtailments in April and May of dry, below normal, and above normal water years that are intended to replicate existing conditions through HRL flow deployment in those water year types (9A_V2A scenario). In April of dry, below normal, and above normal water years, absolute change in genetically-identified natural-origin CHNWR modeled loss increases by up to one modeled fish with no decreases observed under the 9A_V2A scenario at the SWP export facilities compared to Baseline Conditions. In April of below normal and May of wet water years, absolute change of genetically-identified natural-origin CHNSR increases by 7 and 24 modeled fish, respectively, under the 9A_V2A scenario at the SWP export facilities compared to Baseline Conditions. Mean SWP south Delta exports were shown to increase and OMR flows were shown to become more negative in the 9A_V2A scenario compared to Baseline Conditions in April and May for all water year types (see Appendix C – CalSim Modeling Results. These reductions in Delta outflow under the 9A_V2A scenario are reflected in increases in percent modeled loss of genetically-identified natural-origin CHNWR and CHNSR during April and May and CWT-confirmed hatchery-origin CHNWR and CHNSR in April at the SWP export facilities. April is an important Delta migration month for both juvenile CHNWR and CHNSR, and CHNSR continue to migrate through the Delta in May. Genetically-identified natural-origin CHNWR have been observed in salvage between December and April and genetically-identified natural-origin CHNSR have been observed in salvage between January and July (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon). Although genetically-identified natural-origin CHNWR have not been observed in salvage in May during water years 2010 through 2022, it is possible they are still moving through the Delta during this time in small numbers, especially in wetter years when conditions in the Delta remain favorable for rearing. Increased SWP exports and more negative OMR flows during April and May, reflected under the 9A_V2A scenario, are likely to result in increases in entrainment and loss of genetically-identified natural-origin CHNWR in April and genetically-identified natural-origin CHNSR in April and May at the SWP export facilities. Hatchery-origin CHNSR may also be impacted as they are typically released from FRFH in April. Increased entrainment of CHNWR and CHNSR in the latter portion of their migration period could reduce life history diversity over time by selecting against later migrants including those that may be larger having reared longer in-river (Sturrock et al. 2019a).

Modeled loss for genetically-identified natural-origin CHNWR and CHNSR was typically lower in dry and critical water years, which may reflect overall watershed survival differences between water year types. During wetter water years, more juveniles enter the Delta and are exposed to south Delta export operations (Brandes and McLain 2001; Newman and Brandes 2010). Lower salvage in drier years does not necessarily indicate that OMR flow or export restrictions are providing better protections to either

CHNWR or CHNSR populations. Often OMR flows are more negative in drier years even under export restrictions (to preserve water quality per D-1641) because of reduced Delta inflow. Instead, lower salvage in dry years could be related to lower population abundance due to poor conditions in the rivers (NMFS 2019a), however further analyses would be required to investigate this.

Less variation was shown between Baseline Conditions and the two Proposed Project scenarios for modeled loss of hatchery-origin CHNWR and CHNSR when compared to genetically-identified natural-origin results, and fewer changes in loss were modeled for hatchery-origin CHNSR when compared to CHNWR. The lack of differences is likely attributable to the rarity of observing CWT-confirmed hatchery-origin CHNWR and CHNSR in salvage. Only 43 CWT-confirmed hatchery-origin CHNWR and five CWT-confirmed hatchery-origin CHNSR have been observed in combined salvage at the CVP and SWP export facilities from water years 2010 to 2022. This small sample size likely makes it difficult to model loss trends between water year types and export facilities. The low probability of observing CWT-tagged CHNWR and CHNSR in salvage could be a reflection of smolt outmigration behavior (rather than Delta rearing) and due to the smaller number of hatchery-origin CHNWR and CHNSR released into the system each year compared with the number of estimated natural-origin CHNWR and CHNSR. Hatchery-origin Chinook Salmon tend to outmigrate more quickly than natural-origin Chinook Salmon, which indicates they have less opportunity to get entrained into the south Delta and may help explain the low observations of hatchery-origin CHNWR and CHNSR in salvage. Additionally, based on historical CHNWR JPEs, there is a greater proportion of natural-origin CHNWR estimated to enter the Delta as compared to hatchery-origin CHNWR in almost every water year except three during the analysis period (2015, 2016, 2022; see Section 6.2.6.3. – Winter-Run Chinook Salmon Annual Loss Threshold; Tables 41 and 42). Typically, there are approximately half a million CHNWR smolts released in-river annually from LSNFH and CNFH and approximately 2 million CHNSR smolts released in-river annually from the FRFH. Although there is currently no natural-origin CHNSR JPE, catch at Sherwood Harbor trawl shows there are higher numbers of LAD natural-origin CHNSR juveniles compared to CWT-confirmed hatchery-origin CHNSR observed at Sherwood Harbor trawl in all water years between 2010 and 2022.

Salvage-Density Method analyses utilize small sample sizes of genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR and CHNSR observed in salvage to predict future outcomes of Proposed Project operations. It is understood that monitoring small populations, such as CHNWR and CHNSR, is difficult due to low detection probabilities, and may not be reliable for identifying population trends (Börk et al. 2020). Observations of juvenile CHNWR and CHNSR in salvage at the CVP and SWP export facilities can provide information on presence and absence; however, it is not necessarily indicative of population size nor does absence in salvage necessarily mean there is a complete absence of CHNWR or CHNSR in the vicinity of the export facilities. Conclusions regarding changes in modeled loss of CHNWR and CHNSR that may occur under the Proposed Project scenarios compared to Baseline Conditions should be approached with caution as it is not reasonable to make assumptions about trends based on such a limited dataset (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon). It is possible that impacts of the Proposed Project on CHNWR and CHNSR are more pronounced than what are modeled with the Salvage-Density Method due to potential relationship between CHNWR and CHNSR detection in salvage and population size, however further analyses are needed to investigate a potential relationship.

5.2.2. Entrainment of Adult Chinook Salmon

5.2.2.1. Delta Inflow Effects on Adult Chinook Salmon Straying

The hydrology of the Sacramento River, San Joaquin River, and Delta has been highly modified. Dam releases on the major Central Valley rivers are now generally much lower than unimpaired conditions in the winter and spring and higher in the summer and fall. Upstream diversions and water exports in the Delta have reduced January to June outflows by an estimated 56% on average and annual outflow by an estimated 52% on average (SWRCB 2017). Modification of the natural hydrograph, including changes in timing and magnitude of flow, combined with water diversions negatively impacts rearing habitat, connectivity, and ecosystem processes to which salmon have adapted (Lloyd et al. 2004; Lytle and Poff 2004; Flitcroft et al. 2019).

Adult CHNWR presence in the Delta can extend from November through August, whereas adult CHNSR presence in the Delta can extend from January through September (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta) CalSim 3 modeling provided in DWR's ITP Application (DWR 2023f) and through subsequent coordination with DWR suggests that there would be little difference between Baseline Conditions and the two Proposed Project scenarios regarding flow entering the Delta in the Sacramento River at Freeport during the period of upstream migration of adult CHNWR and CHNSR (see Appendix C – CalSim Modeling Results). However, increased SWP exports and more negative OMR flows in April and May associated with the 9A_V2A scenario (and to a lesser extent the ITP_Spring scenario; see Appendix C – CalSim Modeling Results) may lead to greater risk of straying and entrainment for adult CHNWR and CHNSR during their upstream migration. With summer temperatures quickly approaching, entrainment into the south Delta during April and May could lead to prolonged migration time through the Delta and exposure to suboptimal water temperatures during the summer months. Water temperatures greater than 15.5°C (60°F) result in a detrimental effect on adult survival and egg viability (Windell et al. 2017). As discussed further in Sections 5.2.2.2 and 5.2.2.3, historical data indicates that adult Chinook Salmon stray and become entrained in both the Tracy Fish Collection Facility and Skinner Fish Protective Facility, with expanded salvage of 469.5 adult Chinook Salmon observed across water years 1993 and 2022. Deployment of the 50 TAF inflow block of water in March as well as SWP export curtailments in April and May of dry, below normal, and above normal water year types under the Proposed Project 9A_V2A scenario is intended to provide flow benefits across all three months and may minimize risk of straying and entrainment for adult CHNWR and CHNSR; however, these flow benefits are not demonstrated in CalSim 3 modeling results, which show minor flow improvements in the Sacramento River during March as well as increased exports and more negative OMR flows during April and May (see Appendix C – CalSim Modeling Results).

Olfaction is critical to salmonids' ability to return to natal spawning grounds. Adult CHNWR and CHNSR migrating through the Delta and in upstream tributaries require enough flow for olfactory cues to successfully reach natal spawning grounds (CDFG 1998). Flow has been acknowledged as the most important factor affecting overall survival of Chinook Salmon in the Central Valley (Kjelson and Brandes 1989; Zeug et al. 2014; Michel et al. 2015; Iglesias et al. 2017; Notch et al. 2020; Hassrick et al. 2022). Flood bypasses and drainage canals are known stranding areas for adult and juvenile CHNWR and CHNSR as documented by CDFW fish rescue efforts (see Section 4.3.2 – Adult Stranding; Beccio 2016; Gahan et al. 2016; CDFW 2017). Attraction of adult CHNWR and CHNSR into terminal waterways and migration barriers as a result of hydrodynamic changes from south Delta exports may lead to delays or stranding, ultimately affecting spawning success. Given CalSim's inability to predict future conditions, impacts of DWR's Project on future adult CHNWR and CHNSR migration through the Delta are unknown however it is possible to use CalSim to compare scenarios including the Baseline, 9A_V2A and ITP_Spring.

5.2.2.2. Historical Entrainment of Adult Chinook Salmon into Clifton Court Forebay

5.2.2.1.1. Introduction

The loss equation used to estimate entrainment of Chinook Salmon into CCF and the Skinner Fish Protective Facility does not consider adult entrainment into either facility although adult Chinook Salmon have historically been observed in salvage at the Skinner Fish Protective Facility (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). The Delta Model LAD criteria (USFWS 1997) do not include run identification for Chinook Salmon greater than 300 mm as measured by fork length; therefore, the Tracy Fish Collection Facility and Skinner Fish Protective Facility classify this size class as "unknown adults" with no run designation recorded or genetic sample collected. For additional information on adult fork length designation and data limitations, see CDFW (2024b). Currently there are no targeted studies that evaluate adult Chinook Salmon presence in CCF so there is no way to quantify adult take within CCF. However, historical entrainment of adult Chinook Salmon into CCF has been documented during DWR predator removal studies and observations at the entrance to the Skinner Fish Protective Facility (NMFS 2019a; Reclamation 2020; CDFW 2020a).

CDFW conducted the following analysis to evaluate historical take of adult Chinook Salmon through entrainment into CCF.

5.2.2.1.2. Methods

For this analysis, bycatch data were summarized from the CCF Predation Studies (CFPS; Wunderlich 2015, 2017), the CCF Predator Reduction Electrofishing Studies (PRES; Wilder et al. 2018), the CCF Predator Fish Relocation Study (PFRS; CDFW 2020a), and the Enhanced Predatory Fish Removal and Relocation Study (EPFRRS; DWR 2024b). DWR conducted CFPS from 2013 through 2016 to evaluate juvenile salmonid survival and monitor for piscivorous fish and birds around CCF. In 2016, DWR began PRES at the request of NMFS to implement interim measures to remove predators from CCF to reduce pre-screen loss of juvenile Chinook Salmon. Under PRES, DWR electrofished and relocated predators from CCF to Bethany Reservoir (the afterbay for the Banks Pumping Plant and conveyance facility for the California Aqueduct) from 2016 through 2018. Beginning in 2019, DWR started PFRS to relocate predators from CCF using commercial fishing techniques to capture predators. After two years of implementing PFRS, DWR transitioned to EPFRRS in 2021, whereby DWR combined the most successful elements of PRES and PFRS with the intent to maximize the removal of predators in CCF to reduce pre-screen loss of juvenile ESA and CESA-listed species. DWR concluded EPFRRS in 2023.

5.2.2.1.3. Results

During the 2013 CFPS, DWR conducted creel surveys in CCF between April 26, 2013 and December 31, 2013. For 1,101 anglers interviewed, one adult Chinook Salmon was reported caught in October (Wunderlich 2015). October does not directly overlap with adult CHNWR or CHNSR presence in the Delta; therefore, it is assumed this adult was a CHNFR. During the 2015 CFPS, DWR conducted creel surveys in CCF between January 5, 2015 and December 29, 2015. For 1,247 anglers interviewed, one adult Chinook Salmon was reported caught in November (Wunderlich 2017), consistent with CHNWR presence in the Delta (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta).

Adult Chinook Salmon are susceptible to electrofishing and could be stunned as part of PRES conducted in CCF between 2016 and 2018. During the 2018 study season, Wilder et al. (2018) reported 55 Chinook Salmon observed moving into the vicinity of the electrofishing boat in response to the electric field (Table 33). Wilder et al. (2018) does not indicate individual size class, but states that individuals ranged from 3 inches to adult size and were observed from January through May. NMFS (2019a) reports a total loss of 152 Chinook Salmon during the three years of implementing PRES, but the size class of these fish and spatial time scale in which they were observed is unclear. Studies conducted between January and May overlap with presence of adult CHNWR (November through August) and CHNSR (January through September) in the Delta (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta).

Table 33. Chinook Salmon encountered by month in CCF during the 2018 PRES (Wilder et al. 2018).

Month	Number of Chinook Salmon
January	6
February	13
March	7
April	22
May	7
Total	55

Commercial fishing practices employed under PFRS are not able to selectively fish for nonnative predators in CCF; therefore, Chinook Salmon are likely to be entrapped or caught as bycatch. During the 2019 PFRS, 12 adult Chinook Salmon were caught in CCF, including two which were assumed to be CHNSR and CHNWR, respectively, based on presence and time of year (and not genetically confirmed; Table 34; CDFW 2020a; Reclamation 2020). Zero Chinook Salmon were caught in CCF during the 2020 PFRS (Reclamation 2020).

Table 34. Adult Chinook Salmon bycatch data from May 2019 through December 2019 during the 2019 PFRS (CDFW 2020a; Reclamation 2020). Table cells highlighted in green or blue indicate hatchery origin CHNSR and CHNWR, respectively.

Date	Gear Method	Run	Origin	Fork Length (mm)	Life Stage
5/9/2019	Kodiak Trawl	CHNSR	Hatchery	NA	Adult
10/10/2019	Fyke Trap	CHNFR	Natural	614	Adult
11/5/2019	Beach Seine	CHNFR	Hatchery	660	Adult
11/5/2019	Beach Seine	CHNFR	Natural	755	Adult
11/8/2019	Beach Seine	CHNFR	Natural	NA	Adult
11/12/2019	Beach Seine	CHNFR	Natural	752	Adult
11/12/2019	Beach Seine	CHNFR	Natural	670	Adult
11/14/2019	Beach Seine	CHNFR	Natural	807	Adult
11/14/2019	Beach Seine	CHNFR	Natural	790	Adult
11/15/2019	Beach Seine	CHNFR	Hatchery	762	Adult
11/21/2019	Beach Seine	CHNFR	Natural	805	Adult
12/20/2019	Fyke Trap	CHNWR	Hatchery	598	Adult

During the 2021 through 2022 EPFRRS, 22 Chinook Salmon were encountered in CCF (Table 35; DWR 2024b). DWR (2024b) does not indicate individual size class, but states gear method and date of encounter. These fish were observed from March 2021 through May 2022, coinciding with adult CHNWR (November through August) and CHNSR (January through September) presence in the Delta (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta).

Table 35. Adult Chinook Salmon encountered in CCF during the 2021 and 2022 EPFRRS (DWR 2024b).

Date	Gear Method	Number of Chinook Salmon
3/9/2021	Beach Seine	1
3/11/2021	Beach Seine	1
3/15/2021	Electrofishing	1
3/16/2021	Electrofishing	1
3/22/2021	Electrofishing	1
3/24/2021	Electrofishing	1
3/29/2021	Electrofishing	1
4/28/2021	Electrofishing	2
1/3/2022	Electrofishing	1
1/4/2022	Electrofishing	3
1/6/2022	Electrofishing	2
1/18/2022	Electrofishing	2
2/22/2022	Beach Seine	1
3/8/2022	Electrofishing	1
3/22/2022	Electrofishing	1
5/10/2022	Electrofishing	1

In addition to predation studies in CCF, the 2017 Delta Operations for Salmonids and Sturgeon technical advisory team (DOSS; replaced in 2020 with the Salmon Monitoring Team, SaMT) annual report documented observations of adult Chinook Salmon (greater than 300 mm as measured by fork length) at the entrance to the Skinner Fish Protective Facility (DOSS 2017). These fish were observed from November 2016 through May 2017, coinciding with adult CHNWR (November through August) and CHNSR (January through September) presence in the Delta (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta). DOSS (2017) attributed the increase in adult Chinook Salmon entering the Skinner Fish Protective Facility to two factors. Facility workers observe year-round occupancy of sea lions near the entrance to the Skinner Fish Protective Facility. In 2017, facility workers noted the sea lions appeared to be working as a team with elephant seals to chase adult salmon into the direction of the trash rack for feeding. During the annual dive inspection in March 2017, divers noted several locations where the openings between the vertical members of the trash rack were wider than two inches[6]. It is not clear if this damage was caused by marine mammal coordinated hunting, but it is assumed that this contributed to the damage. These locations are expected to result in increased adult entrainment because they create larger spaces for adults to bypass the trash rack.

5.2.2.1.4. Discussion

Targeted studies to evaluate entrainment of adult Chinook Salmon into CCF have not been conducted in the past. During predator reduction studies, adult Chinook Salmon presence has been documented but it should be noted that these studies are not targeted for adult Chinook Salmon and may not overlap

[6] Repairs were made to the trash rack in March 2017, with reduced adult Chinook Salmon salvage in water year 2018 (total count of 2 fish, expanded salvage of 5 fish).

with their timing in the Delta. Therefore, fish collected are not necessarily representative of the abundance that may be present during adult Chinook Salmon upstream migration through the Delta.

The 2009 NMFS BO indicated that there are direct impacts on adult Chinook Salmon from entrainment into CCF, but assumed adults move freely into and out of CCF when hydraulic conditions at the radial gates permit (NMFS 2009). Maximum hourly water velocities through the radial gates can exceed 20 ft/s (Clark et al. 2009), which is double the burst speed of adult salmonids (CDFG 2010). As the radial gates are opened, water flow and water velocities are typically quite strong depending on the difference in water surface elevation between Old River and CCF. This makes egress from CCF difficult until the flow and velocities diminish as the water surface elevations begin to equalize. Any adult Chinook Salmon attempting to exit the CCF would need to swim through the radial gates when inflow velocities were sufficiently low to permit their upstream movement, and before the radial gates are closed at the end of the tidal cycle. It is possible for Chinook Salmon to remain resident within CCF for extended periods of time before conditions are suitable for their exit. This residence time results in delays in upstream spawning and can lead to stranding if fish are unable to exit through the radial gates. False attraction into CCF reduces the number of potential adult salmon spawners, and thereby spawning success, due to delayed migration or pre-spawn mortality.

The presence of adult Chinook Salmon at the entrance of the Skinner Fish Protective Facility in 2017 is characteristic of natural social interactions among salmon. Berdahl et al. (2017) demonstrated that salmon use social interactions to synchronize entry into spawning grounds. Johnson et al. (2016) also showed that adult salmon caught in the ocean are more often from the same genetic group, suggesting that adults rely on collective navigation when migrating to spawning grounds. Attraction flows through the radial gates increase the likelihood of large groups of Chinook Salmon migrating together into CCF exposing them to poor water quality conditions and pre-spawn mortality.

The 2024 SWP ITP includes measures that limit CVP and SWP export operations to provide entrainment protections for ESA and CESA-listed species that overlap partially with the timing of adult CHNWR and CHNSR migration in the Delta.

5.2.2.3. Historical Salvage of Adult Chinook Salmon

5.2.2.2.1. Introduction

The loss equation used to estimate entrainment of Chinook Salmon into the Tracy Fish Collection Facility and Skinner Fish Protective Facility does not consider adult entrainment into either facility although adult Chinook Salmon have historically been observed in salvage at the Tracy Fish Collection Facility and Skinner Fish Protective Facility. As indicated in Section 5.2.2.2, the Delta Model LAD criteria (USFWS 1997) do not include run identification for Chinook Salmon greater than 300 mm as measured by fork length. As a result, the Tracy Fish Collection Facility and Skinner Fish Protective Facility classify Chinook Salmon salvaged in this size class as “unknown adults” with no run designation recorded or genetic sample collected.

CDFW conducted the following analysis to evaluate historical take of adult Chinook Salmon at the Tracy Fish Collection Facility and Skinner Fish Protective Facility.

5.2.2.2.2. Methods

For this analysis, count data of Chinook Salmon with fork lengths greater than 300 mm collected at the Tracy Fish Collection Facility and Skinner Fish Protective Facility from water years 1993 through 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2023e). Natural-origin and hatchery-origin Chinook Salmon were classified based on the presence or absence of an adipose fin ("unclipped" versus "clipped") as documented in the salvage database. Clipped Chinook Salmon were characterized as hatchery-origin and unclipped Chinook Salmon were characterized as natural-origin. Although the presence or absence of a CWT would be a more precise way to verify a hatchery-origin designation, data limitations precluded the use of CWTs to determine Chinook Salmon origin or run. Expanded salvage data were calculated to estimate total salvage during CVP and SWP export operations by using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018); however, loss was not calculated as the loss equation was not designed or intended for estimating loss of adult Chinook Salmon. Fish identified by a special study code in the salvage database have an expanded salvage value of 0 and fish with a predator removal code have an expanded salvage value of 1 (CDFW 2018). Fish identified by a special study code were included in the count data. Salvage in water year 2019 is potentially inaccurate due to Chinook Salmon enumeration issues at CVP export facilities. For additional information on salvage data sources and limitations, see CDFW (2024b).

5.2.2.2.3. Results

Between water years 1993 and 2022[7], 80 adult Chinook Salmon were observed at the salvage facilities, with a greater proportion observed at the Skinner Fish Protective Facility (62.5%) than the Tracy Fish Collection Facility (37.5%; Figure 38). Expanded salvage of adult Chinook Salmon across water years 1993 and 2022 totaled 469.5 fish (Figure 39). The entrainment period for adult Chinook Salmon extended from September through May, which overlaps with adult CHNWR and CHNSR presence in the Delta (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta).

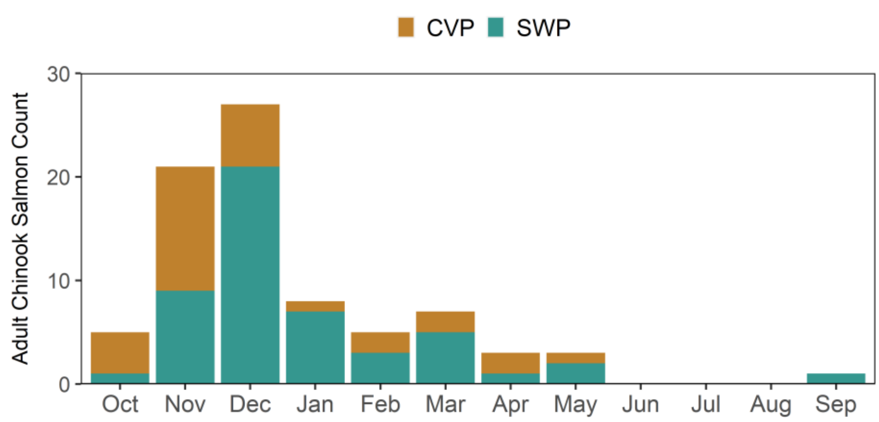

Figure 38. Total count of adult Chinook Salmon, by month, observed at the Tracy Fish Collection Facility (CVP) and Skinner Fish Protective Facility (SWP) for water years 1993-2022.

[7] Although water year 2023 is not included in this analysis, it is important to note that one adult Chinook Salmon was observed in salvage at the Tracy Fish Collection Facility on June 4, 2023 (expanded salvage of 4 fish).

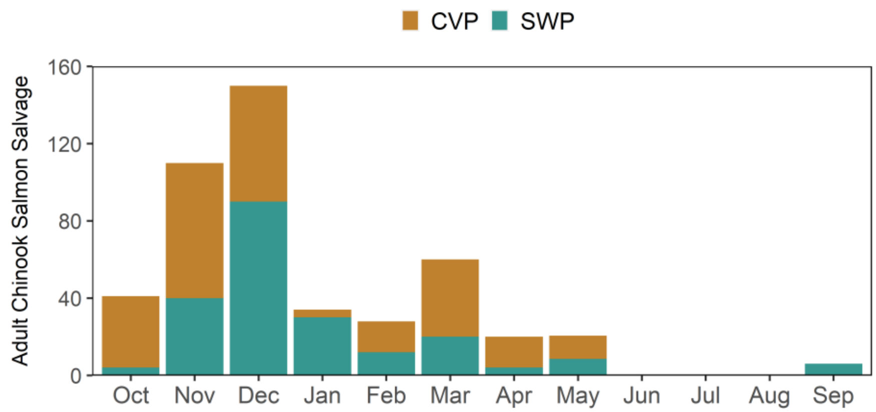

Figure 39. Total expanded salvage of adult Chinook Salmon, by month, at the Tracy Fish Collection Facility (CVP) and Skinner Fish Protective Facility (SWP) for water years 1993-2022.

Of the 80 total adult Chinook Salmon observed (expanded salvage of 469.5) at the salvage facilities, 29 fish were observed at the Skinner Fish Protective Facility (expanded salvage of 90 fish) between November 2016 and January 2017. The greatest annual adult expanded salvage occurred in water year 2017 with a count of 32 fish (expanded salvage of 102.5 fish). The greatest monthly adult expanded salvage occurred in December 2016 with a count of 18 fish (expanded salvage of 54 fish). Further analysis indicates that 83% of the observed adult Chinook Salmon expanded salvage had adipose fins intact (potential natural-origin fish; Figure 40). Eighty-five percent of adult Chinook Salmon expanded salvage at the Tracy Fish Collection Facility had adipose fins intact (potential natural-origin fish; Figure 41). Eighty-one percent of the observed adult Chinook Salmon expanded salvage at the Skinner Fish Protective Facility had adipose fins intact (potential natural-origin fish; Figure 42). It is possible that some unclipped adult Chinook Salmon salvaged during fall months were hatchery-origin CHNFR, which are adipose fin clipped at a 25% rate.

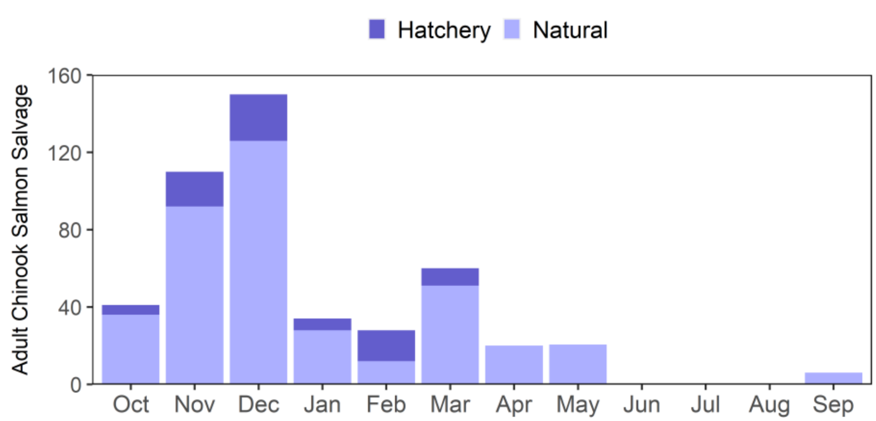

Figure 40. Total expanded salvage of adult Chinook Salmon, separated by natural-origin or hatchery-origin, observed at the Tracy Fish Collection Facility (CVP) and Skinner Fish Protective Facility (SWP) for water years 1993-2022.

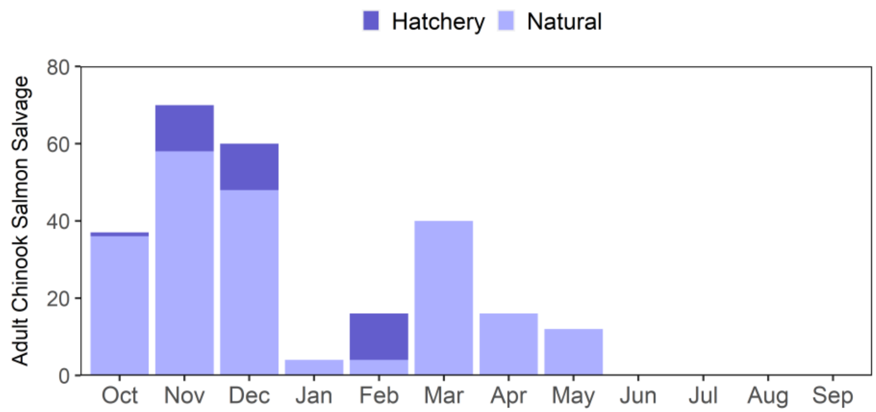

Figure 41. Total expanded salvage of adult Chinook Salmon, separated by natural-origin or hatchery-origin, observed at the Tracy Fish Facility for water years 1993-2022.

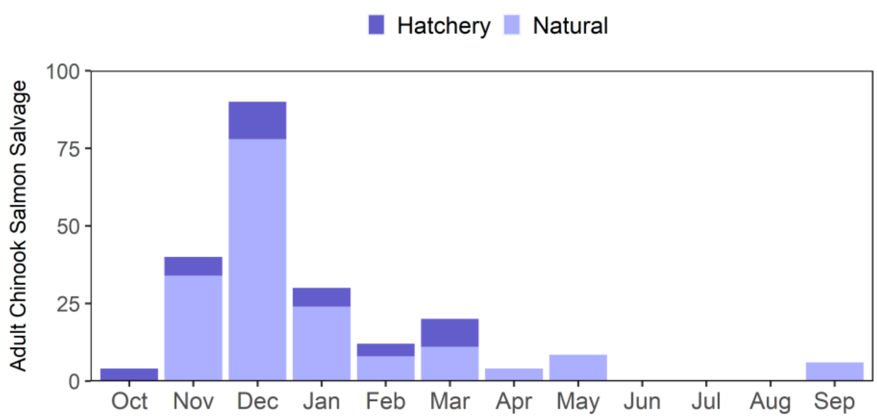

Figure 42. Total expanded salvage of adult Chinook Salmon, separated by natural-origin or hatchery-origin, observed at the Skinner Fish Protective Facility for water years 1993-2022.

5.2.2.2.4. Discussion

Although the trash racks at the Skinner Fish Protective Facility and Tracy Fish Facility were designed to exclude adult Chinook Salmon, adults have been detected in the salvage process at both facilities. Genetic samples are not taken to confirm the presence of adult CHNWR or CHNSR in salvage; however, timing of historical salvage suggests that both CHNWR and CHNSR are likely to be entrained into the CVP and SWP export facilities. The majority of adult Chinook Salmon salvaged historically were assumed natural-origin by the presence of an adipose fin, which is of particular concern given that natural-origin salmon have olfactory imprinting that enables migration to natal spawning grounds that hatchery-origin fish are less likely to acquire due to hatchery practices (e.g., water treatment, trucking production releases; Sturrock et al. 2019b). Presence of unclipped adults in salvage indicates that immigrating adults may experience increased straying in the Delta, likely due to Project related alterations in hydrology, as seen in other systems including the Knights Landing Ridge Cut during the North Delta Flow Action Study (DWR 2019). As indicated earlier, some unclipped adults salvaged during the fall may be hatchery-origin CHNFR, which are only adipose fin clipped at a 25% rate.

The loss equation does not account for historical adult Chinook Salmon loss at either facility and is not applied to adults observed in salvage (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Each component of the loss equation was developed based on performance evaluation studies for juvenile salmonids that behave and respond differently than adult salmonids. For example, pre-screen loss may not be measurable for adults because they may not experience mortality from predators like juveniles but may experience pre-spawn mortality due to stranding stress. Expanded salvage may also underestimate the abundance of adult Chinook Salmon present. Attraction flows from both the CVP and SWP export facilities increase the likelihood of fish straying into the facilities at times when adults are relying on collective navigation from other salmon to find spawning grounds (Johnson et al. 2016). The loss of spawning adults due to straying could decrease the genetic diversity of these populations as well as decrease juvenile production.

In its current form, the loss equation states that fish greater than 100 mm as measured by fork length experience zero loss during handling and transport (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). This does not address impacts from handling and transport during the salvage process, which is known to increase stress related impairment and mortality in adult salmonids (Raquel 1989; Cook et al. 2015; Teffer et al. 2017; Cook et al. 2018a; Cook et al. 2018b). Adult Chinook Salmon that survive handling and transport and continue on to the spawning reaches of their natal streams can have decreased spawning fitness and fecundity due to the energy expenditure and stress related with capture, handing, and release (Wilson et al. 2014).

Cook et al. (2018b) documented both short- and long-term impacts to Coho Salmon in the form of external and physiological injuries caused by netting and handling. In this study, Cook et al. (2018b) demonstrated that dermal injuries and changes in blood chemistry predicted delayed mortality, while reflex impairments, as a result of prolonged anoxia, resulted in an inability to escape predation and decreased survival shortly after release. Teffer et al. (2017) found similar results for Sockeye Salmon on the Fraser River, which experienced high rates of mortality between 5 and 12 days following net entanglement and handling. Additionally, in this study, pre-spawn mortality of handled salmon was linked to higher occurrences of the pathogens *F. psychrophilum* and *C. shasta* in examined carcasses, suggesting that the prevalence of these diseases is likely due to the suppressed immune system response fish experience during the stress of capture and handling.

The 2024 SWP ITP includes measures that limit CVP and SWP export operations to provide entrainment protections for ESA and CESA listed species that partially overlap with the timing of adult CHNWR and CHNSR migration in the Delta.

5.3. Effects of Maintenance at Clifton Court Forebay on Chinook Salmon

DWR will perform aquatic weed and algal bloom maintenance in CCF on an as-needed basis year-round, according to the 2024 SWP ITP and DWR's Clifton Court Forebay Aquatic Weed Management Standard Operating Procedures (DWR 2023j) for the duration of the 2024 SWP ITP. Both chemical and mechanical aquatic weed and algal bloom maintenance are needed to avoid damage to the Skinner Fish Protective Facility and Banks Pumping Plant and have the potential to be harmful to any Chinook Salmon in the vicinity. Herbicides and algaecides used for aquatic weed and algal bloom removal will include Aquathol

K, copper-based compounds, and peroxide-based algaecides. Use of peroxide-based algaecides for algal blooms may occur as-needed. Use of Aquathol K and copper-based compounds for aquatic weeds and algal blooms are expected to occur once in the summer (late June to early July) and once in the fall (mid to late October), which would mostly avoid overlap with CHNWR and CHNSR historical presence in salvage (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon and Section 5.2.2 – Entrainment of Adult Chinook Salmon). However, some CHNWR and CHNSR may be entrained into CCF during their migration period and maintain long-term residence in CCF, which could expose them to summer or fall treatments. Additionally, herbicide treatments could occur outside of summer and fall months if aquatic vegetation removal is necessary during other times of year, average daily water temperatures within CCF are greater than or equal to 25˚C, and approved by CDFW, NMFS, and USFWS. Aquathol K and peroxide-based algaecides will likely have a low impact on CHNWR and CHNSR exposed to the products as the concentration of Aquathol K will be used at a concentration well below that which would impact salmonids and peroxide-based algaecides only produce hydrogen-peroxide and oxygen as instantaneous byproducts, which should not negatively affect salmonids. Copper-based compounds are toxic to fish including juvenile salmonids. Juvenile Chinook Salmon are sensitive to dissolved copper and can experience detrimental sub-lethal effects at concentrations less than 1 ppm (Johannessen and Ross 2002). Notably, copper-based compounds may impair the ability of juvenile salmon to perceive olfactory stimuli, which could negatively impact homing, food detection, and predator detection (NMFS 2009). DWR plans to use copper-based compounds in CCF at concentrations of 1 ppm. Although CCF radial gates are slated to close prior to treatment, the large scour hole below the gates could allow some herbicide or algaecide to leak into Old River, and juvenile salmonids in the immediate vicinity could be exposed to chemical treatments.

Mechanical removal of aquatic weeds by boat-mounted harvesters could occur any time of year, though are likely to be most frequent during the late summer and fall consistent with chemical treatments. Operation of the aquatic weed harvesters may injure CHNWR or CHNSR that encounter the cutting blades and cause mortality. Additionally, aquatic weed mats that are harvested may contain juvenile CHNWR or CHNSR that would perish with removal from the water. It is possible that mortality resulting from contact with cutting blades would be compensated by reducing the presence of piscivorous fish species associated with aquatic weed mats and potentially increasing salvage efficiency at the Skinner Fish Protective Facility (NMFS 2009).

Minimization of effects of maintenance at CCF on CHNWR and CHNSR are discussed in Section 6.3 – Minimization of Effects of Maintenance at Clifton Court Forebay of this Effects Analysis and include the implementation of Conditions of Approval required by the 2024 SWP ITP.

5.4. Effects of Operations and Maintenance at Barker Slough Pumping Plant on Chinook Salmon

DWR will operate and maintain the BSPP, consisting of ten bays and nine pumps individually screened with a positive fish screen, according to the 2024 SWP ITP and DWR’s North Bay Aqueduct Fish Screen Sediment and Aquatic Weed Removal Standard Operating Procedures (DWR 2023i) for the duration of the 2024 SWP ITP. The first two bays have smaller pumps (operating at 14 cfs) designed for a screen approach velocity of 0.2 ft/s. The next seven bays have larger pumps (operating at 28 cfs) designed for a screen approach velocity of 0.4 ft/s. The last bay is not equipped with a pump or fish screen. Each pump is fitted with a fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inches. These fish screens were designed using NMFS fish screen criteria for salmonids to prevent entrainment and minimize impingement of juvenile salmonids larger than 25 mm into the BSPP (NMFS 2023b). Operation of the nine pumps is demand driven, but limited by pipeline capacity and biofilm accumulation within the pipeline. The maximum pipeline capacity at BSPP is 175 cfs, though DWR's normal pumping rate at BSPP is between 0 cfs and 130 cfs, with demand greater in the summer and fall months.

DWR performs BSPP maintenance operations, including fish screen cleaning, sediment removal, and aquatic weed removal (DWR 2023i). During fish screen cleaning, half of the pumps corresponding to the fish screens are shut down and the fish screens are removed from the water for power washing. While the fish screens are removed, fish can move freely into and out of the intake bays. This process occurs monthly, as needed. During sediment removal, sediment accumulated on the trap and concrete apron at the base of the fish screens and in the pump wells is removed and disposed of offsite. Accumulated sediment is removed from the trap and concrete apron by suction dredge as needed, year-round. Removal of sediment from within the pump wells can occur as needed, year-round. During aquatic weed removal, pumps corresponding to the fish screens are shut down and aquatic weeds impinged on the fish screens are removed using a weed rake. This process occurs year-round; however, removal is primarily needed during summer and fall months when weed production is highest. Within the BSPP forebay, a boat-mounted aquatic weed harvester is used on an as-needed basis to remove aquatic weeds.

The BSPP is removed from the direct migration corridor utilized by emigrating Chinook Salmon in the north Delta. Based on available monitoring data, the presence of juvenile CHNWR and CHNSR near BSPP appears unlikely. Monitoring by CDFW for the North Bay Aqueduct larval fish survey indicates that some Chinook Salmon have been observed at the most western monitoring location site (721) in Barker Slough, but in general, observations of Chinook Salmon are rare, and occur farther to the east near the confluence of Miners Slough with the Cache Slough Complex (DWR 2023i). During weed monitoring from September 2020 through March 2023, DWR found no salmonids entangled in the weeds, even when weed accumulation was at its highest (> 4 cubic yards) from April to May and October to November (DWR 2023i). If juvenile CHNWR and CHNSR are entrained into Barkers Slough, impacts from water diversions would be minimized through fish screen design and operating criteria. This is supported by a 2013 through 2015 BSPP fish screen performance study that DWR conducted between January and June, consistent with juvenile CHNWR and CHNSR presence in the north Delta (DWR 2023i). Eight thousand larval fish were collected behind the fish screens with the majority of fish being Threadfin Shad and Prickly Sculpin. One larval DS and no salmonids were identified. This study confirmed that the fish screens were operating as designed, with no fish observed impinged on the screens and no fish larger than 25 mm entrained. Therefore, the likelihood of juvenile CHNWR and CHNSR encounters with the fish screens during water diversion and maintenance is low and the overall effect of the intake on juvenile CHNWR and CHNSR is expected to be minimal.

In addition to direct effects of BSPP operations, BSPP operations also have the potential indirect effect of entraining prey items from the Yolo Bypass system and reducing food availability through exports. Floodplains and other off-channel habitats can provide increased prey availability and potentially reduce juvenile CHNWR and CHNSR encounters with predators, which can improve rearing conditions and increase juvenile CHNWR and CHNSR growth and survival rates (Sommer et al. 2001; Limm and

Marchetti 2003; Moyle et al. 2007; Jeffres et al. 2008). Rearing CHNWR and CHNSR in the Yolo Bypass rely on these food sources for healthy development and maturation and may be negatively impacted if operations of BSPP reduce the availability of these food resources.

Minimization of effects of operations and maintenance at Barker Slough Pumping Plant on CHNWR and CHNSR are discussed in Section 6.4 – Minimization of Effects of Operations and Maintenance at Barker Slough Pumping Plant of this Effects Analysis and include the implementation of Conditions of Approval required by the 2024 SWP ITP.

5.5. Effects of the South Delta Temporary Barriers Project on Chinook Salmon

DWR will operate the South Delta Temporary Barriers Project, consisting of three temporary rock barriers, according to the 2024 SWP ITP and DWR's Annual Construction and Operations Flow Chart for Calendar Years 2023-2027 (DWR 2023k) for the duration of the 2024 SWP ITP, or until such time as permanent operable gates are constructed. Construction and removal of the South Delta Temporary Barriers Project is authorized separately beginning May 9, 2022 through December 31, 2026 under the existing ITP Number 2081-2021-079-03 (CDFW 2022a). DWR installs and removes annually the three barriers located in Old River near Tracy 0.5 mile upstream of the Tracy Fish Collection Facility, in Middle River 0.5 mile upstream of the junction with Victoria Canal, and in Grant Line Canal approximately 400 ft upstream of the Tracy Boulevard Bridge. The purpose of the barriers is to reduce adverse water levels and circulation impacts caused by the CVP and SWP operations in the south Delta on local agricultural diverters within the South Delta Water Agency (CDFW 2022a). The Old River at Tracy Barrier is designed to maintain a stage of 2.3 ft North American Vertical Datum of 1988 (NAVD88) as measured by the Old River at Tracy Road (OLD) gage. The Middle River Barrier is designed to maintain a stage of 2.6 ft NAVD88 as measured by the Middle River at Howard Road (MHR) gage. The Grand Line Canal Barrier is designed to maintain a stage of 2.3 ft NAVD88 as measured by the Doughty Cut (DGL) gage. Water level increases are accomplished by trapping water that passes through the barriers, equipped with flap gates, on incoming tides.

Beginning on or after May 1, DWR may initiate construction of the barriers if DWR can demonstrate that stage maintenance is needed and San Joaquin River flows are less than 5,000 cfs. During barrier construction, all barrier flap gates and the Grant Line Canal Barrier flashboard structure must remain open to allow for fish passage. Following construction and approval from CDFW, NMFS, and USFWS, intermediate culvert operations can begin after May 15 where all but one flap gate is untied at each barrier. The untied flap gates are set to operate tidally. Intermediate culvert operations also include closing the flashboard structure at the Grant Line Canal Barrier. On June 1 or when the average daily water temperature measured at the Mossdale (MSD) station has reached 71.6°F (22°C) for three consecutive days full operation can begin where all flap gates are tidally operated. By September 15, DWR must remove a section of the Old River at Tracy and the Middle River barriers (i.e., notch the weir) and remove the flashboard structure at the Grant Line Canal Barrier to provide passage for up-migrating adult salmonids. By November 30, DWR must remove all three barriers (i.e., weir) and tie open the flap gates for the Old River at Tracy Barrier and the Grant Line Canal Barrier as well as the flashboard structure.

Juvenile CHNWR and CHNSR have historically been observed in salvage at the CVP and SWP export facilities during spring operations of the south Delta temporary barriers. Across water years 1993 through 2022, LAD natural-origin CHNWR loss occurred from December through June, with loss observed in June only in water year 2003 (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon at the CVP and SWP Export Facilities). The number of juvenile CHNWR potentially impacted by the barriers during any given year is unknown as the number of juvenile CHNWR present in the interior Delta varies annually and is largely unmonitored outside of salvage. This is evident by looking at historical loss of LAD natural-origin CHNWR from water years 1993 through 2022, which shows juvenile CHNWR loss ranging from 0 to 1521 fish in April, 0 to 58 fish in May, and 0 to 8 fish in June. Across the same water years, LAD natural-origin CHNSR loss occurred from January through June, with loss observed once in October of water year 1998 and once in September of water year 2000. Genetically-identified natural-origin CHNSR loss was also observed once in July of water year 2017. Historical peak loss of LAD natural-origin CHNSR occurs from March through May, overlapping both construction and intermediate culvert operations, with low levels of loss occurring during full culvert operations. Given yearling and YOY CHNSR life history diversity and historical observed loss, CHNSR are present in the Delta for longer periods of time and at higher numbers than CHNWR. Therefore, CHNSR exposure to the barriers is likely greater than CHNWR.

During construction (May 1-15), the risk of juvenile CHNWR and CHNSR impacts is substantially reduced because the barrier flap gates will be tied open, which will allow juveniles to move freely upstream and downstream of the barriers. During intermediate culvert operations (May 16-31), fish passage is limited due to all but one barrier flap gate in tidal operations. Full culvert operations only begin when average daily water temperature is unsuitable for fish (CDFW 2022a). While flap gates are in tidal operations, fish passage through the barriers can be delayed leading to increased entrainment in Old River, Middle River, and/or the Grant Line Canal resulting in reduced survival and/or routing into the south Delta export facilities, and increased delays in emigration increasing vulnerability to predation and high water temperatures throughout the spring. The temporary barriers may also increase juvenile CHNWR and CHNSR vulnerability to predation through creation of enhanced predatory fish habitat adjacent to the barriers. South Delta exports may facilitate the entrainment and routing of additional CHNWR and CHNSR from the interior Delta into Old River and toward the temporary barriers, ultimately leading to the export facilities.

DWR (2018) evaluated the effects of the South Delta Temporary Barriers Project on the movement and survival of emigrating juvenile salmonids, which further substantiates the impacts identified above. The study showed that juvenile salmonid survival was considerably reduced following the construction of the temporary barriers. Juvenile survival was lowest during full culvert operations (i.e., barriers installed with flap gates set to tidal operations), with juvenile survival improved during intermediate culvert operations (i.e., barriers installed with one flap gate tied open). Juvenile salmonids were typically preyed upon upstream of the barriers, where predator density was highest, while delayed on their downstream migration. The presence of the barriers also increased the time that juvenile salmonids spent in the vicinity of the barriers searching for a pathway through the barrier, which likely increased their vulnerability to predators. Based on construction design, juvenile salmonids encountering the barriers move downstream volitionally through open culverts; however, the DWR (2018) study showed that few fish were also moving over the barrier when flap gates were tied open. When the barrier flap gates were tidally operated, fish passage only occurred when the flood tide pushed the flap gates open. Under these conditions, more juvenile salmonids went over the barrier but could only do so when flows overtopped the barrier on flood tides or on ebb tides before the water elevations declined to the point where water depth was diminished over the crest. By increasing the time that juvenile salmonids spent in the vicinity of the barriers, the fish were also vulnerable to being exposed to elevated water temperatures as the season progressed.

Minimization of effects of the South Delta Temporary Barriers Project on CHNWR and CHNSR are discussed in Section 6.5 – Minimization of Effects of South Delta Temporary Barriers Project of this Effects Analysis and include the implementation of Conditions of Approval required by the 2024 SWP ITP.

5.6. Effects of Water Transfers on Chinook Salmon

DWR and Reclamation will continue to provide a water transfer window from July through November, consistent with modifications to extend the window into November as approved by NMFS (2019a), USFWS (2019), and CDFW (2020d) and as provided in the ITP Application (DWR 2023f). Based on historical observations of juvenile CHNWR and CHNSR in the Delta, juvenile CHNWR are likely to be present in the Delta during the majority of the water transfer window, whereas juvenile CHNSR are only likely to be present at the end of the water transfer window (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta). Specifically, juvenile CHNWR are likely to be present in the Delta as early as August as determined by passage at Knights Landing, with CHNWR presence increasing through November, especially if early season storms create flow conditions in the Sacramento River Basin to stimulate downstream movement (see Section 4.1.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). Juvenile CHNSR are likely to be in the Delta as early as November as determined by passage at Knights Landing and catch at Sherwood Habor and Sacramento beach seining; however yearling CHNSR may be present as early as October, with the majority of migration occurring in November if upstream precipitation events in tributary watersheds stimulate downstream migration (see Section 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta; Johnson and Merrick 2012). Adult CHNWR and CHNSR are likely to be present in the Delta during the water transfer period, with adult CHNWR timing in the Delta beginning in November and extending through August and adult CHNSR timing in the Delta beginning in January and extending through September (see Sections 4.1.8.1 and 4.2.8.1 – Adult Migration).

For CHNWR and CHNSR present in the Delta during the water transfer window, there will be an increase in impacts as a result of altered hydrodynamics in waters adjacent to the CVP and SWP export facilities if exports are increased to implement a water transfer. Altered hydrodynamics and increased exports may lead to an increase in routing alterations for CHNWR and CHNSR and increase the risk of CHNWR and CHNSR entrainment into the interior Delta and CVP and SWP export facilities. Increases in suboptimal routing and entrainment will result in delayed emigration, increased exposure to predators, and decreased survival rates, which may result in more pronounced impacts to juvenile fish as compared to adult fish (NMFS 2019a).

If water transfers originate from reservoir releases, all life stages of CHNWR and CHNSR may be impacted by the transfer window. Particularly, water transfers during the fall months of September through November may contribute to redd dewatering and juvenile stranding downstream of reservoirs, impacting spawning adults, redds, incubating eggs, newly emerged fry, and juveniles. If flow releases from reservoirs are ramped up to conduct a water transfer, spawning adults and rearing juveniles may begin occupying areas in the stream channel that were not previously inundated with water. Spawning adults may build redds and lay eggs in these areas. If flows are dropped or ramped down rapidly, these redds with incubating eggs and/or emerging fry may become dewatered or be subjected to poor water quality conditions such as low dissolved oxygen levels and elevated water temperatures, and suffer subsequent mortality. Inundated areas during transfers may create pools, side channels, or other areas that may attract assemblages of juveniles. If flows are dropped or ramped down rapidly, these juveniles may not react quickly enough to swim out of these areas before they are disconnected from the active stream channel. Juveniles may become stranded where they may be subjected to poor water quality conditions (e.g., low dissolved oxygen, elevated water temperatures), increased predation, and suffer subsequent mortality. DWR has conducted historical redd dewatering monitoring in the Feather River in 2010, 2012 through 2014, 2017, and from 2021 through 2023. Chinook Salmon redd dewatering occurred in the High Flow Channel of the Feather River, where flows are variable, in 2013, 2014, and 2022, resulting in the exposure of one redd, two redds, and four redds, respectively (DWR 2023g).

Since 2021, DWR has monitored flow rates according to a CDFW-approved Water Transfer Monitoring Plan prior to, during, and after all water transfers when triggered by the Feather River Operations Team and initiated redd distribution, redd dewatering, and juvenile stranding monitoring, if needed (DWR 2021c). DWR reported each redd dewatering and juvenile stranding event observed to CDFW within 24 hours of the event. Monitoring and reporting events during the water transfer window help to further understand impacts of water transfers on all life stages of CHNSR. In water years 2021 and 2023, redd dewatering monitoring was initiated following observation of a Hallprint spawned female carcass in the High Flow Channel of the Feather River (DWR 2022a, 2024d). Additional redd dewatering monitoring was conducted to monitor flow changes that could impact downstream CHNSR redds. DWR will continue to use the same procedures and timeframe for reporting detailed in the 2022 Water Transfer Monitoring Plan, or updated plan approved by CDFW, with oversight from the newly developed Feather River Program. The existing interagency Feather River Operations Team will also continue to review the Transfer Operations Study to evaluate whether transfer operations may result in redd dewatering and/or juvenile stranding. If actions proposed to administer water transfers may create a redd dewatering event or exceed monitoring thresholds, DWR will conduct monitoring to document the outcome of the actions (Grimaldo 2024a).

5.7. Effects of Operations at the Suisun Marsh Facilities on Chinook Salmon

Physical facilities in Suisun Marsh and Suisun Bay include SMSCG, the RRDS, the MIDS, and the GYSO. Additional facility details are included in the 2024 SWP ITP Project Description.

5.7.1. Suisun Marsh Salinity Control Gates

The SMSCG are located on Montezuma Slough about two miles downstream of the confluence of the Sacramento and San Joaquin rivers. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough. Low salinity water from the Sacramento River is directed into Montezuma Slough on the outgoing ebb tide. Higher salinity water from Grizzly Bay is restricted from entering Montezuma Slough during incoming tides. The SMSCG are operated as needed during the salinity control season from October through May to meet salinity requirements of D-1641 at multiple compliance points in eastern and western Suisun Marsh. Operation of the SMSCG in response to salinity can be impacted by hydrologic conditions, weather, Delta outflow, tides, and fishery considerations (DWR 2023f). In addition to the October through May operations to meet Suisun Marsh water quality standards, DWR will operate the SMSCG for 60 days to maximize the number of days when Belden's Landing 3-day average salinity is equal to, or less than, 4 practical salinity units (psu) to maximize the spatial and temporal extent of DS low salinity zone habitat in Suisun Marsh and Grizzly Bay between June and October of dry, below normal, and above normal water years (Conditions of Approval 9.1.3 – Delta Smelt Summer-Fall Habitat Action). In dry years following below normal years, DWR will operate SMSCG for 30 days to maximize the number of days when Belden's Landing 3-day average salinity equal to, or less than 6 psu to maximize the spatial and temporal extent of DS low salinity zone habitat in Suisun Marsh and Grizzly Bay (Conditions of Approval 9.1.3 – Delta Smelt Summer-Fall Habitat Action). The gates will most likely be operated during the summer (July and August) when DS habitat needs are high.

Adult CHNWR and CHNSR are likely to be present during the SMSCG operational period of October through May, potentially delaying upstream migration to spawning habitat. The boat lock portion of the gate is held partially open during SMSCG operation to allow continuous salmon passage but could be closed temporarily for boat traffic (DWR 2023f). Adult CHNWR and CHNSR presence during operations between June to October is less likely as most adults have migrated to upstream tributaries by this time, though they may be present in low numbers (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta). Juvenile CHNWR are likely to be present during the SMSCG operational period from October through May, but not during the operational period between June and October. Juvenile CHNSR emigrate as both YOY and yearling, so they have the potential to be present during the October through May operational period and potentially in June and July (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta).

Salmonid smolt predation by Striped Bass (*Morone saxatilis*) and Pikeminnow (*Ptychocheilus oregonensis*) could be exacerbated by operation of the SMSCG. In the Delta, predatory fishes can congregate in areas where prey are displaced from their usual migratory pathways and are more easily targeted due to disorientation from unnatural hydrology or in water structures (Grossman 2016). Pikeminnow are not typically major predators of juvenile salmonids (Brown and Moyle 1981), but both Pikeminnow and Striped Bass are opportunistic predators that will take advantage of localized, unnatural circumstances. The SMSCG provides an enhanced opportunity for predation because fish passage is reduced when the structure is operating. During operation of the gates from October through May, DWR proposes to limit the operation of the SMSCG to periods required for compliance with salinity control standards, and this operational frequency is expected to be 10-20 days per year. This limited operation of the SMSCG will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of Striped Bass and Pikeminnow, so predation impacts are minimal during these operations. As described above, adult and juvenile CHNWR and CHNSR presence is greatly reduced during July and August when the SMSCG would most likely be operated for the Delta Smelt Summer-Fall Action (Condition of Approval 9.1.3), thus predation and other impacts to salmon due to operation of the gates is not anticipated.

5.7.2. Roaring River Distribution System

The RRDS begins at Montezuma Slough just west of the SMSCG and runs westward through Grizzly Island to Grizzly Bay. DWR operates the RRDS to divert water from Montezuma Slough on high tides into the RRDS through a bank of eight 60-inch (1.5-m) diameter culverts equipped with fish screens that empty into a 40-acre intake pond raising the water surface elevation in the RRDS above that of adjacent managed wetlands. The intake pond helps control water levels in the slough running through Grizzly Island to near Grizzly Bay used to deliver 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 intakes are screened to physically exclude fish greater than 25 mm in length from being entrained. DWR operates the RRDS intakes at a maximum average daily approach velocity of 0.2 ft/sec except between September 14 and October 20 when approach velocities increase to 0.7 ft/sec for fall flood-up operations.

Impacts on CHNWR and CHNSR due to RRDS operations may occur in the form of mortality associated with entrainment, impingement, and screen contact. Impacts on CHNWR and CHNSR may also result from non-lethal impingement/screen contact, increased vulnerability to predation, and potential migration delays for adult CHNWR and CHNSR. It is unknown how frequently juvenile or adult CHNWR and CHNSR encounter the RRDS intakes or become impinged or entrained. Given relatively low approach velocities and use of fish screens, the likelihood of juvenile and adult CHNWR and CHNSR contact with the fish screens is low and the overall effect of the RRDS on CHNWR and CHNSR is expected to be minimal.

5.7.3. Morrow Island Distribution System

The MIDS is located on Goodyear Slough south of Pierce Harbor and consists of three unscreened 48-inch (1.2-m) intakes that allow DWR and Reclamation to provide fresher water to managed wetlands by diverting drainage water from Goodyear Slough through a distribution channel bisecting Morrow Island and discharge into Suisun Slough and Grizzly Bay. DWR and Reclamation operate the MIDS 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.

Impacts on CHNWR and CHNSR due to MIDS operations can occur in the form of mortality associated with entrainment through the unscreened intakes. Impacts on CHNWR and CHNSR may also result from increased vulnerability to predation and potential migration delays for adult CHNWR and CHNSR. NMFS (2009) notes that entrainment studies between 2004 and 2006 identified two CHNFR fry (39-44 mm in length) captured indicating that entrainment of fish larger than 25 mm is possible through the MIDS. However, it is unknown how frequently juvenile or adult CHNWR and CHNSR encounter the MIDS intakes or become entrained. The overall effect of the MIDS on CHNWR and CHNSR is expected to be minimal.

5.7.4. Goodyear Slough Outfall

The GYSO is located at the confluence of Goodyear Slough and Suisun Bay and consists of a 21 m wide by 853 m long dredged channel connecting the slough with the bay. The GYSO operates as four unscreened 1.2-m diameter culverts (passive intakes) with flap gates on the Suisun Bay side to allow drainage water from Goodyear Slough to discharge into Suisun Bay. The GYSO is equipped with vertical slide gates on the Goodyear Slough side to allow DWR to close the system for maintenance and repairs. When the slide gates are open only trash racks obstruct entry into and out of the system. The GYSO was designed to increase circulation and reduce salinity in Goodyear Slough to provide higher water quality to managed wetlands flooded by Goodyear Slough water. DWR (2024f) indicates that because the GYSO is an open system, any fish that enter the system would be able to leave via the intake or the outfall.

Impacts on CHNWR and CHNSR due to GYSO operations may occur in the form of mortality associated with entrainment through the unscreened intakes. Impacts on CHNWR and CHNSR may also result from increased vulnerability to predation and potential migration delays for adult CHNWR and CHNSR. It is unknown how frequently juvenile or adult CHNWR and CHNSR encounter the GYSO or become entrained. The overall effect of the GYSO on CHNWR and CHNSR is expected to be minimal.

6. Minimization of Take and Impacts of the Taking on Winter- and Spring-run Chinook Salmon

The following sections describe how Conditions of Approval included in the 2024 SWP ITP will minimize take of CHNWR and CHNSR and impacts of the taking by Project infrastructure and operations.

6.1. Minimization of Project Effects on Routing, Rearing, and Survival of Chinook Salmon

The following Conditions of Approval included in the 2024 SWP ITP minimize take of CHNWR and CHNSR and impacts of the taking resulting from changes in routing, rearing, and through-Delta survival associated with the Project.

6.1.1. Conditions of Approval 8.11.1 Operation of Georgiana Slough Salmonid Migratory Barrier and 7.9.6 Georgiana Slough Salmonid Migratory Barrier Effectiveness Studies

Condition of Approval 8.11.1 requires DWR to continue to annually install and operate the Georgiana Slough Salmonid Migratory Barrier Project through the duration of the 2024 SWP ITP to deter outmigrating juvenile CHNWR and CHNSR from entering the interior Delta, consistent with the Adaptive Management Program for the 2024 SWP ITP (see Attachment 4 to the 2024 SWP ITP). This ongoing effort was initiated in 2021 under the 2020 SWP ITP Condition of Approval 8.9.1 and DWR will adhere to the existing Georgiana Slough Salmonid Migratory Barrier operations and monitoring plans, and any updates to these plans, developed jointly by DWR, CDFW, NMFS, and USFWS (see Section 4.1.6 – Rearing and Outmigrating Juveniles in the Bay-Delta; CDFW 2020d, DWR 2022c, DWR 2022b). DWR (2022c) identified the BAFF as the preferred barrier technology to be installed at the junction of the Sacramento River and Georgiana Slough. The BAFF consists of acoustic transmitters, a bubble curtain to capture the sound, and a light array to illuminate the bubble curtain and simulate a physical barrier. DWR will operate the barrier annually no later than November 16 through April 30, and potentially into May, based on availability of power resources (DWR 2022c). The operations period overlaps with the outmigration of juvenile CHNWR and CHNSR; however, if operations cease before May, some late-migrating CHNSR could be left without routing protection from Georgiana Slough as they complete their downstream emigration (see Section 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). DWR installed and began full operation of a BAFF on November 29, 2023 (DWR 2023e). During operations, DWR will continue pilot investigations (e.g., real-time fish tracking, predator studies) to evaluate and refine the barrier’s efficiency of precluding juvenile CHNWR and CHNSR from entering Georgiana Slough and any subsequent CHNWR and CHNSR through-Delta survival differences for the two migratory pathways (Condition of Approval 7.9.6 – Georgiana Slough Migratory Barrier Effectiveness Studies; DWR 2022b). During the pilot investigations, DWR will also evaluate upstream passage of adult CHNWR and CHNSR to ensure the barrier does not obstruct upstream migration. The operations and monitoring plans include CDFW involvement and approval to ensure the barrier provides benefits to CHNWR and CHNSR and will not be detrimental to the continued management and recovery of CHNWR and CHNSR.

Initial studies to quantify the effect of BAFF operations on juvenile routing into Georgiana Slough were conducted in 2011 and 2012, following the installation of a BAFF at the junction of the Sacramento River and Georgiana Slough (DWR 2012, 2015a). The BAFF was operated during juvenile Chinook Salmon outmigration from March 15 to May 16 in 2011 and from March 6 to April 28 in 2012. Roughly 1,500 acoustically tagged hatchery-origin CHNLFR smolt sized fish were released upstream of the barrier during each study year in small daily groups while BAFF operation switched between on and off over 25-hour tidal cycles. In 2011, tagged hatchery-origin CHNLFR entrainment into Georgiana Slough decreased 67% when the barrier was on compared to when it was not operating. In 2012, tagged hatchery-origin CHNLFR entrainment into Georgiana Slough decreased by about 50% when the barrier was on, compared to when it was not operating. During these studies, flow was found to impact juvenile Chinook Salmon entrainment into Georgiana Slough. Sacramento River flows were higher in 2011 than 2012, which decreased overall entrainment probability into Georgiana Slough in 2011, but entrainment probability was likely reduced further for fish in close proximity to the Georgiana Slough junction. In 2012, the BAFF still decreased entrainment probability even though flows were considered low. It was thought that juvenile Chinook Salmon had more time to orient themselves away from the BAFF. In addition, flows are believed to influence the probability of juvenile Chinook Salmon encountering predators (see Section 5.1.4 – Effects of Georgiana Slough Salmonid Migratory Barrier on Routing and Survival). While these preliminary studies show the potential benefits of the BAFF operation, additional work is needed to understand the efficiency of the barrier and any additional impacts it may have on Chinook Salmon (Condition of Approval 7.9.6 – Georgiana Slough Migratory Barrier Effectiveness Studies).

6.1.2. Condition of Approval 8.11.2 Evaluate Potential Options for Increased Routing into Sutter and Steamboat Sloughs

Condition of Approval 8.11.2 requires DWR continue to investigate and evaluate of potential methods for increasing through-Delta survival of Chinook Salmon and complete actions required under the 2020 SWP ITP Condition of Approval 8.9.2 – Evaluate Benefits of Salmonid Guidance Structures at Sutter and Steamboat Sloughs. Studies have shown that juvenile Chinook Salmon migrating through Steamboat Slough can have higher survival compared to those migrating through alternate pathways particularly during lower flow conditions (Johnston et al. 2018; Singer et al. 2020). Acoustically tagged hatchery-origin CHNFR and CHNSR were found to have higher survival when migrating through Steamboat Slough compared to the Sacramento River mainstem in 2013 and 2015 (Singer et al. 2020), and survival of hatchery-origin CHNLFR and CHNWR through Steamboat Slough was also higher compared to survival through the Sacramento River mainstem, Sutter Slough, and Georgiana Slough in 2021 (NMFS 2024). Modeling conducted for the Sutter and Steamboat Sloughs Guidance Structure Evaluation Report, as required under the 2020 SWP ITP Condition of Approval 8.9.2, also simulated higher baseline survival rates for Steamboat Slough than the Sacramento River mainstem, Sutter Slough, and Georgiana Slough (DWR 2023e). In lower flow conditions, juvenile Chinook Salmon migration through Steamboat Slough has been shown to result in higher survival than other routes. DWR, in collaboration with the Guidance Structure Evaluation Working Group (GSEWG), evaluated the potential benefits of salmonid guidance structures at Sutter and Steamboat sloughs under the 2020 SWP ITP Condition of Approval 8.9.2. However, none of the specific salmonid guidance structure alternatives evaluated were determined by DWR to substantially improve through-Delta survival of juvenile Chinook Salmon. Due to the potential survival benefits for juvenile salmon migrating through Steamboat Slough, other potential methods for increasing routing through Steamboat Slough, possibly including additional technologies that were not previously considered, warrant investigation. Under Condition of Approval 8.11.2, within six months of the effective date of the ITP, DWR will reconvene the GSEWG, which may include representatives from DWR, CDFW, NMFS, USFWS, SWP Contractors, and Reclamation. DWR, with the support of GSEWG, will address CDFW comments and initiate and complete sensitivity analyses defined by CDFW in the Draft Sutter and Steamboat Slough Guidance Structure Evaluation Report developed under the 2020 SWP ITP Condition of Approval 8.9.2. Within two years of the effective date of the ITP, DWR will submit the updated Draft Sutter and Steamboat Slough Guidance Structure Evaluation Report, which incorporates CDFW comments and additional sensitivity analyses, to CDFW for review. Within four months of receiving CDFW review, DWR will update the evaluation report and submit the final Sutter and Steamboat Slough Guidance Structure Evaluation Report to CDFW for approval. Within one year of the finalization of the evaluation report, DWR will reassess actions to improve salmon survival in the Delta, possibly through increased routing into Steamboat Slough, using tools developed and refined through the Sutter and Steamboat sloughs evaluation effort and propose actions for CDFW's approval.

6.1.3. Condition of Approval 8.12 Spring Delta Outflow Implementation

Condition of Approval 8.12 requires DWR to supplement Delta outflow during spring months to minimize take of Covered Species, including CHNWR and CHNSR, by reducing entrainment into the interior Delta and south Delta CVP and SWP export facilities, as well as providing greater quantity and quality of rearing habitat in the Delta from increased water availability. These benefits of spring Delta outflow are anticipated to increase survival of outmigrating juvenile CHNWR and CHNSR. Spring Delta outflow will be achieved initially through implementation of measures that mirror the 2020 SWP ITP Condition of Approval 8.17 – Export Curtailments for Spring Outflow (Condition of Approval 8.12.1 – Spring Delta Outflow Via Export Curtailments). DWR will implement a combination of export reductions and Delta inflow augmentation as required by Conditions of Approval 8.12.2 (Spring Delta Outflow Via the Healthy Rivers and Landscapes Program), 8.12.3 (Planning and Reporting Implementation of Spring Delta Outflow Via the Healthy Rivers and Landscapes Program), and 8.12.4 (Consultation Regarding Deployment of Spring Outflow Via the Healthy Rivers and Landscapes Program) during water years when the HRL is implemented consistent with those Conditions of Approval.

Spring Delta Outflow Implementation will be achieved one of two ways. Condition of Approval 8.12.1 (Spring Delta Outflow Via Export Curtailments) requires DWR to deploy spring Delta outflow in April and May each year consistent with Condition of Approval 8.17 in the 2020 SWP ITP. Specifically, DWR is required to reduce exports from April 1 to May 31 each year to achieve the SWP proportional share (Condition of Approval 8.7) of export reductions established by the ratio of Vernalis flow (cfs) to combined CVP and SWP exports, scaled by water year type, to provide spring outflow. In a critical water year, the ratio of Vernalis flow to CVP and SWP combined exports will be 1 to 1. In a dry water year, the ratio of Vernalis flow to CVP and SWP combined exports will be 2 to 1. In a below normal water year, the ratio of Vernalis flow to CVP and SWP combined exports will be 3 to 1. In an above normal or wet water year, the ratio of Vernalis flow to CVP and SWP combined exports will be 4 to 1[8]. In wet years, SWP export curtailments required by this Condition of Approval for spring outflow in April and May are

[8] Ratio adjustments for multi-year droughts as outlined in the 2009 NMFS BO will apply (NMFS 2009).

limited to 150 TAF. For the purposes of this Condition of Approval, the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and Indicator as defined in the Bay-Delta Water Quality Control Plan (SWRCB 2006) will be used.

Additionally, as a part of Condition of Approval 8.12.1, DWR is not required to restrict operations as described above under either of the following circumstances: 1) if the 3-day average Delta outflow is greater than 44,500 cfs, then Project operations are not controlled by this Condition of Approval until the flows drop below 44,500 cfs on a 3-day average; and 2) DWR will not be required by this Condition of Approval to restrict exports at the Banks Pumping Plant below its minimum health and safety exports of 600 cfs.

In years when the HRL is implemented Condition of Approval 8.12.2 (Spring Delta Outflow Via the Healthy Rivers and Landscapes Program) requires DWR to provide 50 TAF of Delta inflow that is dedicated to Delta outflow in March of dry, below normal, and above normal water years which DWR will facilitate through upstream land fallowing and subsequent reservoir releases, unless approved by CDFW to deploy flows in April or May. Condition of Approval 8.12.2 also requires DWR to provide SWP south Delta foregone exports in April and May of dry, below normal, and above normal water years. Specifically, DWR is required to provide 92.5 TAF of Delta outflow via export reductions in dry and below normal water years, and 117.5 TAF in above normal water years (see Table 5 of the ITP). DWR conducted a comparison of the water volumes in Table 5 of the ITP to the outflows that would be expected, on average, in above normal, below normal, and dry water year types if Condition of Approval 8.12.1 was implemented and concluded that they are equivalent (DWR 2024e). DWR may deploy export reduction flows in March or June, if approved by CDFW. An increase in Delta inflow during spring months is anticipated to increase survival of juvenile CHNSR migrating through the Feather River or Sacramento River by providing improved in-river rearing conditions, including reductions in pathogen loads and exposure. An increase in spring Delta inflow is also anticipated to increase survival of juvenile CHNSR and CHNWR migrating through the Delta by providing improved Delta rearing conditions and reduced entrainment into the interior Delta and south Delta export facilities.

Conditions of Approval 8.12.1 and 8.12.2 are represented in CalSim 3 modeling as two different Proposed Project scenarios. The ITP_Spring modeling scenario incorporates all proposed SWP operations and continued implementation of 2020 SWP ITP Condition of Approval 8.17 – Export Curtailments for Spring Outflow (Condition of Approval 8.12.1). The 9A_V2A modeling scenario incorporates all proposed SWP operations and DWR's contribution to the HRL through export reductions and reductions in tributary diversions as described above (Condition of Approval 8.12.2). See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon and Appendix C – CalSim Modeling Results for additional details on CalSim 3 modeling of the Proposed Project. Conditions of Approval 8.12.1 and 8.12.2 will minimize take of CHNWR and CHNSR migrating through the Delta during spring months. Specifically, Condition of Approval 8.12.1 provides equivalent outflow conditions when implemented in April and May and Condition of Approval 8.12.2 provides improved outflow conditions when implemented between March and May. Condition of Approval 8.12.2 also provides improved outflow conditions for juvenile CHNSR on the Feather River or the Sacramento River when the 50 TAF Delta inflow block is deployed.

6.1.4. Condition of Approval 7.9.3 Spring-Run Chinook Salmon Juvenile Production Estimate and Condition of Approval 7.9.4 Spring-Run Chinook Salmon Life Cycle Model

Condition of Approval 7.9.3 requires DWR to fund and support the continued development of a CHNSR JPE framework initiated in 2020 under the 2020 SWP ITP Condition of Approval 7.5.2 (CDFW 2020d), consistent with the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP) for the 2024 SWP ITP (see Section 4.2.2.1.1 – Juvenile Production Estimate Development). This ongoing effort will utilize the existing CHNSR JPE Science Plan (DWR et al. 2020), the CHNSR JPE Interim Monitoring Plan (Allison et al. 2021), the CHNSR JPE Run Identification Research and Initial Monitoring Plan (Boro et al. 2023), the CHNSR JPE Data Management Strategy (Harvey et al. 2022), and the CHNSR JPE Decision Charter (Horndeski 2022), and any updates to these plans, to meet the goal of developing an annual CHNSR JPE for implementation in 2026.

The CHNSR JPE Science Plan established the CHNSR JPE Core Team with representatives from DWR, CDFW, NMFS, Reclamation, USFWS, and SWP Contractors as well as four subteams to manage different aspects of CHNSR JPE development (DWR et al. 2020). With guidance from the CHNSR JPE Interim Monitoring Plan (Allison et al. 2021), Stream Teams initiated new and ongoing monitoring in CHNSR natal tributaries upstream of the Delta and at Delta entry. Monitoring includes adult passage and escapement surveys, juvenile emigration monitoring using RSTs and fyke traps, trap capture efficiency studies, and juvenile outmigration survival studies. The Run Identification Team initiated rapid genetics, i.e., the SHERLOCK methodology (Baerwald et al. 2023), and traditional genetic techniques at these key ecological and management relevant locations to enhance identification accuracy of CHNSR by informing the development of the PLAD model for future run identification (Boro et al. 2023). This improvement in run identification over the existing LAD model will help estimate CHNSR juvenile abundance and cohort strength across the freshwater landscape and expand and enhance real-time fish survival and movement monitoring.

The CHNSR JPE Core Team has proposed six draft JPE approaches (DWR 2023c) that are currently being further developed by the Modeling Team and Data Management Team using environmental and biological monitoring data coupled with PLAD model outputs to estimate CHNSR abundance (Harvey et al. 2022). Guided by SDM (Horndeski 2022), the CHNSR JPE Core Team will develop a CHNSR JPE framework in 2025 composed of the recommended approach to calculate the CHNSR JPE and the monitoring program required to provide data to calculate the annual CHNSR JPE. The Adaptive Management Steering Committee, made of up representatives from DWR, CDFW, Reclamation, USFWS, and NMFS, will submit the CHNSR JPE Core Team's recommended framework to an independent peer review panel seeking feedback prior to 2026. After incorporating the review panel's recommendations, DWR and Reclamation, in coordination with CDFW, USFWS, and NMFS, will prepare a draft CHNSR JPE Plan in 2026 that describes the approach to calculating a CHNSR JPE, as well as monitoring and special studies needed to collect data for the annual JPE. DWR and Reclamation will also submit this draft CHNSR JPE Plan to the CHNSR JPE Core Team for review and feedback. No later than six months after the independent peer review, DWR and Reclamation will submit the final JPE recommended framework to CDFW and NMFS for review and approval for implementation in 2026. Once the CHNSR JPE recommendation is approved by CDFW and NMFS, DWR will convene the CHNSR JPE Core Team and four subteams to provide an annual CHNSR JPE using new data as it becomes available through continued monitoring and science development.

Once developed, the CHNSR JPE is expected to serve a similar purpose for CHNSR as the current CHNWR JPEs provide for CHNWR. The development of a CHNSR JPE is needed to facilitate the development of additional CHNSR protective measures beyond the Spring-run Chinook Salmon Surrogate Annual Loss Thresholds (see Section 6.2.8; Condition of Approval 8.4.5) that are informed by natural and hatchery-origin CHNSR production entering the Delta. In 2026, the CHNSR JPE Core Team will evaluate the minimization provided by the Spring-Run Chinook Salmon Protective Action and Surrogate Annual Loss Thresholds (Section 6.2.8; Condition of Approval 8.4.5). Subsequently, DWR, CDFW, Reclamation, and NMFS will meet to discuss development of a new or modified OMR minimization measure for CHNSR. In 2027, if approved by CDFW and NMFS, DWR in coordination with Reclamation will implement the new or modified CHNSR OMR minimization measure using the initial CHNSR JPE approach. DWR will also implement any changes to monitoring recommended through the CHNSR JPE Core Team SDM process and continue to refine the JPE model and incorporating new data as it becomes available.

In 2028, the Adaptive Management Steering Committee will, in coordination with the CHNSR JPE Core Team, consider chartering and convening an independent peer review panel to provide feedback on the CHNSR JPE model. In 2029 and 2030, if an independent peer review is convened, the CHNSR JPE Core Team will review independent peer review panel feedback, and the CHNSR JPE Core Team will use SDM to evaluate and implement changes to the CHNSR JPE model.

In conjunction with the development of a CHNSR JPE, Condition of Approval 7.9.4 requires DWR to fund and support the development of a CHNSR life cycle model for the purpose of informing management actions to improve CHNSR populations across the Central Valley. This life cycle model will reflect current and future monitoring and will synopsize our understanding of various facets of CHNSR behavior, strategy, and environmental impacts and how that relates to CHNSR survival over space and time. DWR and Reclamation will assemble a CHNSR Life Cycle Model Management Team with representatives from DWR, CDFW, NMFS, Reclamation, and USFWS to define management issues and objectives to be addressed by the life cycle model. The CHNSR JPE Core Team will be responsible for guiding the development of the life cycle model with the support of a lead life cycle modeler and CHNSR Life Cycle Modeling Subteam, included but not limited to, representatives from DWR, CDFW, Reclamation, USFWS, and NMFS. In 2028, the CHNSR Life Cycle Modeling Subteam, in coordination with the CHNSR JPE Core Team, will recommend an initial CHNSR life cycle model for potential independent peer review coordinated through the Adaptive Management Steering Committee. If an independent peer review is convened, the CHNSR Life Cycle Modeling Subteam, in coordination with the CHNSR JPE Core Team, will review the review panel feedback and the CHNSR JPE Core Team will use SDM to evaluate and implement changes to the initial CHNSR life cycle model. Together, the CHNSR JPE and the life cycle model are key tools needed to reduce uncertainty regarding the timing and abundance of YOY and yearling CHNSR entering the Delta from the Sacramento River and assess impacts of a variety of stressors on CHNSR. As further explained in Section 6.2.8.4, the CHNSR JPE and life cycle model will be used through adaptive management to develop minimization measures for reducing take of CHNSR migrating through the Delta during Project operations (see Attachment 4 to the 2024 SWP ITP).

6.1.5. Condition of Approval 7.9.5 Salmon Delta Occupancy, Distribution, and Survival Studies

Condition of Approval 7.9.5 requires DWR to continue implementation of annual regional juvenile Chinook Salmon survival studies within the Delta to evaluate juvenile Chinook Salmon reach-specific survival, behavior, and route entrainment in the Sacramento River and Delta. Additionally, Condition of Approval 7.9.5 requires DWR to lead a new working group to draft and implement a study plan to expand the existing acoustic receiver network prioritizing co-location of physical and biological data collection throughout the Delta. Expansion of the acoustic receiver array will inform forecasting of entrainment rates, Delta occupancy timing and distribution, and reach-specific survival. The new working group will also investigate other ways to improve monitoring of juvenile Chinook Salmon rearing, routing and through-Delta survival such as increased passive integrated transponder (PIT) tagging and monitoring. Condition of Approval 7.9.5 requires DWR to submit a draft study plan to CDFW for review and approval within a year of the effective date of the 2024 SWP ITP, and subsequently finalize the study plan for implementation within four months of receiving CDFW feedback. DWR will also convene the working group at least quarterly each year to review and revise annual study plans, discuss study progress, and review study data.

Enhanced monitoring of juvenile Chinook Salmon movement through the Delta paired with environmental data will provide a more comprehensive understanding of Delta occupancy and survival including specific areas that may be more frequently utilized for rearing and contribute to higher survival rates. Expanding methods and coverage of juvenile Chinook Salmon monitoring programs in the Delta will also bolster our understanding of how Project operations impact juvenile CHNWR and CHNSR migration behavior, habitat utilization, residence time, predation, and long-term routing, which are currently areas of uncertainty (see Section 5.1.1 – Effects of South Delta Export Operations on Juvenile Chinook Salmon Rearing). For example, enhanced PIT tag monitoring will provide more information on rearing and migration of smaller-sized juveniles, which is currently lacking, and may help support more comprehensive routing and survival modeling that incorporate behavior of multiple juvenile life stages of Chinook Salmon rather than only larger smolt-sized Chinook Salmon that rapidly transit the Delta (see Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon). These data will inform real-time management of Project operations and will support elements of the Adaptive Management Plan (see Attachment 4 to the 2024 SWP ITP), such as the development of a CHNSR life cycle model and a CHNWR migration model. Additionally, these data may aid in the development of habitat restoration projects focused on improving quality of and connectivity between juvenile Chinook Salmon rearing areas in the Delta.

6.2. Minimization of Project Effects on Entrainment of Chinook Salmon

The following Conditions of Approval included in the 2024 SWP ITP minimize take of CHNWR and CHNSR and impacts of the taking resulting from changes in entrainment associated with the Project.

6.2.1. OMR Management as an Entrainment Minimization Measure

OMR Management in response to increases in loss of Covered Species and their surrogates at the south Delta export facilities minimizes take of juvenile CHNWR and CHNSR emigrating through the Delta. Management of OMR flows is recognized to help reduce negative effects of exports on CHNWR and CHNSR, as stated in SST (2017):

> *Export effects that incrementally increase the routing of juvenile salmonids (either from the Sacramento River or from the San Joaquin River) into the Interior Delta will incrementally reduce overall survival…In addition to the predicted effects of exports on routing, the conceptual model predicts that OMR reverse flow management will decrease mortality by increasing the probability that juveniles that enter the South Delta (San Joaquin River mainstem and channels to the south and west of the San Joaquin River mainstem) will successfully migrate out of the South Delta to Chipps Island. Mechanisms by which this might occur include: 1) reducing entrainment at the export facilities…; 2) reducing confusing navigational cues caused by OMR reverse flow; and 3) increasing the duration and magnitude of ebb tide flows and velocities, relative to flood tides, which is expected to reduce the residence time of juveniles in the South Delta and, therefore, reduce exposure time to agents of mortality*.

OMR Management was designed to reduce negative net OMR flows when real-time OMR restrictions are triggered by loss of Covered Species, including juvenile CHNWR and CHNSR surrogates, at the CVP and SWP export facilities. A less negative net OMR flow is accomplished by export reductions at the CVP and SWP export facilities. As indicated in Section 5.2, combined salvage from both facilities provides the best means to effectively extrapolate the effects of south Delta SWP export operations on entrainment of CHNWR and CHNSR into the interior and south Delta (Smith 2019). OMR restrictions and export reductions provide protections to CHNWR and CHNSR by reducing further entrainment into the interior Delta and the CVP and SWP export facilities. As documented in SST (2017), higher numbers of juvenile Chinook Salmon are salvaged during times when OMR is more negative. Reductions in the average daily negative OMR flows will reduce entrainment of CHNWR and CHNSR into the interior Delta and increase their survival by accelerating their emigration through the Delta (Perry et al. 2016). Thus, it is important to have minimization measures that will regulate OMR flows to ultimately prevent or reduce the number of fish entrained into the interior Delta and the CVP and SWP export facilities, where they would experience high mortality rates. It is important that minimization measures provide protection for the full scope of life history strategies exhibited by CHNWR and CHNSR throughout their emigration period (see Section 4.4 – Importance of Life History Diversity for Chinook Salmon). An OMR flow index (OMR index) is calculated using an equation published by Hutton (2008) and used to determine CVP and SWP export limitations described in sections below.

6.2.2. Condition of Approval 8.1.2 Salmon Monitoring Team and Condition of Approval 8.1.6.2 Salmon Monitoring Team Role

Condition of Approval 8.1.2 requires DWR to convene the Salmon Monitoring Team (SaMT) with membership from DWR, CDFW, NMFS, Reclamation, USFWS, and SWRCB. The SaMT will meet during the OMR flow management season (October through June), and otherwise as needed, and review hydrologic, SWP and CVP operational, fishery, and water quality data, and provide opportunities for engagement and discussion among biologists and operators on relevant information and issues associated with the Project and Risk Assessments prepared by DWR and Reclamation as required by Condition of Approval 8.4.5 (see Section 6.2.8 – Spring-run Chinook Salmon Protection Action and Surrogate Annual Loss Thresholds).

DWR and Reclamation will conduct weekly risk assessments to assess the risk of CHNSR entrainment into the interior Delta and into CVP and SWP export facilities. SaMT will discuss and review information included in these risk assessments to inform discussions in WOMT. The weekly risk assessments for natural-origin CHNSR (see Section 6.2.8; Condition of Approval 8.4.5) will evaluate a suite of monitoring and hydrologic data sources to characterize CHNSR presence and distribution within the Delta and hydrologic factors that influence entrainment risk. SaMT has a role in identifying yearling and YOY CHNSR hatchery surrogates (see Section 6.2.8; Condition of Approval 8.4.5) and informing the implementation of Storm Flex (see Section 6.2.9; Condition of Approval 8.5). SaMT will also convene and provide operational advice following the exceedance of 100% of the natural-origin or hatchery-origin CHNWR annual loss thresholds (see Section 6.2.6; Condition of Approval 8.4.3).

According to Condition of Approval 8.1.6.2, SaMT agency leads will provide expert advice to their associated Water Operations Management Team (WOMT) representatives on real-time management of Delta water operations that benefit emigrating CHNWR and CHNSR. SaMT agency leads will notify their agency's WOMT representative if an ITP identified threshold or protection is or will be met, provide input on Risk Assessments prepared by DWR and Reclamation, and discuss and document differing perspectives (e.g., non-consensus) on the relevant assessments and Conditions of Approval of the ITP. If consensus is not reached in SaMT, agency representatives will compose and email to WOMT summarizing the elevation topic and any supporting information and recommendations. The supporting information and recommendations, when elevated to the WOMT, can be used to determine when protective actions for CHNWR and CHNSR are needed to minimize take at SWP export facilities.

6.2.3. Condition of Approval 8.1.4 Water Operations Management Team and Condition of Approval 8.1.5 Collaborative Approach to Real-time Decision Making

Condition of Approval 8.1.4 requires DWR to convene the WOMT composed of manager-level representatives from DWR, CDFW, NMFS, Reclamation, USFWS, and SWRCB. Each week during the OMR flow management season (October through June), and otherwise as needed, WOMT considers expert advice provided by the SaMT to make final determinations for CHNWR and CHNSR take minimization needs and Delta water operations. The WOMT has the authority to request operational changes at the CVP and SWP export facilities to manage OMR flows to an average daily OMR index less negative than the current daily OMR index. Condition of Approval 8.1.5 (Collaborative Approach to Real-time Decision Making) describes the process by which all available biological, abiotic, and operational information to inform operational recommendations will be transmitted from the SaMT to the WOMT, and to the Directors of CDFW and DWR if resolution is not achieved in WOMT. If the Directors of CDFW and DWR do not agree, the Director of CDFW may require DWR to implement an operational recommendation provided by CDFW, consistent with the Coordinated Operations Agreement, as amended in 2018 (Condition of Approval 8.7 – SWP Proportional Share; Reclamation and DWR 2018). Changes toward a more positive average daily OMR index in response to risk assessments and operational advice will reduce entrainment of CHNWR and CHNSR into the interior Delta and increase their survival by reducing their emigration time through the Delta (Perry et al. 2016).

6.2.4. Condition of Approval 8.3 Onset of OMR Management

6.2.4.1. Introduction

Condition of Approval 8.3 requires DWR to reduce exports to achieve a 14-day average OMR index no more negative than -5,000 cfs during the duration of OMR Management. OMR Management is intended to minimize take of Covered Species, including juvenile CHNWR and CHNSR emigrating through the Delta, by creating less negative net OMR flows during the time that Covered Species are expected to be present in the Delta and at risk of entrainment into the interior and south Delta. Less negative net OMR flows are accomplished through CVP and SWP export reductions and help reduce entrainment of juvenile CHNWR and CHNSR into the interior Delta and the CVP and SWP export facilities in the south Delta. For junctions on both the Sacramento River and San Joaquin River, a -5,000 cfs OMR reverse flow limit provides protection compared to more negative OMR reverse flow levels that would exert a larger influence on flow routing at distributary junctions and, thus, on juvenile routing and survival (SST 2017).

OMR Management can begin any time after December 1 if a First Flush Action (see Section 6.6; Condition of Approval 8.3.1) or Adult Longfin Smelt Entrainment Protection Action (see Section 6.6; Condition of Approval 8.3.3) occur, or any time after December 20 if an Adult Delta Smelt Entrainment Protection Action (see Section 6.6; Condition of Approval 8.3.2) occurs. DWR will reduce exports to achieve a new OMR index within three days of an action that requires changes to OMR flows. If none of these actions occur in December, OMR Management begins automatically on January 1 and can extend through the end of June (see Section 6.2.10 – End of OMR Management; Condition of Approval 8.6), which overlaps with the emigration timing of juvenile CHNWR and CHNSR. Juvenile CHNWR begin to enter the Delta as early as August and YOY CHNSR have been seen entering the Delta as early as November (CalFish 2023c), though yearling CHNSR have also historically been observed in September and October on occasion (see Section 5.2.1.2.2 – Historical Loss of Spring-run Chinook Salmon). Juvenile salmonids can spend up to three months rearing in the Delta before making their entry into saltwater (del Rosario et al. 2013), which exposes these fish to risk of entrainment into the interior Delta and CVP and SWP export facilities in the south Delta during the duration of their rearing and outmigration period.

CDFW compared natural-origin CHNWR and CHNSR loss at the CVP and SWP export facilities to natural-origin CHNWR and CHNSR catch data from the Knights Landing RST and Sherwood Harbor trawl monitoring programs to assess the timing of juvenile CHNWR and CHNSR entry and presence in the Delta by January 1, which is the latest possible start date of OMR Management. Knights Landing is the point on the Sacramento River where juvenile CHNWR and CHNSR are expected to be entering the Delta imminently, and Sherwood Harbor is just below the northernmost boundary of the legal Delta.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.3 (Onset of OMR Management) in minimizing take of juvenile natural-origin CHNWR and CHNSR.

6.2.4.2. Methods

6.2.4.2.1. Data Retrieval

For this analysis, salvage data of natural-origin CHNWR and CHNSR collected at the CVP and SWP export facilities in water years 2010 to 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018).

The Delta Model LAD criteria (USFWS 1997) were used to identify juvenile CHNWR and CHNSR at the CVP and SWP export facilities. Natural-origin CHNWR and CHNSR were classified based on the presence of an adipose fin ("unclipped"). Loss was also calculated for genetically-identified natural-origin CHNWR and CHNSR. The genetically-identified natural-origin CHNWR database for water years 2010 to 2022 was consolidated by DWR, Reclamation, and CDFW (DWR et al. 2023). A collaborative QA/QC process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds (see Section 6.2.7; Condition of Approval 8.4.4) for OMR Management. The genetically-identified natural-origin CHNSR loss database for water years 2017 to 2022 was consolidated by DWR and CDFW and does not include water years 2010 to 2016 (DWR and CDFW 2023b). There are caveats for both the LAD and genetic databases for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss is also potentially inaccurate for both the genetic and LAD database due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility.

Catch data for LAD natural-origin CHNWR and CHNSR from the Knights Landing RST for water years 2010 to 2022 were obtained from the CalFish website (CalFish 2023c). Genetically-identified natural-origin CHNWR and CHNSR catch data from the Knights Landing RST were obtained from the CDFW North Central Region for water years 2017 to 2019 (CDFW 2020b). Catch data for both LAD and genetically-identified natural-origin CHNWR and CHNSR from Sherwood Harbor trawls were collected by the Delta Juvenile Fish Monitoring Program and downloaded from the Environmental Data Initiative (EDI) website (Buttermore et al. 2021b). Sherwood Harbor trawl catch data for LAD natural-origin CHNWR and CHNSR were available for water years 2010 to 2022 and catch data for genetically-identified natural-origin CHNWR and CHNSR were available for water years 2017 to 2021. It is important to note that Chinook Salmon captured at the Knights Landing RST and Sherwood Harbor trawl were subsampled for genetics, so catch of genetically-identified natural-origin CHNWR and CHNSR does not represent the total number of natural-origin CHNWR or CHNSR that may have been encountered. Additionally, catch numbers at the Knights Landing RST and Sherwood Harbor trawl do not constitute total abundance estimates, rather they are catch indices, and should not be used to assess population status. For additional information on data sources and limitations see CDFW (2024b).

To determine historical start of OMR Management for each water year, dates from Attachment 5, Sections 9.3.1.1, 9.3.1.2, and 6.3.1 to the 2024 SWP ITP, which examines when the First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Entrainment Protection Action Conditions of Approval would have been met for water years 2010 to 2022, were analyzed to see if conditions would have triggered Onset of OMR Management earlier than January 1. If First Flush Action, Adult Longfin Smelt Entrainment Protection Action, or Adult Delta Smelt Entrainment Protection Action conditions were not met, an OMR Management start date of January 1 was utilized in this analysis. Note that the Adult Longfin Smelt Entrainment Protection Action would not have historically been triggered between water years 2010 and 2022.

6.2.4.2.2. Evaluation of Juvenile CHNWR and CHNSR Entrainment Period

To evaluate the level of minimization provided by Onset of OMR Management (Condition of Approval 8.3) in minimizing take of CHNWR and CHNSR, timing of natural-origin CHNWR and CHNSR loss at the CVP and SWP export facilities, catch at the Knights Landing RST, and catch at Sherwood Harbor trawl were compared to the start date of OMR Management. For LAD and genetically-identified natural-origin CHNWR, loss data for water years 2010 to 2022 were analyzed for first date of loss for each water year. Length-at-date natural-origin CHNSR loss data for water years 2010 to 2022 and genetically-identified natural-origin CHNSR loss data for 2017 to 2022 were also analyzed for first date of loss. Percent of loss before January 1 was calculated for LAD and genetically-identified natural-origin CHNWR and CHNSR by summing loss prior to January 1 and dividing by total loss at the CVP and SWP export facilities for each water year.

Cumulative daily percent loss at the CVP and SWP export facilities was compared to cumulative daily percent catch from the Knights Landing RST and Sherwood Harbor trawl for both LAD and genetically-identified natural-origin CHNWR and CHNSR. The number of days from January 1 when daily loss and catch of CHNWR and CHNSR at Knights Landing RST and Sherwood Harbor trawl occurred was also evaluated to understand how the timing of CHNWR and CHNSR observations differed between monitoring programs in the context of when OMR Management begins. One-way analysis of variance (ANOVA) tests were used to determine if there were any significant differences in the mean number of days from January 1 across the two monitoring sites and loss at CVP and SWP export facilities. The Tukey method was used to determine which groups were statistically different. Loss and catch data for LAD natural-origin CHNWR and CHNSR were paired, and loss and catch data for genetically-identified natural-origin CHNSR and CHNWR were paired for comparison purposes in these evaluations. Genetic catch data for natural-origin CHNWR and CHNSR were available for both Knights Landing RST and Sherwood Harbor trawl in water years 2017 to 2019, with additional data available for Sherwood Harbor trawl through water year 2021. Cumulative daily percent loss and catch were calculated separately for each monitoring program by summing daily loss and dividing by total loss or summing daily catch and dividing by total catch, respectively, for each water year.

6.2.4.3. Results

6.2.4.3.1. CHNWR Entrainment Period

LAD natural-origin CHNWR:

In 8 out of the 13 years evaluated (water years 2010-2022), LAD natural-origin CHNWR loss occurred before January 1, with the average date of first loss occurring on January 8 (Table 36). When considering the First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action, the Onset of OMR Management would have occurred after the date of first loss for LAD natural-origin CHNWR in 5 of the 13 years analyzed (Figure 43). Across 13 years of analysis, on average, about 10% of the annual combined loss for LAD natural-origin CHNWR occurred prior to January 1.

Table 36. First date of observed loss for LAD natural-origin CHNWR at the CVP and SWP export facilities for water years 2010-2022.

Water Year	Date of First Loss	% Loss by January 1
2010	December 8	0.18%
2011	December 3	5.60%
2012	January 25	0.00%
2013	December 4	32.61%
2014	March 3	0.00%
2015	December 24	41.26%
2016	December 28	15.35%
2017	December 20	20.89%
2018	February 5	0.00%
2019	December 29	0.92%
2020	January 20	0.00%
2021	March 8	0.00%
2022	December 19	12.74%
Average	January 8	9.97%

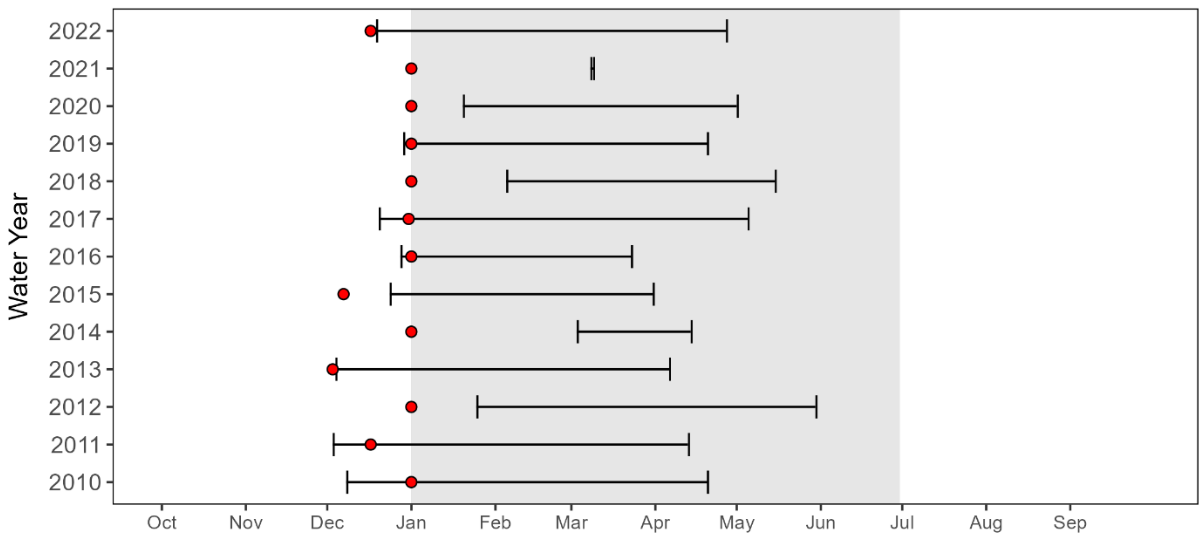

Figure 43. LAD natural-origin CHNWR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for LAD natural-origin CHNWR each water year. The red dots indicate when OMR Management would have started each water year, considering the Onset of OMR Management, First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively.

LAD natural-origin CHNWR catch timing at the Knights Landing RST and Sherwood Harbor trawl was somewhat variable with relation to loss observations at the CVP and SWP export facilities (Figures 44, 45, and 46), although catch at both upstream monitoring locations typically began before loss was observed. Catch usually began at the Knights Landing RST first, which is further upstream on the Sacramento River. Catch of LAD natural-origin CHNWR at Sherwood Harber trawl has continued even after no more loss is observed at the CVP and SWP export facilities. Across all thirteen years combined, the median date of Knights Landing RST LAD natural-origin CHNWR catch occurred before January 1, while the median dates of catch at Sherwood Harbor trawl and loss at the CVP and SWP export facilities occurred several weeks after January 1 (Figure 47).

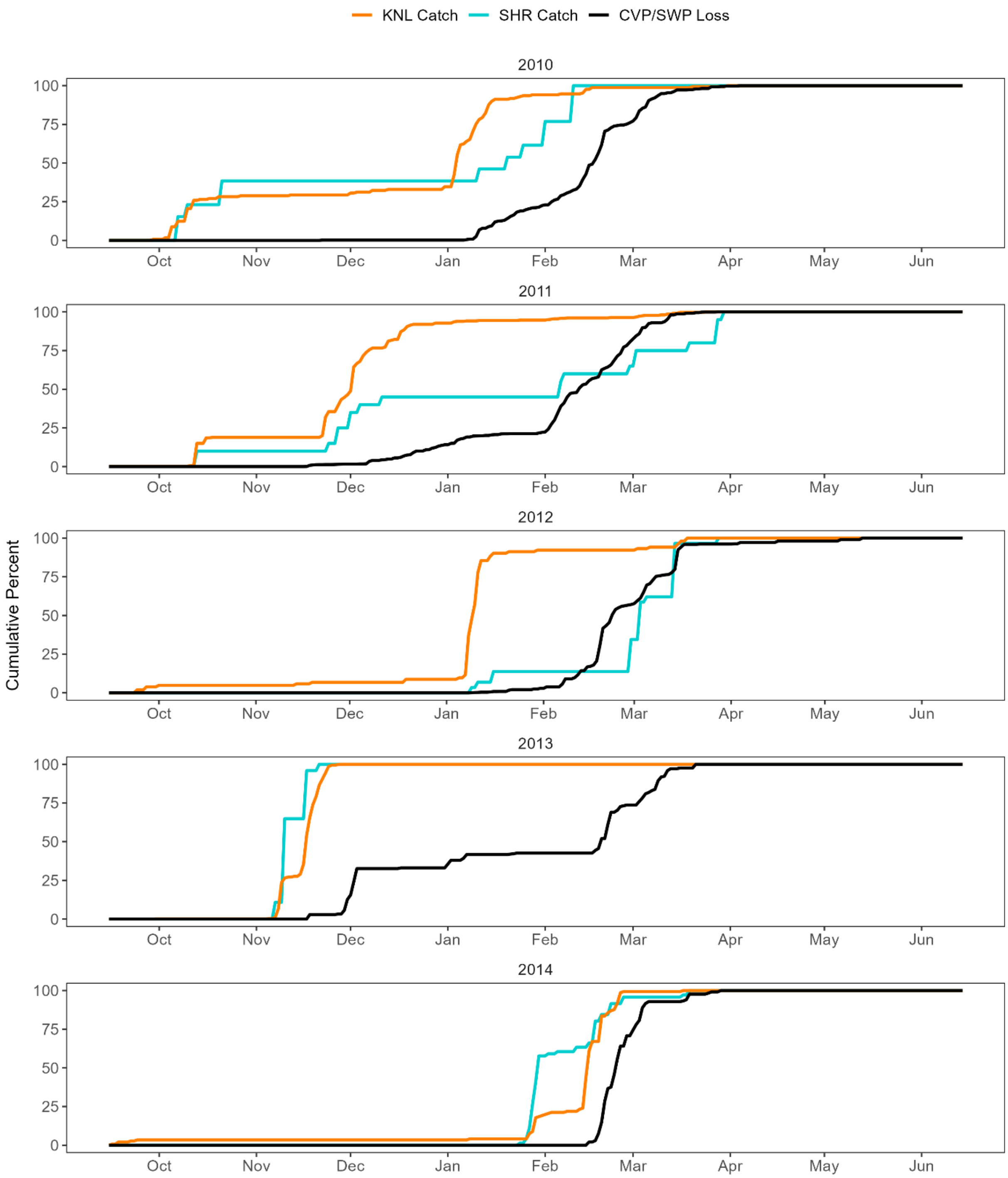

Figure 44. Daily cumulative percent of catch of LAD natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNWR at the CVP and SWP export facilities for water years 2010-2014. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

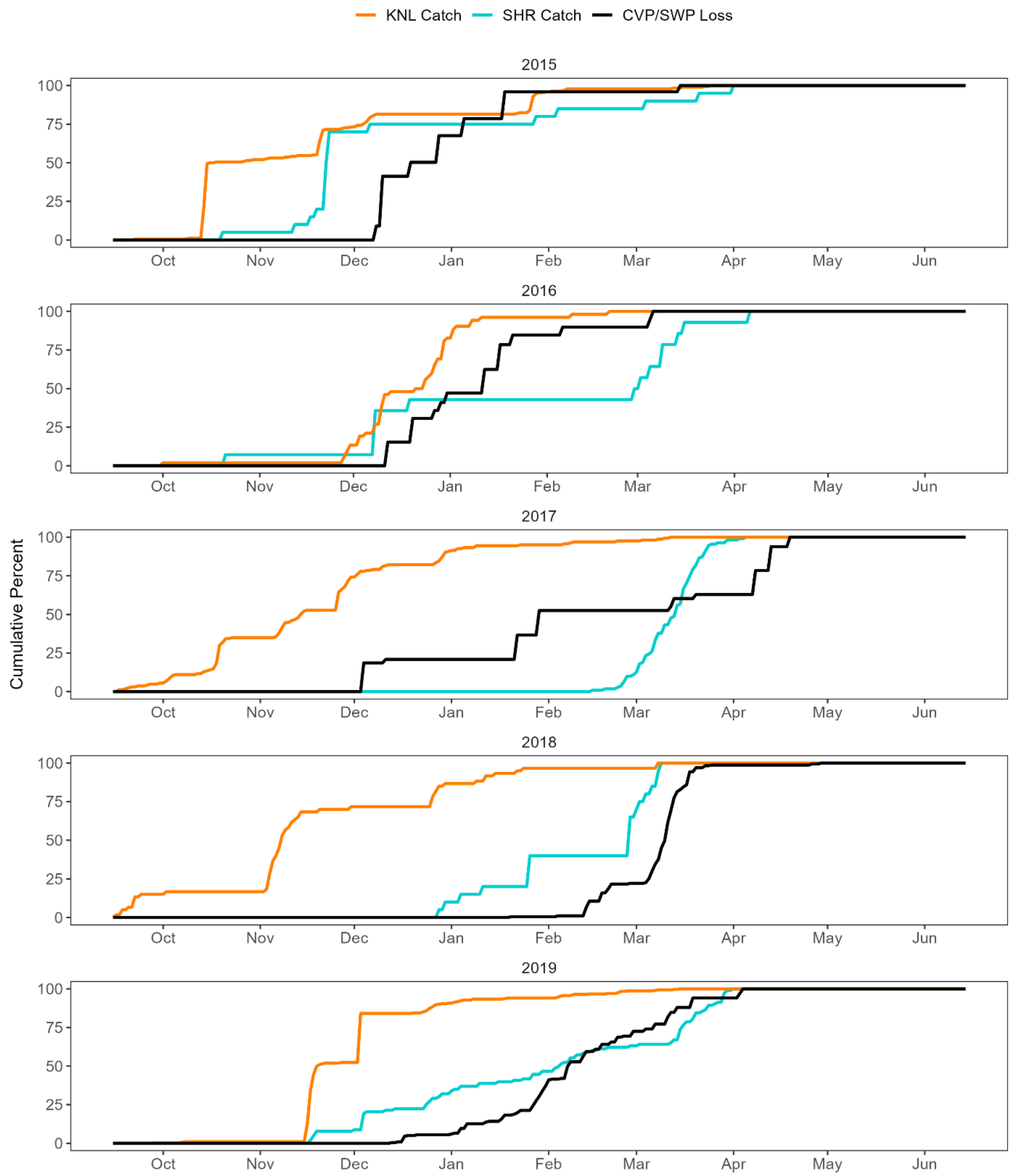

Figure 45. Daily cumulative percent of catch of LAD natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNWR at the CVP and SWP export facilities for water years 2015-2019. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

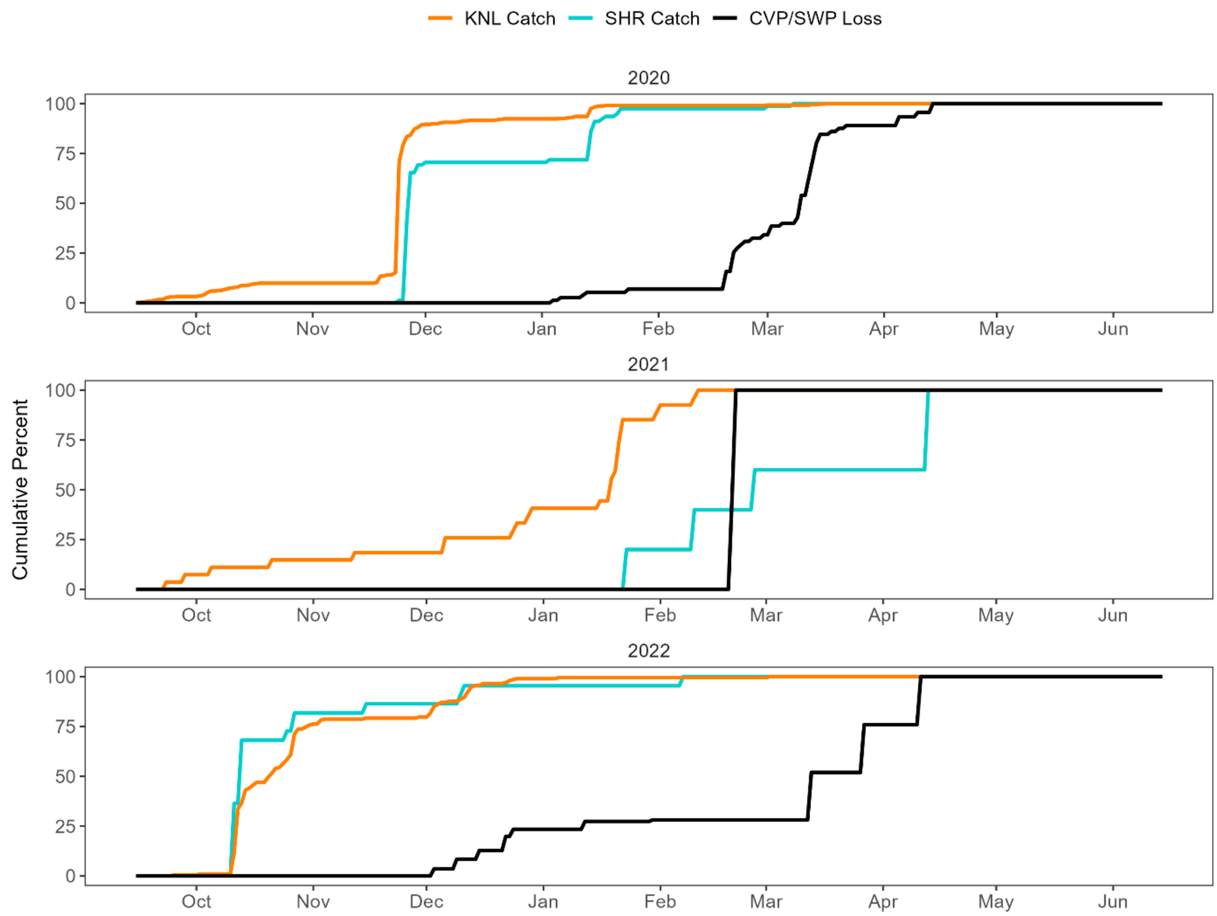

Figure 46. Daily cumulative percent of catch of LAD natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNWR at the CVP and SWP export facilities for water years 2020-2022. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

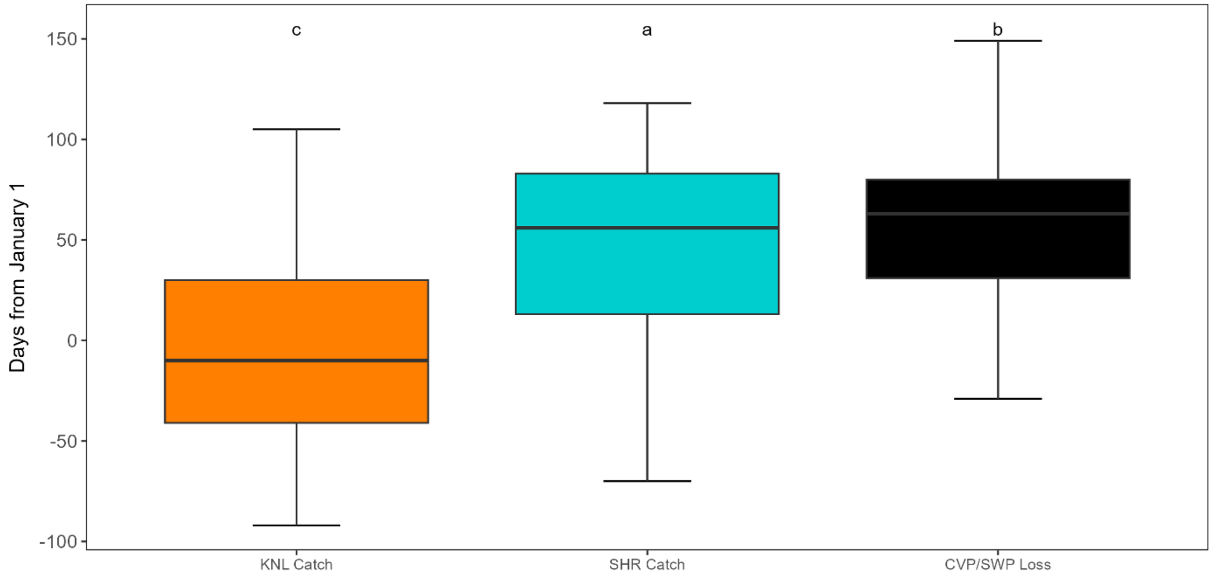

Figure 47. Days from January 1 when daily occurrence of catch of LAD natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily occurrence of loss of LAD natural-origin CHNWR at the CVP and SWP export facilities, occurred for water years 2010-2022. The orange box represents catch at Knights Landing RST (KNL), the blue box represents catch at Sherwood Harbor trawl (SHR), and the black box represents loss at the CVP and SWP export facilities. The black line in the middle of the boxes represents the median day value and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum day values. Outliers [1.5 x (Quartile 3 - Quartile 1)], if present, are represented as points. Letters above the box plots indicate significant differences.

<u>Genetically-identified natural-origin CHNWR</u>:

In 3 out of the 13 years evaluated (water years 2010-2022), genetically-identified natural-origin CHNWR loss occurred before January 1, with the average date of first loss occurring on January 28 (Table 37). In 2 of the 13 water years, loss would have occurred before the start of OMR Management, including consideration of the First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action (water years 2010 and 2011; Figure 48). On average, less than 1% of historical loss for genetically-identified natural-origin CHNWR occurred prior to January 1.

Table 37. First date of observed loss for genetically-identified natural-origin CHNWR at the CVP and SWP export facilities for water years 2010-2022.

Water Year	Date of First Loss	% Loss by January 1
2010	December 8	0.31%
2011	December 6	2.17%
2012	February 14	0.00%
2013	December 13	2.49%
2014	March 3	0.00%
2015	-	0.00%
2016	January 28	0.00%
2017	-	0.00%
2018	March 6	0.00%
2019	January 18	0.00%
2020	March 6	0.00%
2021	March 8	0.00%
2022	-	0.00%
Average	January 28	0.38%

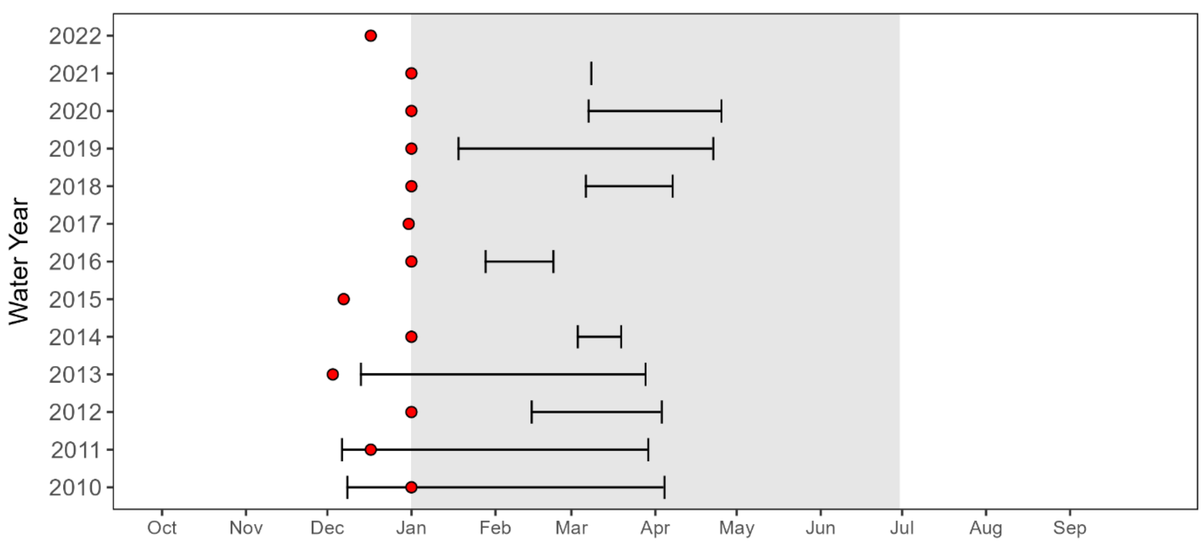

Figure 48. Genetically-identified natural-origin CHNWR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for genetically-identified natural-origin CHNWR each water year. The red dots indicate when OMR Management would have started each water year, considering the Onset of OMR Management, First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively.

Cumulative daily percent loss of genetically-identified natural-origin CHNWR appears to be more closely aligned with cumulative daily percent of catch at Sherwood Harbor trawl compared to the Knights Landing RST (Figure 49). For years that genetic data were available for the three monitoring programs (water years 2017-2019), cumulative daily percent of catch of genetically-identified natural-origin CHNWR occurred first at Knights Landing in 2 out of the 3 years. The median date of catch at the Knights Landing RST occurred after January 1, while timing of catch at Sherwood Harbor trawl and timing of loss at the CVP and SWP export facilities were later but not significantly different from each other (Figure 50).

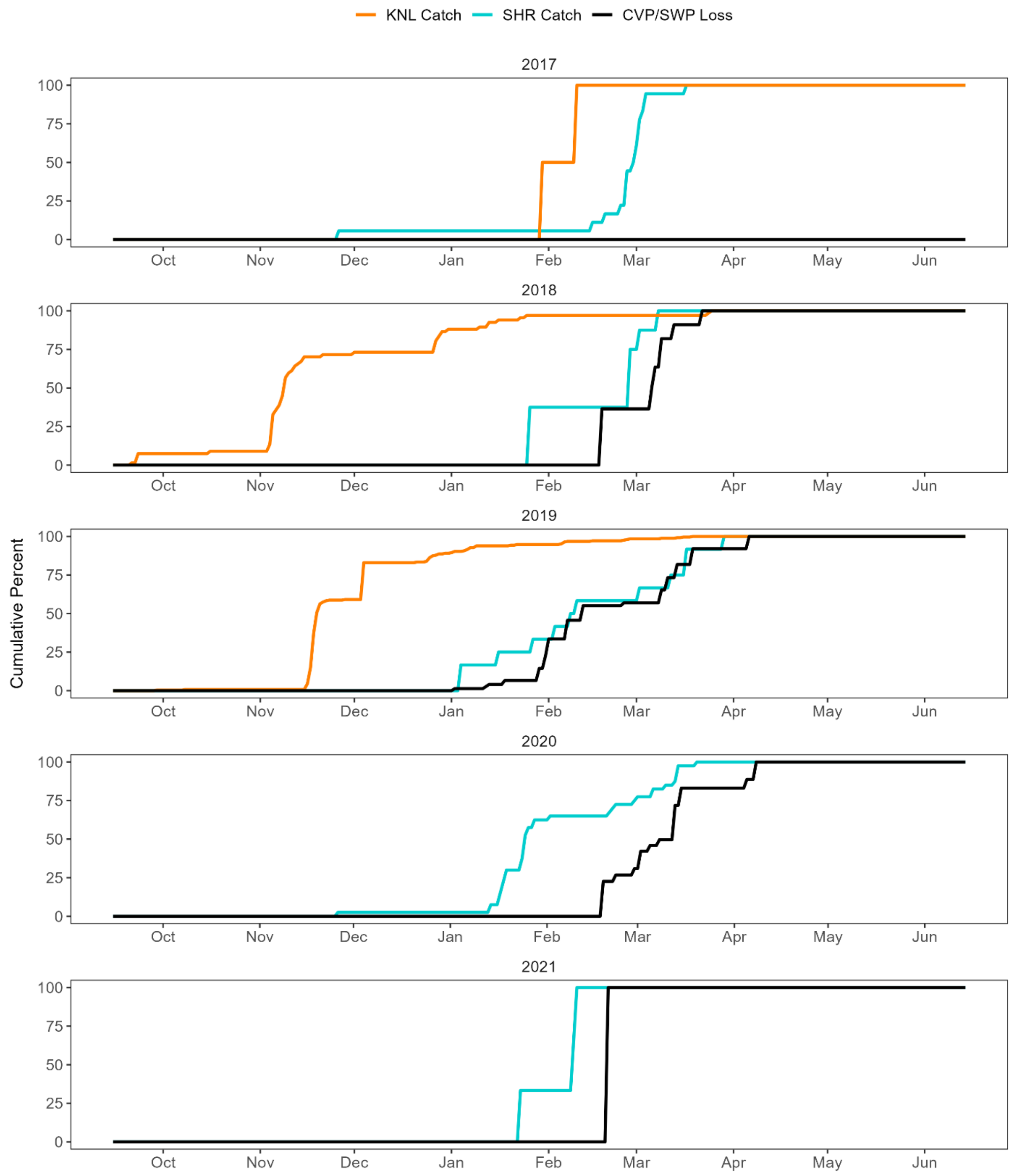

Figure 49. Daily cumulative percent of catch of genetically-identified natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of genetically-identified natural-origin CHNWR at the CVP and SWP export facilities for water years 2017-2021. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities. Genetic samples were not collected at the Knights Landing RST in water years 2020-2021.

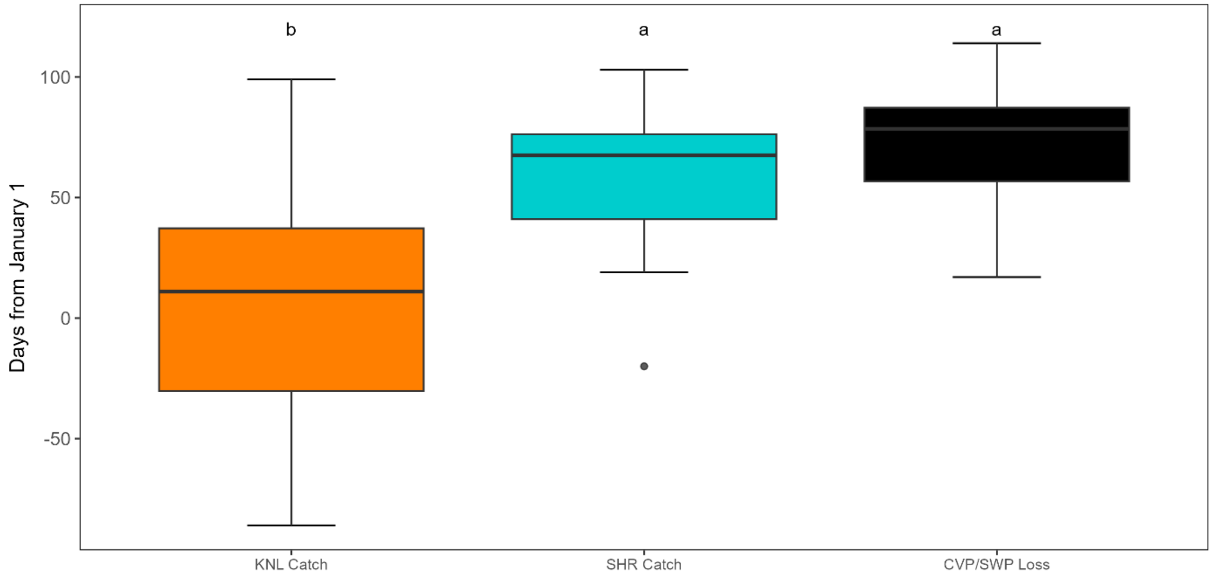

Figure 50. Days from January 1 when daily occurrence of catch of genetically-identified natural-origin CHNWR at Knights Landing RST and Sherwood Harbor trawl, and daily occurrence of loss of genetically-identified natural-origin CHNWR at the CVP and SWP export facilities, has occurred for water years 2017-2021, when available. The orange box represents catch at Knights Landing RST (KNL), the blue box represents catch at Sherwood Harbor trawl (SHR), and the black box represents loss at the CVP and SWP export facilities. Genetic samples were not collected at the Knights Landing RST in water years 2020-2021. The black line in the middle of the boxes represents the median day value and the box encompasses the range of the first and third quantiles. The ends of the whiskers represent the minimum and maximum day values. Outliers [1.5 x (Quartile 3 - Quartile 1)], if present, are represented as points. Letters above the box plots indicate significant differences.

6.2.4.3.2. CHNSR Entrainment Period

LAD natural-origin CHNSR:

Across the 13 years evaluated (water years 2010-2022), the average date of first loss for LAD natural-origin CHNSR occurred on March 7 (Table 38). No LAD natural-origin CHNSR loss occurred before January 1 or before the start of OMR Management, including consideration of the First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action (Figure 51).

Table 38. First date of observed loss for LAD natural-origin CHNSR at the CVP and SWP export facilities for water years 2010-2022.

Water Year	Date of First Loss	% Loss by January 1
2010	March 9	0.00%
2011	January 3	0.00%
2012	March 10	0.00%
2013	March 17	0.00%
2014	March 13	0.00%
2015	March 30	0.00%
2016	February 11	0.00%
2017	February 16	0.00%
2018	March 14	0.00%
2019	February 19	0.00%
2020	March 18	0.00%
2021	March 29	0.00%
2022	April 11	0.00%
Average	March 7	0.00%

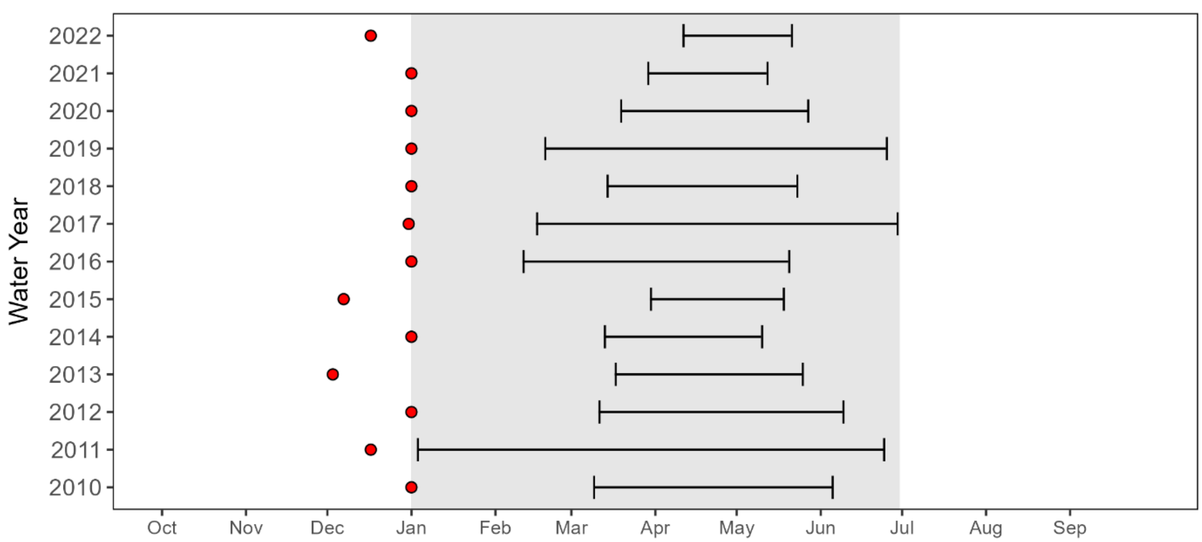

Figure 51. LAD natural-origin CHNSR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for LAD natural-origin CHNSR each water year. The red dots indicate when OMR Management would have started each water year, considering the Onset of OMR Management, First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively.

Catch of LAD natural-origin CHNSR at the Knights Landing RST usually began earlier and ends earlier than catch at Sherwood Harbor trawl or loss at the CVP and SWP export facilities (Figures 52, 53, and 54). For all water years combined, the median date of catch and loss of LAD natural-origin CHNSR occurred several months after January 1 and the dates were staggered earliest to latest moving from upstream to downstream (Figure 55).

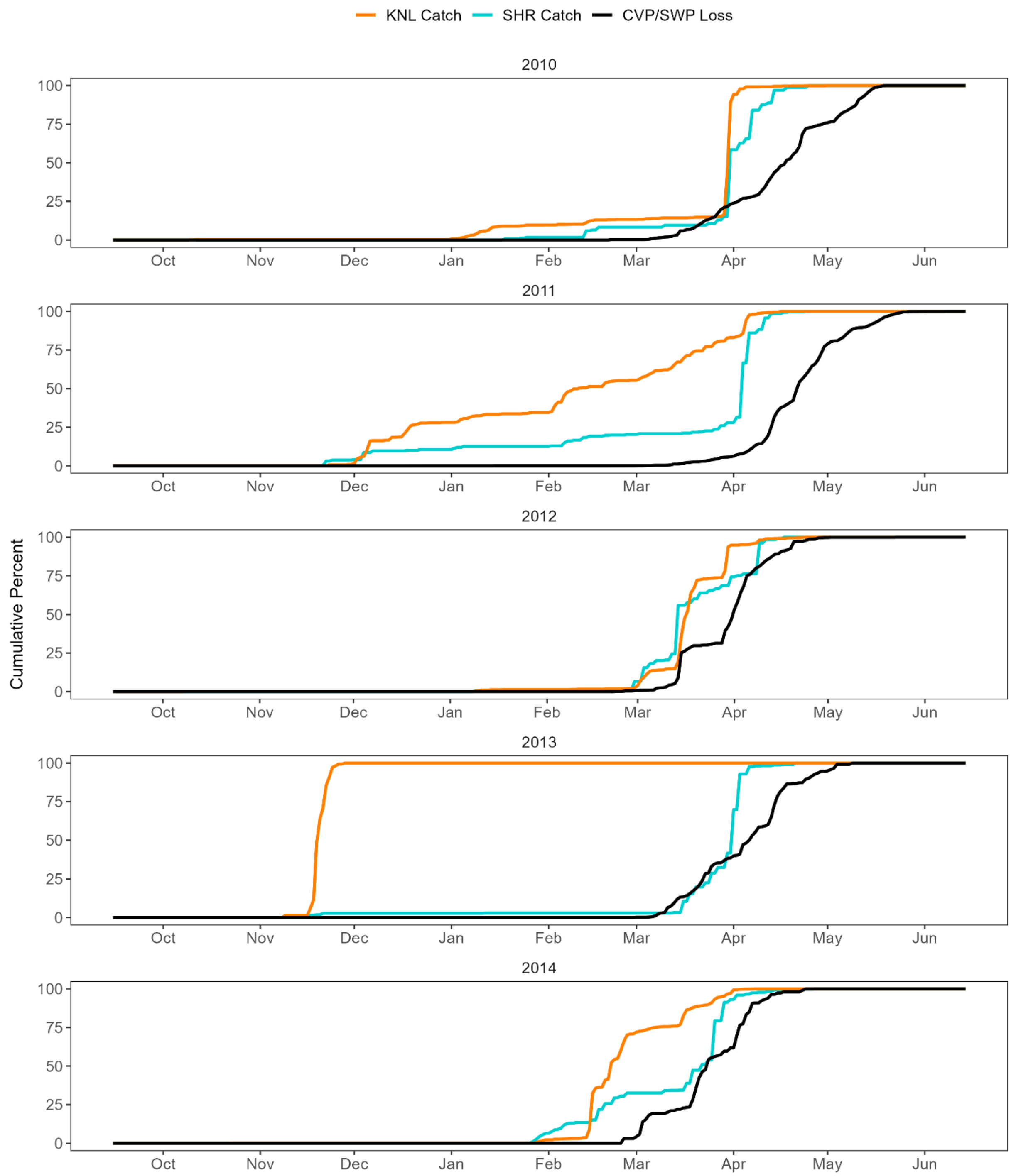

Figure 52. Daily cumulative percent of catch of LAD natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNSR at the CVP and SWP export facilities for water years 2010-2014. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

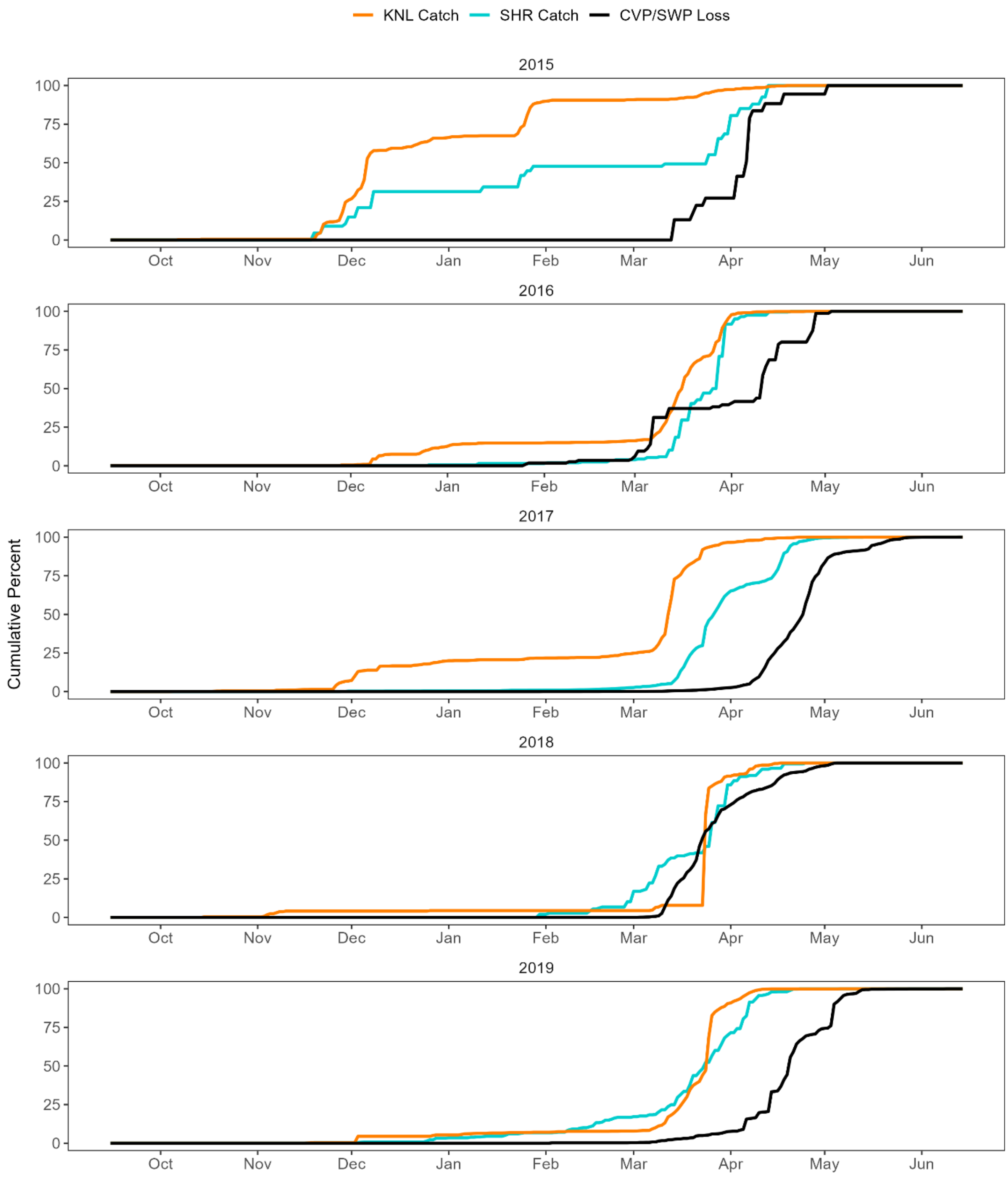

Figure 53. Daily cumulative percent of catch of LAD natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNSR at the CVP and SWP export facilities for water years 2015-2019. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

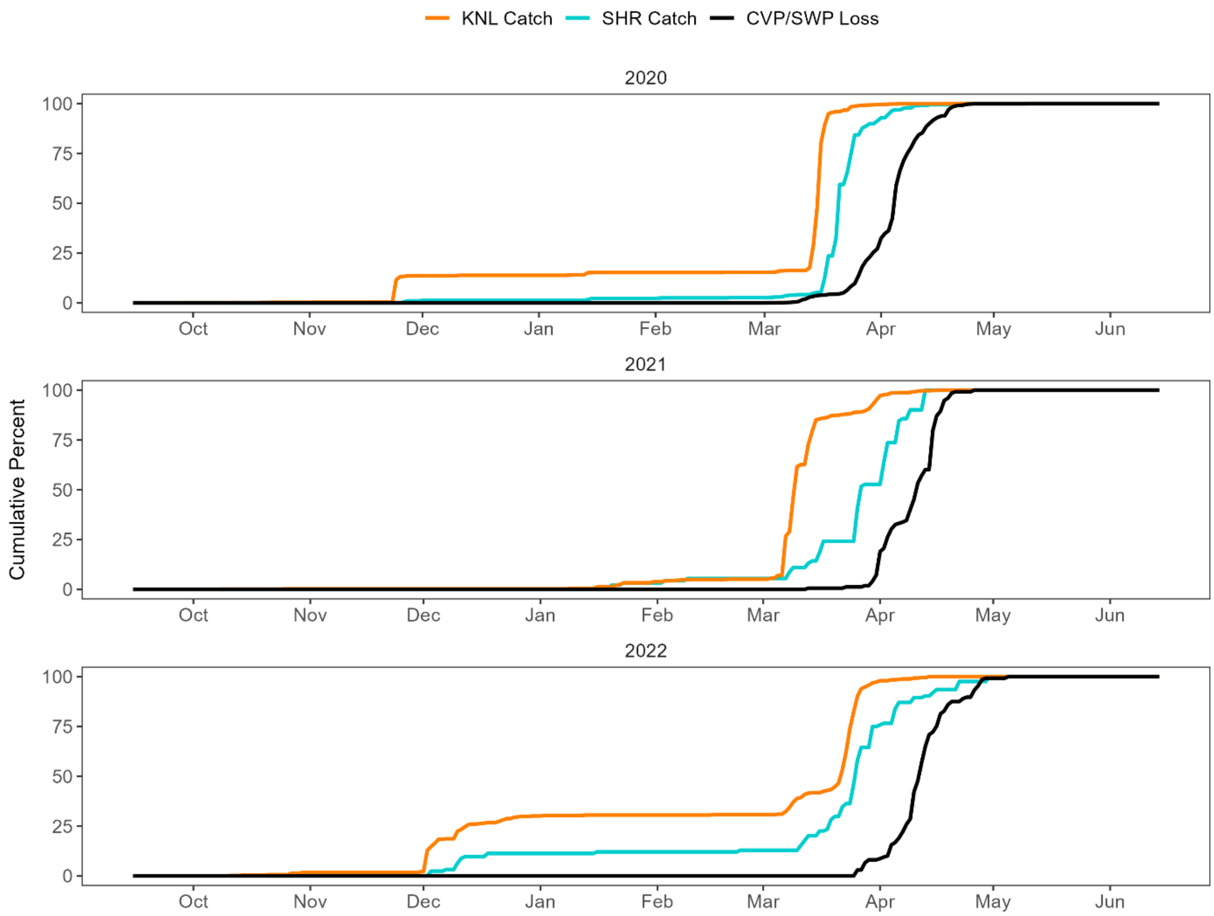

Figure 54. Daily cumulative percent of catch of LAD natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of LAD natural-origin CHNSR at the CVP and SWP export facilities for water years 2020-2022. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities.

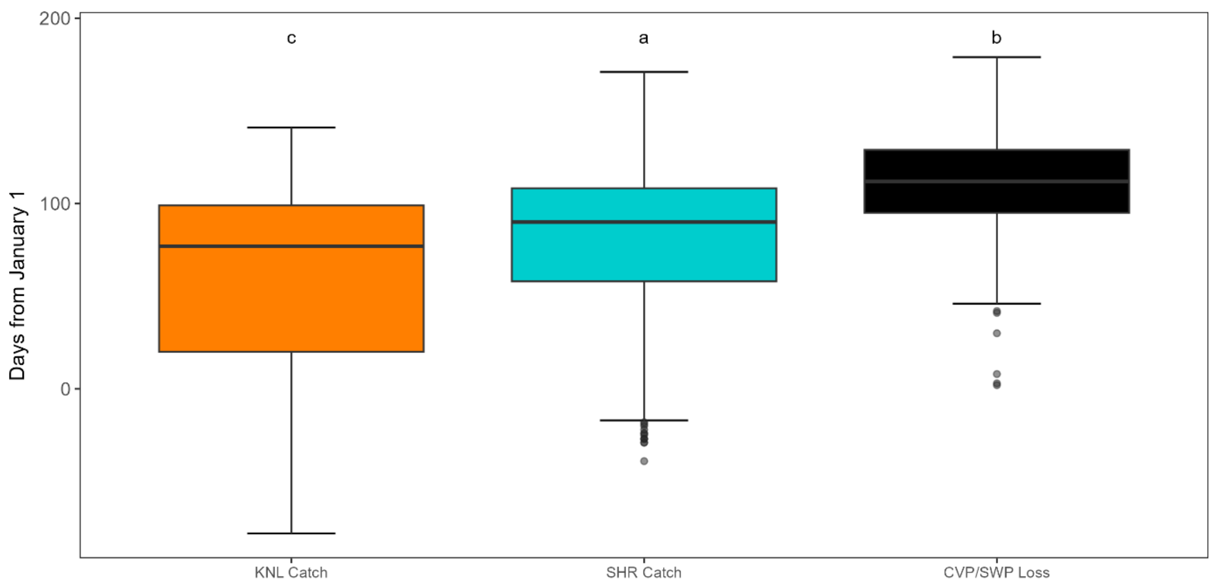

Figure 55. Days from January 1 when daily occurrence of catch of LAD natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily occurrence of loss of LAD natural-origin CHNSR at the CVP and SWP export facilities, occurred for water years 2010-2022. The orange box represents catch at Knights Landing RST (KNL), the blue box represents catch at Sherwood Harbor trawl (SHR), and the black box represents loss at the CVP and SWP export facilities. The black line in the middle of the boxes represents the median day value and the box encompasses the range of the first and third quantiles. The ends of the whiskers represent the minimum and maximum day values. Outliers [1.5 x (Quartile 3 - Quartile 1)], if present, are represented as points. Letters above the box plots indicate significant differences.

Genetically-identified natural-origin CHNSR:

Across the 13 years evaluated (water years 2010-2022), the average date of first loss for genetically-identified natural-origin CHNSR occurred on March 11, a few days after the average LAD natural-origin CHNSR date of first loss (Table 39). No genetically-identified natural-origin CHNSR loss occurred before January 1 or before the start of OMR Management, including consideration of the First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action (Figure 56). Almost all loss for genetically-identified natural-origin CHNSR took place during OMR Management; however, one genetically-identified natural-origin CHNSR was observed in salvage in July of water year 2017 (Figure 56).

Table 39. First date of observed loss for genetically-identified natural-origin CHNSR at the CVP and SWP export facilities for water years 2017-2022.

Water Year	Date of First Loss	% Loss by January 1
2017	January 21	0.00%
2018	March 25	0.00%
2019	March 16	0.00%
2020	April 7	0.00%
2021	May 12	0.00%
2022	January 7	0.00%
Average	March 11	0.00%

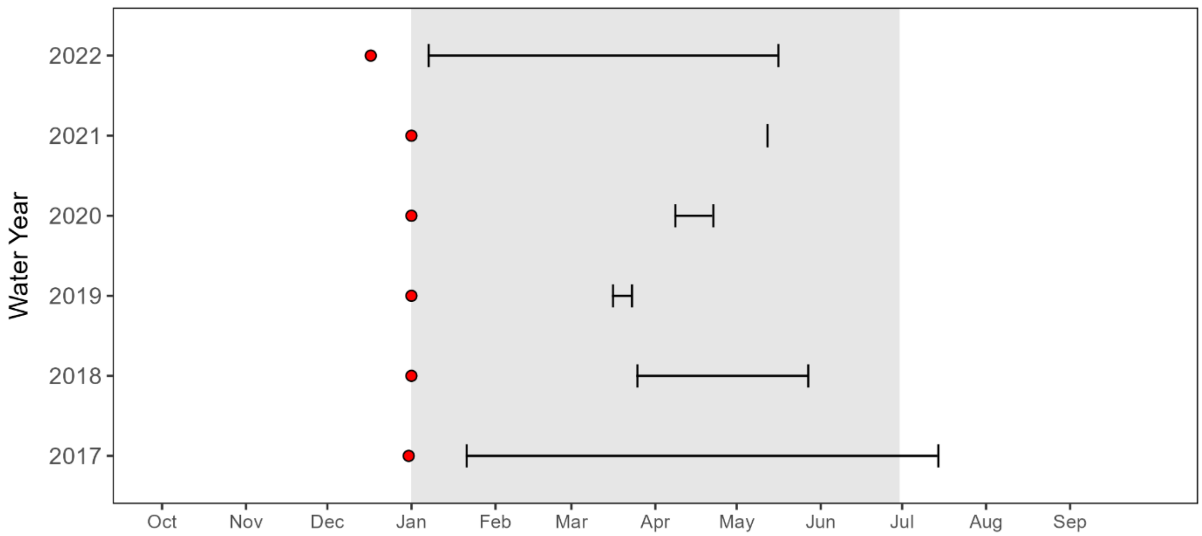

Figure 56. Genetically-identified natural-origin CHNSR entrainment period at the CVP and SWP export facilities for water years 2017-2022. The vertical bars on the ends of each line indicate the first and last date of loss for genetically-identified natural-origin CHNSR each water year. The red dots indicate when OMR Management would have started each water year, considering the Onset of OMR Management, First Flush Action, Adult Longfin Smelt Entrainment Protection Action, and Adult Delta Smelt Protection Action. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively.

For years that genetic data were available across the three monitoring programs (water years 2017-2019), cumulative daily percent of catch of genetically-identified natural-origin CHNSR usually occurred first at the Knights Landing RST, followed by Sherwood Harbor trawl, and lastly loss was observed at the CVP and SWP export facilities (Figure 57). For all water years combined, the median date of catch and loss of genetically-identified natural-origin CHNSR occurred several months after January 1, and the dates were staggered earliest to latest moving from upstream to downstream (Figure 58). The median date of catch of genetically-identified natural-original CHNSR at the Knights Landing RST occurred earlier than for LAD CHNSR, but most catch occurred after the start of OMR Management.

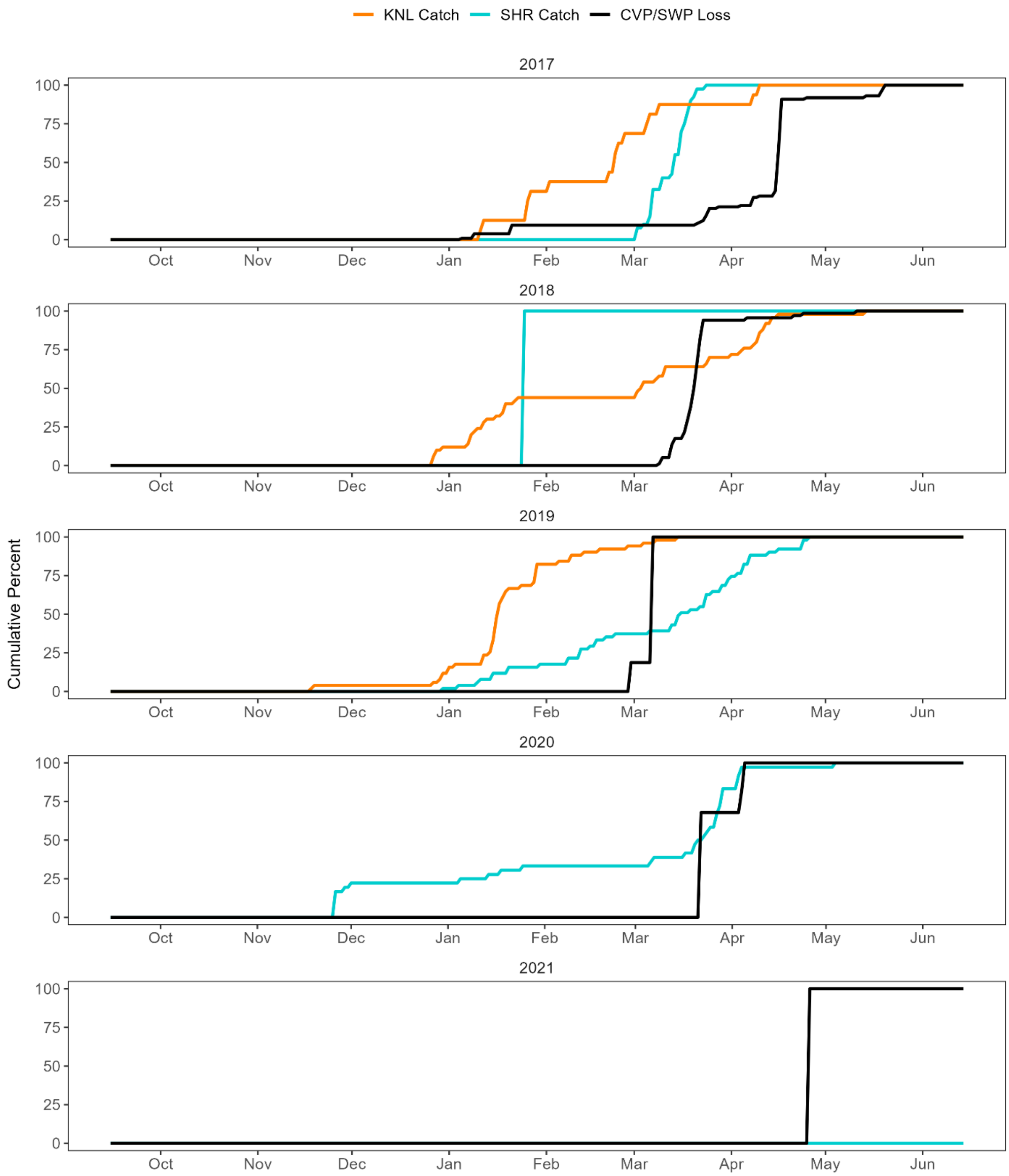

Figure 57. Daily cumulative percent of catch of genetically-identified natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily cumulative percent loss of genetically-identified natural-origin CHNSR at the CVP and SWP export facilities for water years 2017-2021. The orange line represents catch at Knights Landing RST (KNL), the blue line represents catch at Sherwood Harbor trawl (SHR), and the black line represents loss at the CVP and SWP export facilities. Genetic samples were not collected at the Knights Landing RST in water years 2020-2021.

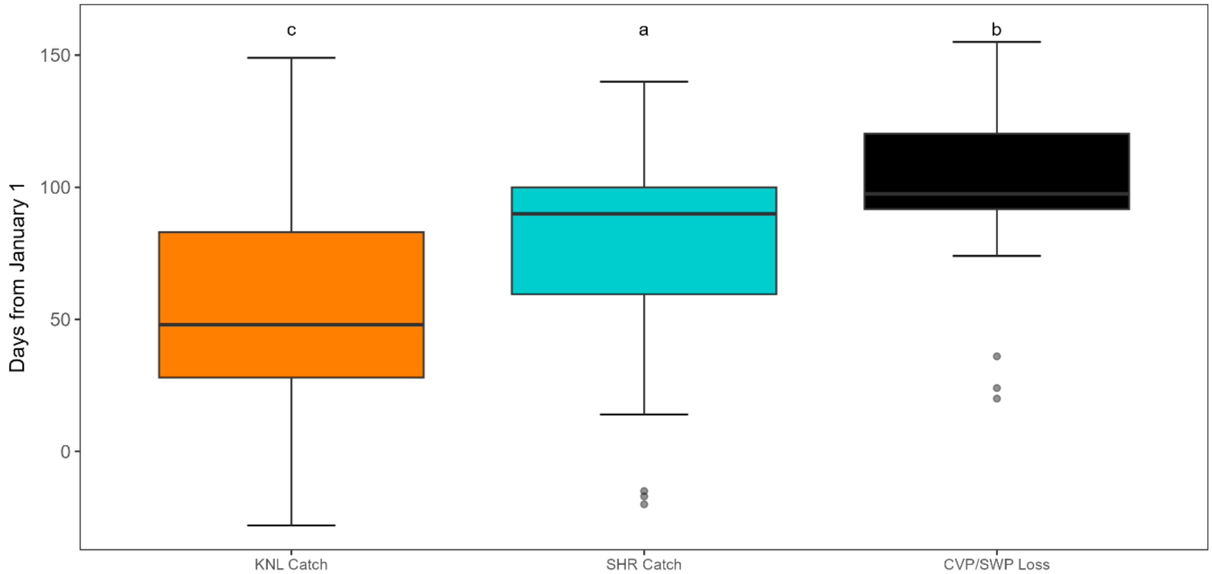

Figure 58. Days from January 1 when daily occurrence of catch of genetically-identified natural-origin CHNSR at Knights Landing RST and Sherwood Harbor trawl, and daily occurrence of loss of genetically-identified natural-origin CHNSR at the CVP and SWP export facilities, occurred for water years 2017-2021, when available. The orange box represents catch at Knights Landing RST (KNL), the blue box represents catch at Sherwood Harbor trawl (SHR), and the black box represents loss at the CVP and SWP export facilities. Genetic samples were not collected at the Knights Landing RST in water years 2020-2021. The black line in the middle of the boxes represents the median day value and the box encompasses the range of the first and third quantiles. The ends of the whiskers represent the minimum and maximum day values. Outliers [1.5 x (Quartile 3 - Quartile 1)], if present, are represented as points. Letters above the box plots indicate significant differences.

6.2.4.4. Discussion

For natural-origin CHNWR, both LAD and genetically-identified loss at the CVP and SWP export facilities historically occurred before January 1 but more commonly occurred after the start of OMR Management. For natural-origin CHNSR, all LAD and genetically-identified loss at the CVP and SWP export facilities occurred during the OMR Management period, except for one genetically-identified natural-origin CHNSR observed in salvage in July of water year 2017. These trends in historical loss illustrate the importance of OMR Management for minimizing take by reducing exports and targeting less negative OMR flows during times when CHNWR and CHNSR are present in the Delta. Timing of hatchery-origin CHNWR and CHNSR observations in salvage were not analyzed since historical releases, and future releases, occur during OMR Management.

Relationships between catch of CHNWR and CHNSR at monitoring locations and loss at the CVP and SWP export facilities are intuitive both temporally and spatially, as the Knights Landing RST is further upstream on the Sacramento River and would be encountered earlier by outmigrating juvenile Chinook Salmon than the other two downstream monitoring locations. This concept matches the general pattern of CHNWR and CHNSR catch beginning and ending earlier at the Knights Landing RST compared to catch at Sherwood Harbor trawl and loss at the CVP and SWP export facilities. Historical catch of Chinook Salmon at Knights Landing and Sherwood Harbor shows that juvenile CHNWR, and in some years CHNSR, are entering the Delta prior to the start of OMR Management. Using travel speeds identified in Hendrix et al. (2017), salmonids can enter the Delta within 2.5 days after detection at Knights Landing. Given that Knights Landing RST does not provide a passage estimate for salmonids nor is it 100% effective at catching all salmonids in the Sacramento River, it is therefore reasonable to assume that salmonids may pass Knights Landing even earlier than documented by sampling. Catch at the Knights Landing RST and the Sherwood Harbor trawl before January 1 can provide an early indicator of juvenile Chinook Salmon entry into the Delta.

Condition of Approval 8.3 will minimize take, and related impacts of the taking, of juvenile CHNWR and CHNSR, by limiting negative OMR flows during juvenile CHNWR and CHNSR migration through the Delta. An OMR flow of -5,000 cfs limits the degree to which CVP and SWP exports incrementally increase routing of juvenile CHNWR and CHNSR into distributaries leading into the interior Delta from the Sacramento and San Joaquin rivers (SST 2017).

Early migrating juvenile Chinook Salmon entering the Delta before the start of OMR Management will likely encounter more negative OMR flows and face a greater risk of entrainment into the interior Delta, which can result in exposure to higher predation, degraded habitat, and poorer outmigration conditions. The Natural-origin Winter-run Chinook Salmon Early Season Weekly Loss Thresholds in November and December (see Section 6.2.5; Condition of Approval 8.2.1) are intended to minimize take of early migrating CHNWR that are present in the Delta prior to OMR Management by limiting OMR flows to no more negative than -5,000 cfs for seven days when weekly loss thresholds are exceeded prior to January 1. DS actions like the First Flush Action (see Section 6.6; Condition of Approval 8.3.1) may also minimize take of early migrating juvenile CHNWR and CHNSR but are not expected to occur every year.

6.2.5. Condition of Approval 8.2.1 Natural-Origin Winter-Run Chinook Salmon Early Season Weekly Loss Thresholds

6.2.5.1. Introduction

Condition of Approval 8.2.1 was developed collaboratively between CDFW, NMFS, DWR, and Reclamation to minimize take and related impacts of the taking of genetically-identified natural-origin CHNWR before the Onset of OMR Management (see Section 6.2.4; Condition of Approval 8.3). The CHNWR early season weekly loss thresholds accompany the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and weekly distributed loss threshold (see Section 6.2.7; Condition of Approval 8.4.4), and acts as a minimization measure to reduce the likelihood of exceeding the total annual loss threshold. Condition of Approval 8.2.1 defines a weekly loss threshold to provide entrainment minimization for genetically-identified natural-origin CHNWR in November and December. OMR Management can begin any time after December 1 if a First Flush Action (see Section 6.6; Condition of Approval 8.3.1) or Adult Longfin Smelt Entrainment Protection Action (See Section 6.6; Condition of Approval 8.3.3) occur or any time after December 20 if an Adult Delta Smelt Entrainment Protection Action (see Section 6.6; Condition of Approval 8.3.2) occurs. If neither of these actions occur, OMR Management starts automatically on January 1. Therefore, Condition of Approval 8.2.1 was developed to reduce take of early migrating natural-origin CHNWR moving through the Delta in November and December.

Changes in OMR flows will be initiated within three days following a weekly loss threshold exceedance prior to OMR Management to minimize additional subsequent entrainment and loss of CHNWR at the CVP and SWP export facilities in the south Delta. Specifically, Condition of Approval 8.2.1 aims to protect early migrating juvenile CHNWR in November and December before the start of OMR Management. Condition of Approval 8.2.1 requires DWR to reduce exports to achieve a 7-day average OMR index no more negative than -5,000 cfs for seven consecutive days when the 7-day rolling sum of genetically-identified natural-origin CHNWR loss at the CVP and SWP export facilities exceeds the following thresholds (see Section 6.2.5.2.2 below and Attachment 2 to the 2024 SWP ITP for calculation details):

- From November 1 through November 30: Product of November Multiplier and the Red Bluff Diversion Dam juvenile CHNWR brood year passage total at the end of the second biweekly period in October, whereby the November Multiplier is:

  November Multiplier = 0.0011 x 0.25 x $Survival_{Fry\text{-}to\text{-}Smolt}$ x $Survival_{Smolt}$

- From December 1 through December 31: Produce of December Multiplier and the Red Bluff Diversion Dam juvenile CHNWR brood year passage total estimated at the end of the second biweekly period in November, whereby the December Multiplier is:

  December Multiplier = 0.0021 x 0.25 x $Survival_{Fry\text{-}to\text{-}Smolt}$ x $Survival_{Smolt}$

Consistent with Conditions of Approval 8.4.3 and 8.4.4, OMR action responses for loss associated with the Natural-origin Winter-run Chinook Salmon Early Season Weekly Loss Thresholds will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon and may be adjusted, pending genetic analyses. Loss of natural-origin CHNWR will be genetically confirmed through SHERLOCK and GT-seq methods. If genetic analysis of a natural-origin older juvenile Chinook Salmon observed in salvage at the CVP and SWP export facilities indicates that any given juvenile Chinook Salmon is not a genetically-identified CHNWR, the fish will not count toward the weekly loss thresholds. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment. Additionally, if genetic identification is pending or if genetic identification is not possible, OMR action responses will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.2.1 (Natural-origin Winter-Run Chinook Salmon Early Season Weekly Loss Thresholds) in minimizing take of juvenile natural-origin CHNWR before the Onset of OMR Management.

6.2.5.2. Methods

6.2.5.2.1. Data Retrieval

For this analysis, salvage data of natural-origin Chinook Salmon collected at the CVP and SWP export facilities in water years 2010 to 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see

Attachment 8 to the 2024 SWP ITP; CDFW 2018). For the analysis of the weekly loss thresholds, loss was calculated for genetically-identified natural-origin CHNWR. The genetically-identified natural-origin CHNWR database for water years 2010 to 2022 was consolidated by DWR, Reclamation, and CDFW (DWR et al. 2023). A collaborative QA/QC process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds (see Section 6.2.7; Condition of Approval 8.4.4) for OMR Management. However, there are caveats to the database for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss for both the genetic and LAD database is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on salvage data sources and limitations, see CDFW (2024b).

Catch data for natural-origin CHNWR from the RBDD RST were obtained from USFWS for water years 2010 to 2022 (USFWS 2023a).

6.2.5.2.2. Development of Natural-Origin CHNWR Early Season Weekly Loss Thresholds

The CHNWR early season weekly loss thresholds are in effect in November and December, prior to the issuance of the annual CHNWR JPE for the brood year. In lieu of having a CHNWR JPE for the brood year, the CHNWR early season weekly loss thresholds were developed as the product of cumulative biweekly CHNWR passage estimates at RBDD RST and a Multiplier (see Attachment 2 to the 2024 SWP ITP). The November threshold is calculated using the seasonal passage to date from the second biweekly RBDD RST CHNWR passage estimate in October. The December threshold is calculated using the seasonal passage to date from the second biweekly RBDD RST CHNWR passage estimate in November. The multiplier, applied to both November and December thresholds, is the product of the estimated percent of juvenile CHNWR present in the Delta for a given month[9] scaled to week (multiplied by 0.25), fry-to-smolt survival ($\text{Survival}_{\text{Fry-to-Smolt}}$), and smolt survival from RBDD to the Delta ($\text{Survival}_{\text{Smolt}}$).

$$\text{November Multiplier: } 0.0011 \times 0.25 \times \text{Survival}_{\text{Fry-to-Smolt}} \times \text{Survival}_{\text{Smolt}}$$

$$\text{December Multiplier: } 0.0021 \times 0.25 \times \text{Survival}_{\text{Fry-to-Smolt}} \times \text{Survival}_{\text{Smolt}}$$

For brood year 2022, the following variables apply to the November and December Multipliers using survival terms from the brood year 2022 JPE letter (WR PWT 2023):

$$\text{November Multiplier: } 0.0011 \times 0.25 \times 0.4946 \times 0.3245 = 0.0044\%$$

$$\text{December Multiplier: } 0.0021 \times 0.25 \times 0.4946 \times 0.3245 = 0.0084\%$$

[9] The November and December estimated percent of juvenile CHNWR present in the Delta are based on Table 4 of 2024 SWP ITP (see Table 46 of this Effects Analysis), which includes calculated values for the percent of CHNWR present in the Sherwood Harbor trawl (Delta entry) and the percent of CHNWR present in Chipps Island trawl (Delta exit), as determined by genetic analyses for water years 2017-2022. For the first week of January (January 1-7), Table 46 indicates that 0.32% of CHNWR are historically present in the Delta (scaled to 100%; Column E). The November Multiplier assumes that one third of CHNWR presence in the Delta by the first week of January occurred as early as November (one third of 0.32% = 0.0011). The December Multiplier assumes that two thirds of CHNWR presence in the Delta by the first week of January occurred as early as December (two thirds of 0.32% = 0.0021).

where 0.0011 and 0.0021 represent the estimated percent of juvenile CHNWR present in the Delta for November and December, respectively, 0.25 represents one quarter of the month or approximately one week, 0.4946 is the fry-to-smolt survival term based on O'Farrell et al. (2018), and 0.3245 is the smolt survival term from RBDD to the Delta.

In subsequent years, the fry-to-smolt survival term and the smolt survival term from RBDD to the Delta will be updated annually during the CHNWR brood year's JPE process; therefore, the November and December Multipliers may change slightly (see Attachment 2 to the 2024 SWP ITP).

6.2.5.2.3. Evaluation of Natural-Origin CHNWR Early Season Weekly Loss Threshold Exceedances and Action Response Days

Weekly loss thresholds were applied to historical loss of genetically-identified natural-origin CHNWR at the CVP and SWP export facilities in water years 2010 to 2022 to evaluate the how often threshold exceedances would have occurred and how many days of OMR action response would have resulted. Weekly loss thresholds were calculated for water years 2010 to 2022 as a product of the cumulative biweekly CHNWR passage estimates at RBDD RST and the November and December Multipliers, assuming the percentage calculated for brood year 2022. Juvenile CHNWR passage estimates are available on a biweekly basis and provide total cumulative passage for the season to date for each brood year. Brood year totals for juvenile CHNWR were acquired from the end of the second biweekly period in October and the end of the second biweekly period in November in water years 2010 through 2022 for calculating the November and December weekly loss thresholds, respectively. The most up to date trap efficiency estimates and updated genetic data were used to estimate total natural-origin CHNWR passage. The calculated weekly loss threshold for November applies to the entire month of November, whereas the calculated weekly loss threshold for December applies to the entire month of December.

The weekly loss thresholds were compared to historical loss of genetically-identified natural-origin CHNWR at CVP and SWP export facilities. Data were limited to include November and December loss for each water year. A 7-day rolling sum of genetically-identified natural-origin CHNWR loss was calculated, summing loss over the current day and the six previous consecutive days. The 7-day rolling sum of loss was then compared to the corresponding weekly loss threshold for each corresponding month and water year. Threshold exceedances were recorded when the cumulative 7-day sum of loss on any single day exceeded the weekly loss threshold. For each threshold exceedance, an OMR action response, whereby OMR flow is managed to achieve a 7-day average of no more negative than -5,000 cfs, is initiated for seven consecutive days. If an additional threshold exceedance occurs within the 7-day action response, the action response starts over at day one rather than stacking in a cumulative manner. Threshold exceedance days and action response days were summed both by month and by water year to understand trends across different metrics.

6.2.5.3. Results

The weekly loss thresholds for November and December varied among water years (Table 40) due to the inter-annual variation in biweekly RBDD RST CHNWR passage. The highest threshold occurred in December of water year 2010, which had the greatest November CHNWR brood year total passage (n = 4,265,212), followed by December of water year 2020 (n = 3,512,199).

Table 40. November and December natural-origin CHNWR early season weekly loss thresholds for each water year as a product of cumulative biweekly CHNWR passage estimates at RBDD RST and the November and December Multipliers.

Water Year	October RBDD Passage Total	November Weekly Threshold	November RBDD Passage Total	December Weekly Threshold
2010	4,200,154	184.81	4,265,212	358.28
2011	859,723	37.83	1,147,634	96.40
2012	605,096	26.62	715,357	60.09
2013	642,542	28.27	953,914	80.13
2014	845,991	37.22	1,248,598	104.88
2015	279,948	12.32	354,873	29.81
2016	217,488	9.57	252,677	21.23
2017	363,832	16.01	484,841	40.73
2018	319,580	14.06	658,218	55.29
2019	644,547	28.36	897,283	75.37
2020	2,893,314	127.31	3,512,199	295.03
2021	1,484,411	65.31	1,840,939	154.64
2022	434,699	19.13	549,296	46.14

No genetically-identified natural-origin CHNWR loss occurred during the month of November in water years 2010 through 2022. Genetically-identified natural-origin CHNWR loss occurred in December during water years 2010, 2011, and 2013 (Figure 59) with the earliest recorded date of loss occurring on December 8, 2009. The 7-day rolling sum of loss of genetically-identified natural-origin CHNWR ranged from 1.95 to 25.21 fish during the month of December. The 7-day rolling sum of loss of genetically-identified natural-origin CHNWR never exceeded the weekly loss thresholds; therefore, there were zero threshold exceedances in November and December and zero OMR action response days (Figures 59, 60, and 61).

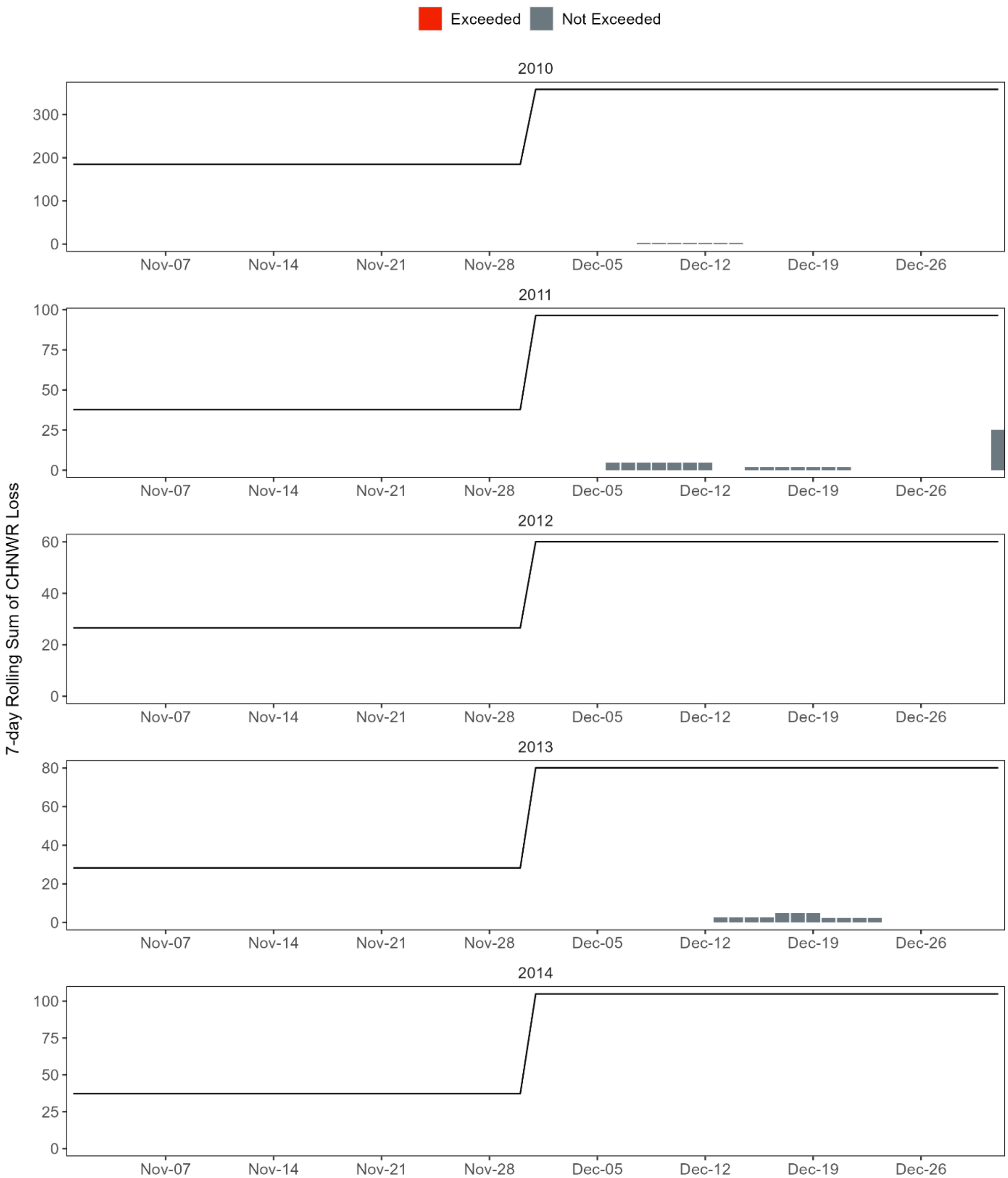

Figure 59. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day in November and December for water years 2010-2014. The black line represents the natural-origin CHNWR early season weekly loss thresholds. Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR early season weekly loss threshold.

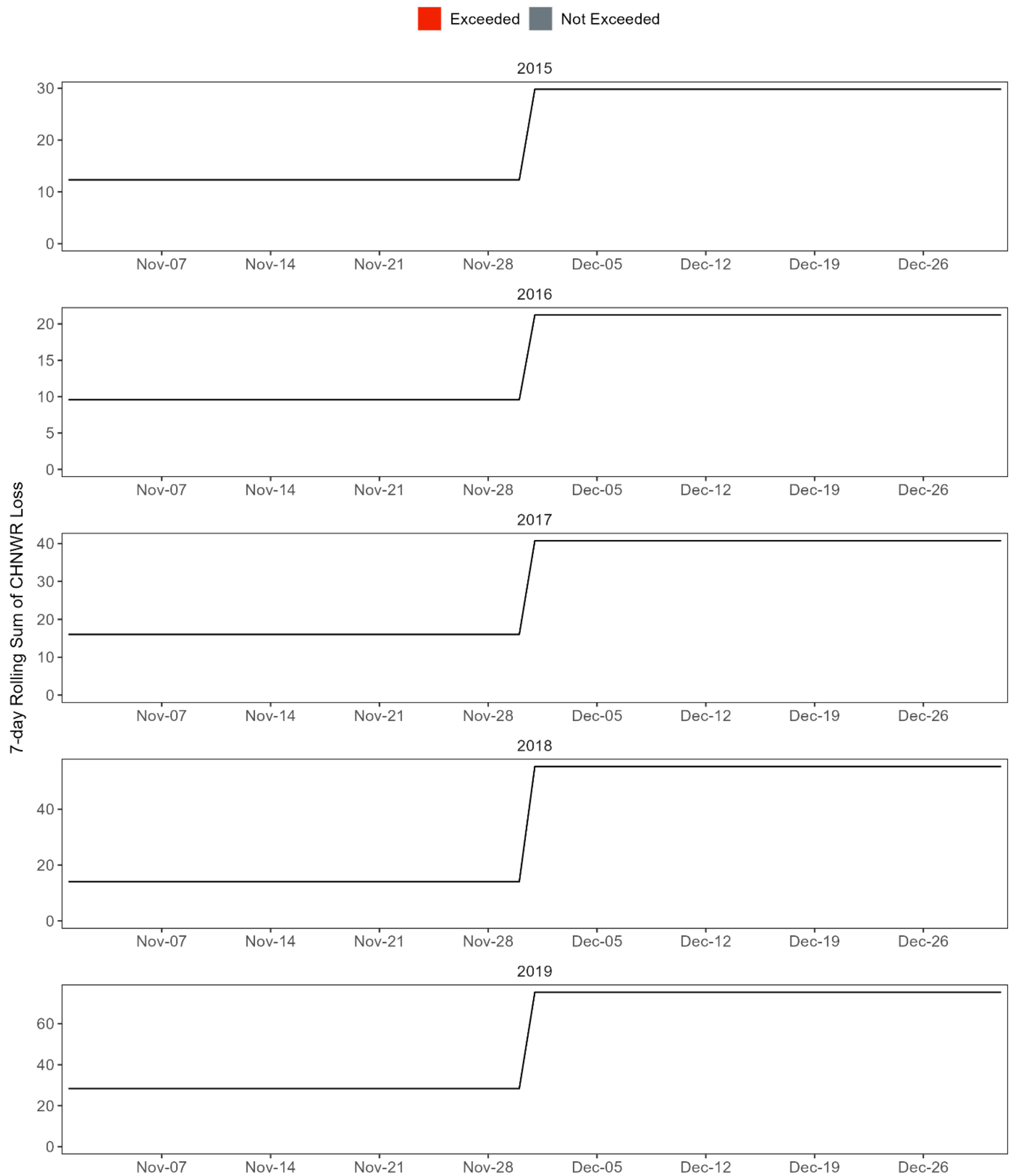

Figure 60. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day in November and December for water years 2015-2019. The black line represents the natural-origin CHNWR early season weekly loss thresholds. Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR early season weekly loss threshold.

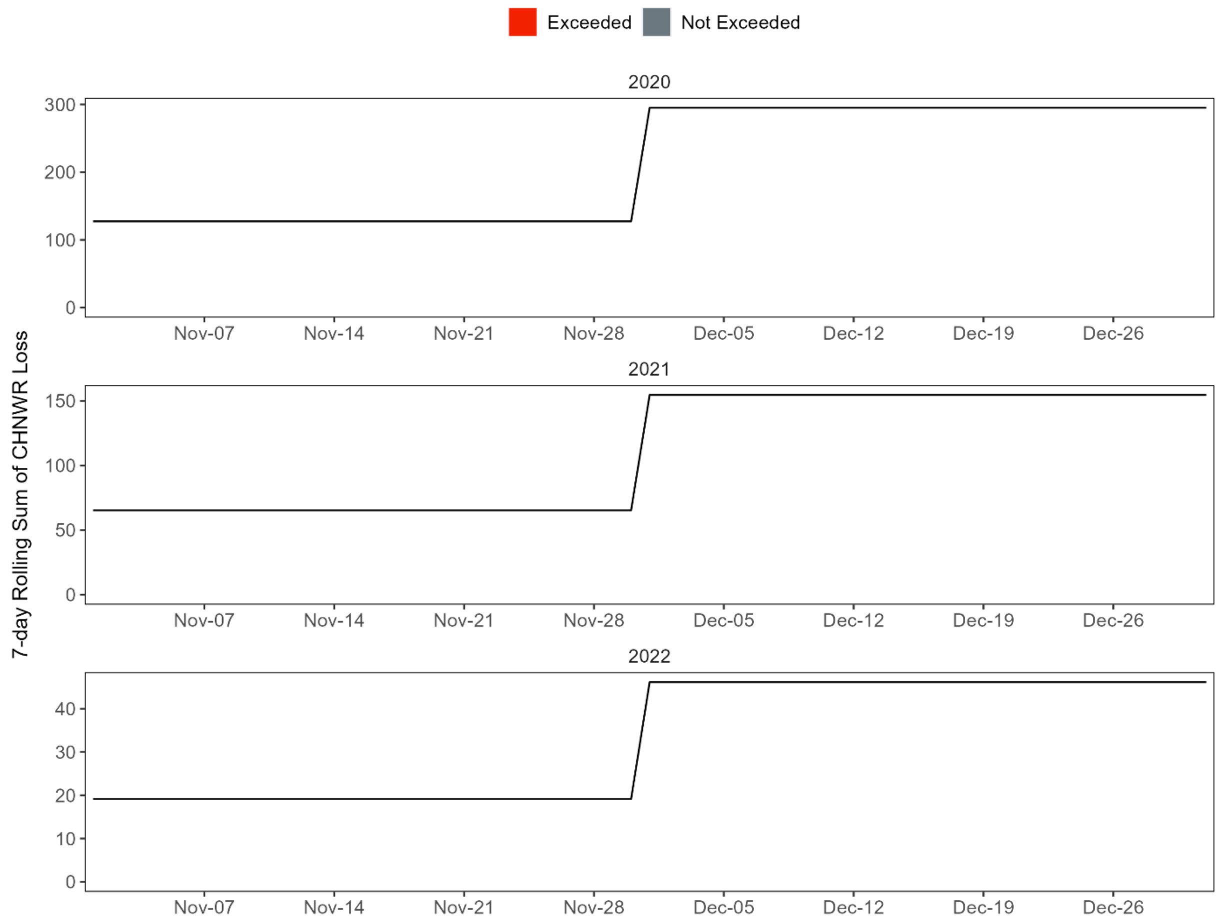

Figure 61. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day in November and December for water years 2020-2022. The black line represents the natural-origin CHNWR early season weekly loss thresholds. Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR early season weekly loss threshold.

6.2.5.4. Discussion

Natural-origin Winter-run Chinook Salmon Early Season Loss Thresholds were developed to minimize take of juvenile natural-origin CHNWR at the CVP and SWP export facilities in November and December. Using historical loss data, there would have been zero exceedances of the natural-origin CHNWR early season weekly loss thresholds. Historical loss data from the CVP and SWP export facilities show that low numbers of genetically-identified natural-origin CHNWR are entrained in the facilities during November and December. For water years 2010 through 2022, CHNWR passage at RBDD RST was highly variable, which could indicate that CHNWR may be seen inconsistently in salvage, particularly during low passage years. More recent years that had high passage at Red Bluff in October and November (i.e., water years 2020 and 2021), but no genetic salvage, may indicate that juvenile CHNWR are experiencing poor through-Delta survival and thus are not observed in salvage (see Section 4.3 – Additional Chinook Salmon Stressors).

If genetic identification is pending or if genetic identification is not possible, OMR action responses will be implemented based on initial Delta Model LAD (USFWS 1997) identification of natural-origin older juvenile Chinook Salmon. However, the OMR action response may discontinue if genetic identification confirms CHNWR loss does not exceed the weekly loss threshold. Given the 3-day allowance requested by DWR between a threshold exceedance and implementation of any change to OMR flows, it is likely that genetic analyses will occur prior to initiation of an OMR action response. This will result in only genetically-identified natural-origin CHNWR loss contributing to threshold exceedances which could reduce the extent to which this measure minimizes impacts to natural-origin older juvenile Chinook Salmon that are present in salvage. In addition to a 3-day allowance for implementing an OMR action response, loss of genetically-identified natural-origin CHNWR has the potential to accumulate up to seven days before triggering an action response due to the 7-day rolling sum of loss, which allows up to a 10-day lag between a daily loss event and an OMR action response.

However, weekly loss thresholds also have the potential to be more reactive to observations of CHNWR in salvage in some situations compared to the 2020 SWP ITP daily loss thresholds (Condition of Approval 8.6.2; CDFW 2020d). For example, under the 2020 SWP ITP, the December daily loss threshold was 26 natural-origin older juvenile Chinook Salmon, so there could have been multiple days in a row with loss values of 25 natural-origin older juvenile Chinook Salmon or less without any exceedances of the threshold and no OMR action response. Under the weekly loss threshold approach, continuous low-level loss within a 7-day period has the potential to accumulate and exceed the thresholds, which are designed to respond to patterns of continued loss rather than individual days of observed loss. Thus, multiple days of lower loss that would not have exceeded a daily threshold have the potential to accumulate and exceed the weekly loss threshold, which would initiate an OMR action response. Especially in more recent years, observations of genetically-identified natural-origin CHNWR in salvage have become increasingly rare (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon), and do not often occur on consecutive days. There were zero observations of genetically-identified natural-origin CHNWR in salvage in November and only a few observations in December during water years 2010 to 2022.

If threshold exceedances occur in the future, they will offer protections to juvenile CHNWR present in the Delta before onset of OMR Management and minimize entrainment into the interior Delta and CVP and SWP export facilities. Protections to juvenile CHNSR may also be provided indirectly if other OMR action responses occur. First Flush Actions, Adult Delta Smelt Entrainment Protection Actions, and Adult Longfin Smelt Entrainment Protection Actions may also provide benefits to CHNWR and CHNSR during the early season if they occur (see Section 6.6 and Attachment 5, Sections 9.3.1.1, 9.3.1.2, and 6.3.1 to the 2024 SWP ITP; Conditions of Approval 8.3.1, 8.3.2, and 8.3.3). The weekly loss thresholds in November and December were designed specifically for early-migrant CHNWR. Disproportionate take of specific CHNWR migration strategies (early, peak, and late) can lead to a decrease in life history diversity (Sturrock et al. 2019a). It is important to preserve all migrants of salmonid populations to maintain the portfolio effect of each species. This portfolio effect contributes to population sustainability and abundance by distributing risk throughout the run and reducing intraspecific competition (Healey 1991; Greene et al. 2010; Carlson and Satterthwaite 2011; Sturrock et al. 2015). As a result, the ITP includes Conditions of Approval focused on improving our understanding of the abundance and distribution of CHNWR in the Delta including improved estimates of through Delta survival for migration salmon

(Condition of Approval 7.9.2, 7.9.5 and 7.9.6) as well as improvements to the loss calculation used to quantify fish in salvage (Condition of Approval 7.9.1).

6.2.6. Condition of Approval 8.4.3 Winter-Run Chinook Salmon Annual Loss Thresholds

6.2.6.1. Introduction

Condition of Approval 8.4.3 was developed collaboratively between CDFW, NMFS, DWR, and Reclamation to minimize take and related impacts of the taking of natural-origin and hatchery-origin CHNWR during OMR Management. CHNWR Chinook Salmon Annual Loss Thresholds include both a natural-origin and a hatchery-origin annual loss threshold. The annual loss threshold for natural-origin CHNWR is equivalent to loss of 0.5% of the natural-origin CHNWR JPE. The annual loss threshold for hatchery-origin CHNWR is equivalent to loss of 0.12% of the hatchery-origin CHNWR JPE.

If the cumulative loss of natural-origin or hatchery-origin CHNWR in a brood year exceeds 50% of either annual loss threshold, DWR and Reclamation will restrict south Delta exports to maintain a 7-day average OMR index no more negative than -3,500 cfs for seven consecutive days. If additional salvage of natural-origin or hatchery-origin CHNWR occurs during the 7-day action corresponding to the respective annual loss threshold, the action response will be extended for another seven consecutive days.

If the cumulative loss of natural-origin or hatchery-origin CHNWR in a brood year exceeds 75% of either annual loss threshold, DWR and Reclamation will restrict south Delta exports to maintain a 7-day average OMR index no more negative than -2,500 cfs for seven consecutive days if the WRCML Model and associated OMR Conversion Tool predict that the OMR index change to -2,500 cfs will shift the model output to a classification of CHNWR absence with a minimum probability of absence prediction of 0.559 for one of 30 sub-models for any of the seven most recent prediction days. Once 75% of either annual loss threshold is exceeded, each additional CHNWR observed in salvage would trigger another 7-day response of -2,500 cfs for seven consecutive days if the WRCML Model and associated OMR Conversion Tool predict that the OMR index change to -2,500 cfs will shift the model output to a classification of CHNWR absence with a minimum probability of absence prediction of 0.559 for one of 30 sub-models for any of the seven most recent prediction days. These prediction values are calculated based on LAD and will be updated once genetic analysis is fully adopted (Condition of Approval 7.9.2 – Winter-run Chinook Salmon Machine Learning Model Development).

If the cumulative loss of natural-origin or hatchery-origin CHNWR in a brood year exceeds 100% of either annual loss threshold, DWR and Reclamation will immediately convene the SaMT to review recent fish distribution information and operations and provide advice regarding future planned CVP and SWP operations to minimize subsequent CHNWR loss during that year. The SaMT will report the results of this review and advice to the WOMT. DWR and Reclamation will also convene an independent peer review panel to review CVP and SWP operations and the annual loss thresholds prior to November 1. The purpose of the independent peer review is to review the actions and decisions contributing to the loss trajectory that led to an exceedance of the annual loss threshold and make recommendations on modifications to CVP and SWP operations, or additional actions to be conducted to stay within the annual loss threshold in subsequent years.

Consistent with Conditions of Approval 8.2.1 and 8.4.4, OMR action responses for loss associated with the natural-origin CHNWR annual loss threshold will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon and may be adjusted, pending genetic analyses. Loss of natural-origin CHNWR will be genetically confirmed through SHERLOCK and GT-seq methods. If genetic analysis of a natural-origin older juvenile Chinook Salmon observed in salvage at the CVP and SWP export facilities indicates that any given juvenile Chinook Salmon is not a genetically-identified CHNWR, the fish will not count toward the natural-origin CHNWR annual loss threshold. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment. Additionally, if genetic identification is pending or if genetic identification is not possible, OMR action responses will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon. Following an exceedance of 50%, 75%, or 100% of either annual loss threshold, changes in OMR flows will be initiated within three days of an exceedance to reduce the likelihood of additional subsequent entrainment and loss of CHNWR at the CVP and SWP export facilities in the south Delta.

The cumulative loss of hatchery-origin CHNWR will contribute to two separate hatchery-origin CHNWR annual loss thresholds. The first annual loss threshold incorporates the hatchery-origin JPE produced for LSNFH CHNWR production with loss of CHNWR released from LSNFH, which are 100% CWT, counting towards the threshold. The second annual loss threshold incorporates the hatchery-origin JPE produced for Battle Creek CHNWR production (jumpstarters) with loss of CHNWR released from CNFH and historically LSNFH, which are both 100% CWT, counting towards the threshold.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.4.3 (Natural-origin and Hatchery-origin CHNWR Annual Loss Thresholds) in minimizing take of juvenile natural-origin and hatchery-origin CHNWR.

6.2.6.2. Methods

6.2.6.2.1. Data Retrieval

For this analysis, salvage data of natural-origin CHNWR collected at the CVP and SWP export facilities from water years 2010 to 2022 was summarized from the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). The genetically-identified natural-origin CHNWR loss database for water years 2010 to 2022 was consolidated by DWR, Reclamation, and CDFW using the salvage database expanded to loss and associated genetic database (DWR et al. 2023). A collaborative QA/QC process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds (see Section 6.2.7; Condition of Approval 8.4.4) for OMR Management.

Salvage data of hatchery-origin LSNFH CHNWR collected at the CVP and SWP export facilities from water years 2010 to 2022 were summarized from SacPAS (2023b) based on LSNFH CWT releases and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Salvage data of hatchery-origin Battle Creek CHNWR collected at the CVP and SWP export facilities from water years 2018 to 2022 were summarized from SacPAS (2023b) based on LSNFH and CNFH CWT releases and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). SacPAS (2023b) only contained CWT-confirmed hatchery-origin Chinook Salmon loss for water years 2011 through 2022. Therefore, CWT-confirmed hatchery-origin Chinook Salmon observations in salvage for water year 2010 were obtained from USFWS (USFWS 2023c) and loss was then calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018).

The genetic and LAD (with includes CWT) salvage databases have caveats for water years 2016 and 2019. Water year 2016 observed genetic loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss for the genetic and LAD database is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on salvage data sources and limitations, see CDFW (2024b).

Natural-origin and hatchery-origin CHNWR JPE's for brood years 2009 through 2021 (corresponding to water years 2010 through 2022) were consolidated for the development of the annual loss thresholds (NMFS 2019b, 2020; CDFW 2020e; WR PWT 2021, 2022).

6.2.6.2.2. Development of Natural-origin and Hatchery-origin CHNWR Annual Loss Thresholds

The natural-origin CHNWR annual loss threshold is the product of 0.5% and the annual natural-origin CHNWR JPE. The factor 0.5% was determined by calculating 90% of the greatest annual loss of genetically-identified natural-origin CHNWR as a proportion of the annual natural-origin CHNWR JPE for water years 2010 through 2022 (greatest annual loss occurred in water year 2012; Table 41).

Table 41. Natural-origin CHNWR annual JPE and associated genetically-identified natural-origin CHNWR annual loss, annual loss as a proportion of the JPE, and 90% of annual loss as a proportion of the JPE for water years 2010-2022. The greatest annual loss as a proportion of the JPE occurred in water year 2012 as indicated in bold italic font.

Water Year	Natural-origin CHNWR JPE	Annual Loss	Annual Loss as % of JPE	90% of Annual Loss as % of JPE
2010	1,179,633	964.64	0.08%	0.07%
2011	332,012	1469.64	0.44%	0.40%
2012	***162,051***	***900.49***	***0.56%***	***0.50%***
2013	532,809	198.2	0.04%	0.03%
2014	1,196,387	48.45	0.00%	0.00%
2015	124,521	0	0.00%	0.00%
2016	101,716	11.47	0.01%	0.01%
2017	166,189	0	0.00%	0.00%
2018	201,409	97.28	0.05%	0.04%
2019	433,176	212.37	0.05%	0.04%
2020	854,941	76.92	0.01%	0.01%
2021	330,130	3.88	0.00%	0.00%
2022	125,038	0	0.00%	0.00%

The natural-origin CHNWR annual loss threshold is calculated as follows:

Natural-origin CHNWR Annual Loss Threshold: 0.90 x (900.49/162,051) x JPE = 0.005 x JPE

where 900.49 is the total annual loss of genetically-identified natural-origin CHNWR in water year 2012, 162,051 is the natural-origin CHNWR JPE for brood year 2011 (water year 2012), and JPE is the current annual natural-origin CHNWR JPE. For example, if applied to water year 2022, the natural-origin CHNWR annual loss threshold would be calculated as follows:

Natural-origin CHNWR Annual Loss Threshold: 0.005 x 125,038 = 625.19

The hatchery-origin CHNWR annual loss threshold is the product of 0.12% and the annual hatchery-origin CHNWR JPE. The factor 0.12% was determined by calculating 90% of the greatest annual loss of CWT-confirmed hatchery-origin CHNWR (combined loss of LSNFH and CNFH) as a proportion of the annual hatchery-origin CHNWR JPE for water years 2010 through 2022 (greatest annual loss occurred in water year 2010; Table 42).

Table 42. Hatchery-origin CHNWR annual JPE and associated CWT-confirmed hatchery-origin CHNWR annual loss, annual loss as a proportion of the JPE, and 90% of annual loss as a proportion of the JPE for water years 2010-2022. The greatest annual loss as a proportion of the JPE occurred in water year 2010 as indicated in bold italic font.

Water Year	Hatchery-origin CHNWR JPE	Annual Loss	Annual Loss as % of JPE	90% of Annual Loss as % of JPE
2010	***108,725***	***139.59***	***0.13%***	***0.12%***
2011	66,734	0	0.00%	0.00%
2012	96,525	16.96	0.02%	0.02%
2013	96,525	8.59	0.01%	0.01%
2014	30,880	0	0.00%	0.00%
2015	185,600	8.4	0.00%	0.00%
2016	148,000	11.19	0.01%	0.01%
2017	58,188	0	0.00%	0.00%
2018	92,904	54.86	0.06%	0.05%
2019	86,699	0	0.00%	0.00%
2020	94,528	0	0.00%	0.00%
2021	97,888	0	0.00%	0.00%
2022	151,544	6.7	0.00%	0.00%

The hatchery-origin CHNWR annual loss threshold is calculated as follows:

Hatchery-origin CHNWR Annual Loss Threshold: 0.90 x (139.59/108,725) x JPE = 0.0012 X JPE

where 139.59 is the total annual loss of CWT-confirmed hatchery-origin CHNWR in water year 2010, 108,725 is the hatchery-origin CHNWR JPE for brood year 2009 (water year 2010), and JPE is the current annual hatchery-origin CHNWR JPE. For example, if applied to water year 2022, the hatchery-origin CHNWR annual loss threshold would be calculated as follows:

Hatchery-origin CHNWR Annual Loss Threshold: 0.0012 x 151,544 = 181.85

See Tables 43 and 44 for all natural-origin and hatchery-origin annual loss threshold values, respectively, for water years 2010 through 2022.

6.2.6.2.3. Evaluation of Natural-origin and Hatchery-origin CHNWR Annual Loss Threshold Exceedances

The natural-origin and hatchery-origin CHNWR annual loss thresholds were applied to natural-origin genetically-identified natural-origin CHNWR loss and CWT-confirmed hatchery-origin CHNWR loss, respectively, from water years 2010 to 2022 to evaluate the level of minimization provided by the CHNWR annual loss thresholds. The 50% and 75% thresholds were calculated by taking the product of the annual loss threshold and 0.5 and 0.75, respectively. During implementation of Condition of Approval 8.4.3, the hatchery-origin CHNWR annual loss threshold will be applied separately to LSNFH CHNWR production releases and Battle Creek CHNWR jumpstarters. However, there has been zero historical loss of hatchery-origin Battle Creek CHNWR at the CVP and SWP export facilities; therefore, the analyses provided below only reference the LSNFH CHNWR production releases.

6.2.6.3. Results

6.2.6.3.1. Natural-origin CHNWR Annual Loss Threshold

Table 43 provides a summary of threshold exceedances across each water year, including the natural-origin CHNWR annual loss threshold (i.e., 0.5% of the JPE), 50% and 75% of the annual loss threshold, and total observed loss of genetically-identified natural-origin CHNWR. The natural-origin CHNWR annual loss threshold was exceeded by historical CHNWR loss in 1 of the 13 water years evaluated, specifically water year 2012 (Figure 63). Genetically-identified natural-origin CHNWR loss exceeded 50% of the annual loss threshold and 75% of the annual loss threshold in 2 of the 13 water years evaluated, specifically water years 2011 and 2012 (Figure 62 and Figure 63). In water year 2011, 50% of the annual loss threshold was exceeded by historical loss on March 12, 2011 and 75% of the annual loss threshold was exceeded by historical loss on March 18, 2011. In water year 2012, 50% of the annual loss threshold was exceeded by historical loss on March 7, 2012, 75% of the annual loss threshold was exceeded by historical loss on March 11, 2012, and the annual loss threshold was exceeded by historical loss on March 24, 2012.

Table 43. Natural-origin CHNWR annual JPE and associated annual loss thresholds, including 50% and 75% of the annual loss thresholds, and total observed genetically-identified natural-origin CHNWR loss for water years 2010-2022. Table cells highlighted red indicate water years when either the annual loss threshold or 50% or 75% of the threshold were exceeded by historical loss.

Water Year	Natural-origin CHNWR JPE	Annual Loss Threshold (0.5% of JPE)	50% of the Annual Loss Threshold	75% of the Annual Loss Threshold	Annual Loss
2010	1,179,633	5898.17	2949.08	4423.62	964.64
2011	332,012	1660.06	830.03	1245.05	1469.64
2012	162,051	810.26	405.13	607.69	900.49
2013	532,809	2664.05	1332.02	1998.03	198.20
2014	1,196,387	5981.94	2990.97	4486.45	48.45
2015	124,521	622.61	311.30	466.95	0
2016	101,716	508.58	254.29	381.44	11.47
2017	166,189	830.95	415.47	623.21	0
2018	201,409	1007.05	503.52	755.28	97.28
2019	433,176	2165.88	1082.94	1624.41	212.37
2020	854,941	4274.71	2137.35	3206.03	76.92
2021	330,130	1650.65	825.33	1237.99	3.88
2022	125,038	625.19	312.60	468.89	0

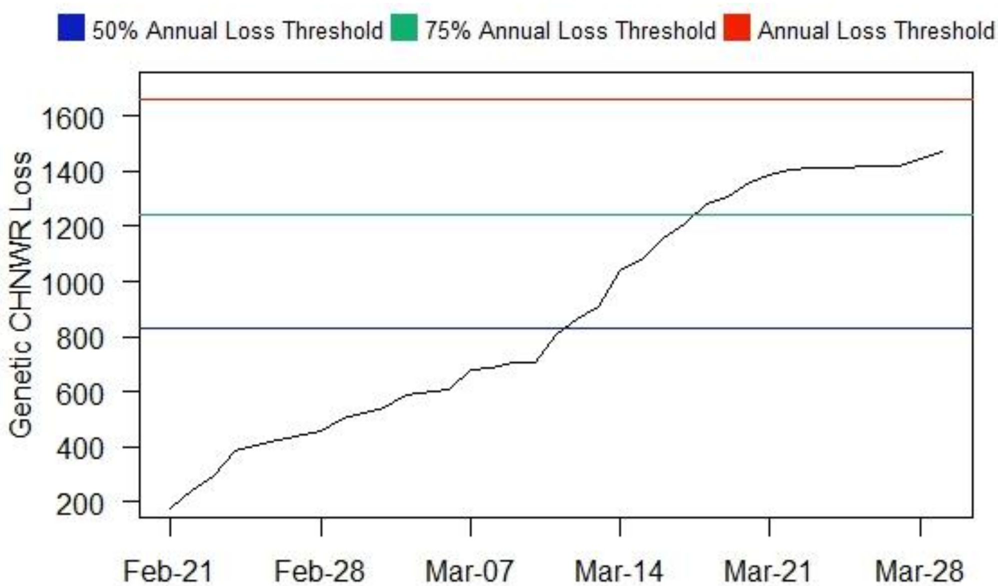

Figure 62. Water year 2011 cumulative daily loss of genetically-identified natural-origin CHNWR from February 21, 2011 – March 29, 2011 at CVP and SWP export facilities. The blue horizontal line represents 50% of the annual loss threshold. The green horizontal line represents 75% of the annual loss threshold. The red horizontal line represents the annual loss threshold calculated as 0.5% of the natural-origin CHNWR JPE.

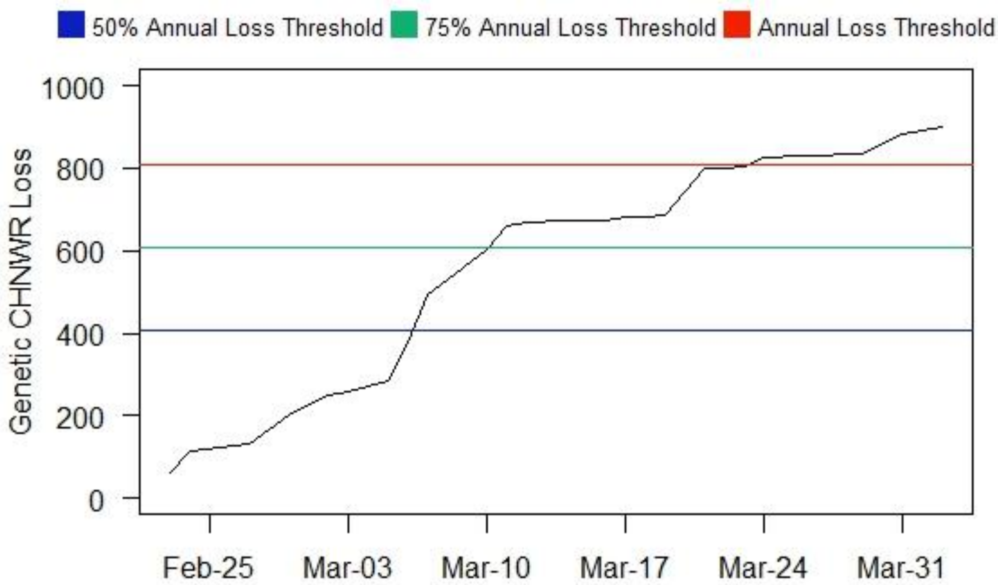

Figure 63. Water year 2012 cumulative daily loss of genetically-identified natural-origin CHNWR from February 23, 2012 – April 2, 2012 at CVP and SWP export facilities. The blue horizontal line represents 50% of the annual loss threshold. The green horizontal line represents 75% of the annual loss threshold. The red horizontal line represents the annual loss threshold calculated as 0.5% of the natural-origin CHNWR JPE.

6.2.6.3.2. Hatchery-origin LSNFH CHNWR Annual Loss Threshold

Table 44 provides a summary of the threshold exceedances across each water year, including the hatchery-origin CHNWR annual loss threshold (i.e., 0.12% of the JPE), 50% and 75% of the annual loss threshold, and total observed loss of hatchery-origin LSNFH CHNWR. The hatchery-origin LSNFH CHNWR annual loss threshold was exceeded by historical CWT-confirmed hatchery-origin CHNWR loss in 1 of the 13 water years evaluated, specifically water year 2010. Hatchery-origin LSNFH CHNWR loss exceeded 50% of the annual loss threshold and 75% of the annual loss threshold in 1 of the 13 water years evaluated, specifically water year 2010 (Figure 64). In water year 2010, 50% of the annual loss threshold was exceeded by historical loss on March 7, 2010, 75% of the annual loss threshold was exceeded by historical loss on March 8, 2010, and the annual loss threshold was exceeded by historical loss on March 13, 2010.

Table 44. Hatchery-origin LSNFH CHNWR annual JPE and associated annual loss thresholds, including 50% and 75% of the annual loss thresholds, and total observed loss of CWT-confirmed hatchery-origin LSNFH CHNWR for water years 2010-2022. Table cells highlighted red indicate water years when either the annual loss threshold or 50% or 75% of the threshold were exceeded by historical loss.

Water Year	Hatchery-origin CHNWR JPE	Annual Loss Threshold (0.12% of JPE)	50% of the Annual Loss Threshold	75% of the Annual Loss Threshold	Annual Loss[a]
2010	108,725	130.47	65.24	97.85	139.59
2011	66,734	80.08	40.04	60.06	0
2012	96,525	115.83	57.92	86.87	16.96
2013	96,525	115.83	57.92	86.87	8.59
2014	30,880	37.06	18.53	27.79	0
2015	185,600	222.72	111.36	167.04	8.40
2016	148,000	177.60	88.80	133.20	11.19
2017	58,188	69.83	34.91	52.37	0
2018	92,904	111.48	55.74	83.61	54.86
2019	86,699	104.04	52.02	78.03	0
2020	94,528	113.43	56.72	85.08	0
2021	97,888	117.47	58.73	88.10	0
2022	151,544	181.85	90.93	136.39	6.70

[a] CWT-confirmed hatchery-origin CHNWR loss data were obtained from SacPAS (2023b) and further confirmed with CDFW Bay Delta Region salvage database (CDFW 2022d). Loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018).

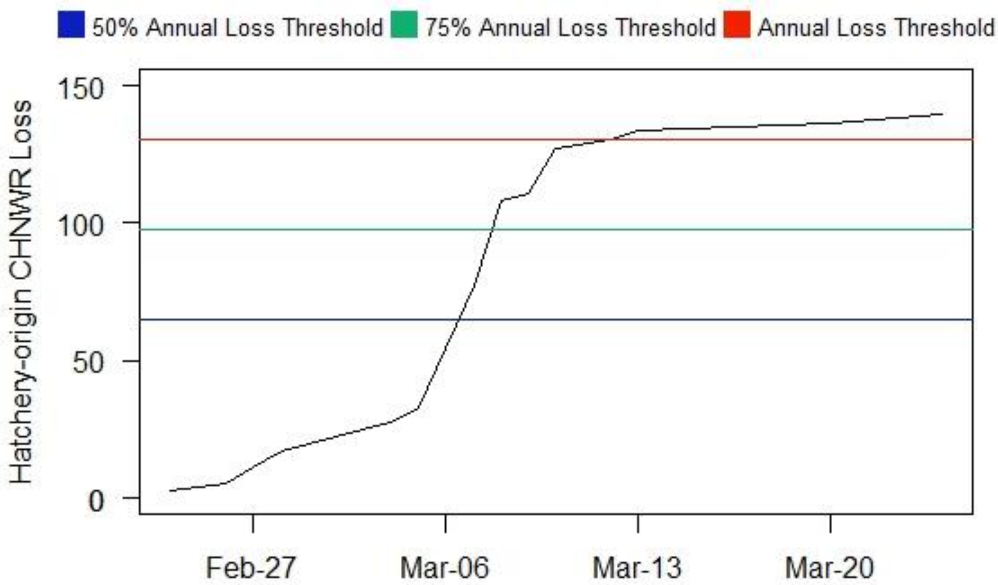

Figure 64. Water year 2010 cumulative daily loss of CWT-confirmed hatchery-origin LSNFH CHNWR from February 24, 2010 – March 24, 2010 at CVP and SWP export facilities. The blue horizontal line represents 50% of the annual loss threshold. The green horizontal line represents 75% of the annual loss threshold. The red horizontal line represents the annual loss threshold calculated as 0.12% of the hatchery-origin CHNWR JPE.

6.2.6.4. Discussion

6.2.6.4.1. Natural-origin CHNWR Annual Loss Threshold

Based on this analysis, the natural-origin CHNWR annual loss threshold would have provided protections for juvenile natural-origin CHNWR in two years between water years 2010 to 2022 and would have been implemented due to a loss greater than 50% of the threshold in mid-to-late March. However, because of its annual, cumulative nature, this measure would not offer protections to earlier migrants (i.e., November-February). The annual loss threshold only provides minimization through OMR action responses (i.e., -3,500 cfs and -2,500 cfs OMR index) after the majority of CHNWR emigration through the Delta has occurred (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta). Thus, managing to the annual loss threshold alone does not balance loss in a way to encourage and preserve life history diversity. In order to provide minimization through OMR action responses before the majority of CHNWR migration has occurred, the CHNWR weekly loss thresholds were developed (see Section 6.2.5; Condition of Approval 8.2.1 and Section 6.2.7; Condition of Approval 8.4.4). These additional loss thresholds are intended to more evenly distribute loss over the juvenile CHNWR emigration season, to avoid reaching the 50% and 75% thresholds and exceeding the annual loss threshold.

6.2.6.4.2. Hatchery-origin CHNWR Annual Loss Threshold

Based on this analysis, the hatchery-origin LSNFH CHNWR annual loss threshold would have provided protections for juvenile hatchery-origin LSNFH CHNWR in one year between water years 2010 to 2022 and would have been implemented due to a loss greater than 50% of the threshold between mid-

February to mid-March. Historical loss of hatchery-origin Battle Creek CHNWR totaled zero for all water years that they were released, specifically water years 2018 to 2022; therefore, an additional analysis of the hatchery-origin annual loss threshold was not conducted.

OMR action responses (i.e., -3,500 cfs and -2,500 cfs OMR index) when 50% and 75% of the hatchery-origin CHNWR annual loss thresholds are exceeded, respectively, will minimize entrainment of additional fish into the interior Delta and subsequently reduce further CHNWR loss at the CVP and SWP export facilities.

6.2.7. Condition of Approval 8.4.4 Natural-Origin Winter-Run Chinook Salmon Weekly Distributed Loss Threshold

6.2.7.1. Introduction

Condition of Approval 8.4.4 was developed collaboratively between CDFW, NMFS, DWR, and Reclamation to minimize take and related impacts of the taking of genetically-identified natural-origin CHNWR during OMR Management. The weekly distributed loss threshold accompanies the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and acts as a minimization measure to reduce the likelihood of exceeding the total annual loss threshold. The weekly distributed loss threshold is a product of the weekly percentage of genetically-identified natural-origin CHNWR present in the Delta, scaled to 100%, and 50% of the natural-origin CHNWR annual loss threshold (0.5% of the JPE; see Section 6.2.6, Condition of Approval 8.4.3). Weekly distributed loss thresholds are intended to distribute loss across the OMR Management period rather than allowing loss to accumulate until the annual loss threshold is exceeded, which could disproportionately impact earlier migrating natural-origin CHNWR.

Following a weekly distributed loss threshold exceedance during OMR Management, changes in OMR flows will be initiated within three days of an exceedance to reduce the likelihood of additional subsequent entrainment and loss of CHNWR at the CVP and SWP export facilities in the south Delta. Specifically, Condition of Approval 8.4.4 requires DWR to reduce exports to achieve a 7-day average OMR index no more negative than -3,500 cfs for seven consecutive days if the weekly distributed loss threshold is exceeded on any single day by the 7-day rolling sum of genetically-identified natural-origin CHNWR loss at the CVP and SWP export facilities.

Consistent with Conditions of Approval 8.2.1 and 8.4.3, OMR action responses for loss associated with the Natural-origin Winter-run Chinook Salmon Weekly Distributed Loss Thresholds will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon and may be adjusted, pending genetic analyses. Loss of natural-origin CHNWR will be genetically confirmed through SHERLOCK and GT-seq methods. If genetic analysis of a natural-origin older juvenile Chinook Salmon observed in salvage at the CVP and SWP export facilities indicates that any given juvenile Chinook Salmon is not a genetically-identified CHNWR, the fish will not count toward the weekly loss thresholds. Given that SHERLOCK is a new methodology currently undergoing peer review and field testing, both methodologies will be used to determine the final identification. In the event that SHERLOCK and GT-seq provide different run assignments, the results from the GT-seq method will be used to determine the final run assignment. Additionally, if genetic identification is pending or if genetic identification is not possible, OMR action responses will be implemented based on initial LAD identification of natural-origin older juvenile Chinook Salmon.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.4.4 (Winter-run Chinook Salmon Weekly Distributed Loss Thresholds) in minimizing take of juvenile natural-origin CHNWR.

6.2.7.2. Methods

6.2.7.2.1. Data Retrieval

For this analysis, salvage data of natural-origin Chinook Salmon collected at the CVP and SWP export facilities in water years 2010 to 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). For the analysis of the weekly distributed loss thresholds, loss was calculated for genetically-identified natural-origin CHNWR. The genetically-identified natural-origin CHNWR database for water years 2010 to 2022 was consolidated by DWR, Reclamation, and CDFW (DWR et al. 2023). A collaborative QA/QC process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds for OMR Management (Condition of Approval 8.4.4). There are caveats to the database for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility.

Catch data from Sherwood Harbor trawl (representing the Delta entry point for juvenile CHNWR) and Chipps Island trawl (representing the Delta exit point), collected by the Delta Juvenile Fish Monitoring Program for water years 2017 to 2021, were downloaded from the Environmental Data Initiative (EDI) website (Buttermore et al. 2021a, 2021b). It is important to note that Chinook Salmon captured at Sherwood Harbor trawl and Chipps Island trawl were subsampled for genetics, so catch of genetically-identified natural-origin CHNWR does not represent the total number of natural-origin CHNWR that may have been encountered. Additionally, catch numbers at Sherwood Harbor trawl and Chipps Island trawl do not constitute total abundance estimates, rather they are catch indices, and should not be used to assess population status. Natural-origin CHNWR JPE estimates for calculating the annual loss threshold and weekly distributed loss thresholds were obtained from annual JPE letters from NMFS and the Winter-run Project Work Team (NMFS 2018, 2019b, and 2020; CDFW 2020e; WR PWT 2021, 2022, and 2023). For additional information on data sources and limitations see CDFW (2024b).

6.2.7.2.2. Development of Natural-Origin CHNWR Weekly Distributed Loss Thresholds

Weekly distributed loss thresholds based on the weekly percentage of genetically-identified natural-origin CHNWR in the Delta scaled to the annual JPE (Table 45) were developed to replace daily loss thresholds from the 2020 SWP ITP (Condition of Approval 8.6.3). Weekly distributed loss thresholds are designed to distribute potential annual loss of natural-origin CHNWR at the CVP and SWP export facilities across the OMR Management period with the goal of protecting the full life history diversity of migrating juvenile CHNWR rather than accumulating loss at the beginning of the OMR Management period without measures to reduce subsequent loss. Weekly distributed loss thresholds for OMR Management are the product of the weekly percent of natural-origin CHNWR in Delta, scaled to 100%, and 50% of the annual loss threshold (0.5% of the JPE; see Section 6.2.6; Condition of Approval 8.4.3).

Table 45. Water year type (DWR 2023a) for the Sacramento Valley and annual natural-origin CHNWR JPE for water years 2010-2022 (corresponding to brood years 2009-2021).

Water Year	Water Year Classification	Natural CHNWR JPE
2010	Below Normal	1,179,633
2011	Wet	332,012
2012	Below Normal	162,051
2013	Dry	532,809
2014	Critical	1,196,387
2015	Critical	124,521
2016	Below Normal	101,716
2017	Wet	166,189
2018	Below Normal	201,409
2019	Wet	433,176
2020	Dry	854,941
2021	Critical	330,130
2022	Critical	125,038

To calculate the percent of natural-origin CHNWR present in the Delta, genetically-identified natural-origin CHNWR catch data were obtained from the Sherwood Harbor trawl dataset (Buttermore et al. 2021b), representing Delta entry, and Chipps Island trawl dataset (Buttermore et al. 2021a), representing Delta exit. Catch of genetically-identified natural-origin CHNWR at Delta entry (Sherwood Harbor trawl) was summed by week (7-day period) starting January 1 separately for each water year that data were available; 2017 through 2021. The same was done for catch at Delta exit (Chipps Island trawl). In leap years, week 9 includes eight days to maintain consistent week numbers across years. For each water year, any catch that occurred between October 1 and December 31 (prior to OMR Management) was included in the sum of catch for week 1 (January 1-7) of OMR Management in that water year. Weekly catch for each water year was then averaged across water years 2017 through 2021 separately for Sherwood Harbor trawl and Chipps Island trawl data. Finally, average weekly catch was summed in a cumulative manner for individual weeks to determine the cumulative percent of natural-origin CHNWR entering the Delta (Table 46, column B) and the cumulative percent of natural-origin CHNWR exiting the Delta each week of OMR Management (Table 46, column C).

The weekly percent of CNHWR present in the Delta was calculated as the difference between the cumulative weekly percent of natural-origin CHNWR exiting the Delta and the cumulative weekly percent of natural-origin CHNWR entering the Delta (Table 46, column D). The sum of weekly percentages of natural-origin CHNWR present in the Delta (Table 46, column D) exceeds 100%, which could allow for the exceedance of the annual loss threshold in the middle of OMR Management rather than distributing loss throughout the OMR Management period. To reduce the likelihood of exceeding the annual loss threshold, weekly percentages of natural-origin CHNWR present in the Delta were scaled to 100%, allowing for the sum of weekly in Delta percentages to add to 100% rather than exceeding 100% (Table 46, column E). For week 14, the weekly percent of natural-origin CHNWR present in Delta was calculated as a negative number due to a greater cumulative percent of CHNWR exiting the Delta than entering the Delta in that week. This negative value was replaced with a weekly percent of natural-origin CHNWR present in Delta of zero (Table 46, column E).

Table 46. Historical presence of natural-origin CHNWR entering the Delta (B), exiting the Delta (C), present in the Delta (D), and present in the Delta scaled to 100% (E) for each week of OMR Management (A) for water years 2017-2021.

Week (Dates)	**Historical Cumulative Percent Entering the Delta (Sherwood Harbor)**	**Historical Cumulative Percent Exiting the Delta (Chipps Island)**	**Historical Percent Present in Delta**	**Historical Percent Present in Delta (Scaled to 100%)**
(A)	(B)	(C)	(D)	(E)
Week 1 (1/1-1/7)	2.47%	1.65%	0.82%	0.32%
Week 2 (1/8-1/14)	2.47%	1.65%	0.82%	0.32%
Week 3 (1/15-1/21)	4.94%	1.65%	3.29%	1.30%
Week 4 (1/22-1/28)	4.94%	1.65%	3.29%	1.30%
Week 5 (1/29-2/4)	19.75%	2.20%	17.55%	6.91%
Week 6 (2/5-2/11)	38.27%	4.95%	33.32%	13.13%
Week 7 (2/12-2/18)	43.21%	5.49%	37.72%	14.86%
Week 8 (2/19-2/25)	46.91%	9.89%	37.02%	14.59%
Week 9 (2/26-3/4)[a]	50.62%	18.13%	32.49%	12.80%
Week 10 (3/5-3/11)	55.56%	30.77%	24.79%	9.77%
Week 11 (3/12-3/18)	77.78%	38.46%	39.32%	15.49%
Week 12 (3/19-3/25)	85.19%	64.84%	20.35%	8.02%
Week 13 (3/26-4/1)	93.83%	90.11%	3.72%	1.47%
Week 14 (4/2-4/8)	98.77%	99.45%	-0.68%	0.00%[b]
Week 15 through end of OMR Management (4/9-6/30)	100.00%	100.00%	0.00%	0.00%

[a] Week 9 includes eight days in leap years.

[b] Replaced negative value with zero.

6.2.7.2.3. Evaluation of Natural-Origin CHNWR Weekly Distributed Loss Threshold Exceedances and OMR Action Response Days

Weekly distributed loss thresholds were applied to historical loss of genetically-identified natural-origin CHNWR at the CVP and SWP export facilities in water years 2010 to 2022 to evaluate how often threshold exceedances would have occurred and how many days of OMR action response would have resulted. Weekly distributed loss thresholds were calculated for water years 2010 to 2022 as a product of the weekly percent of CHNWR present in Delta, scaled to 100%, and 50% of the corresponding annual loss threshold.

For each day of OMR Management, a 7-day rolling sum of genetically-identified natural-origin CHNWR loss was calculated, summing loss over the current day and the six previous consecutive days. This 7-day rolling sum was compared to the weekly distributed loss threshold corresponding to the OMR Management week in which the day evaluated occurs. Threshold exceedances were recorded when the cumulative 7-day sum of loss on any single day exceeded the weekly distributed loss threshold. For each threshold exceedance, an OMR action response, whereby the OMR index is managed to achieve a 7-day average of no more negative than -3,500 cfs, is initiated for seven consecutive days. If an additional threshold exceedance occurs within the 7-day action response, the action response re-starts on that day and continues for seven days. Threshold exceedance days and action response days were summed both by month and by water year to understand trends across different metrics.

6.2.7.3. Results

In water years 2010 to 2022, loss of genetically-identified natural-origin CHNWR occurred between December and April, with the latest seasonal observation occurring on April 30, 2020. December loss was not counted towards the exceedance of weekly distributed loss thresholds. Weekly distributed loss thresholds would have been the highest in February and March, when a larger percentage of CHNWR were present in the Delta as determined by historical catch at the Sherwood Harbor and Chipps Island trawls. Weekly distributed loss thresholds would have been exceeded in 8 out of the 13 water years evaluated (Table 47).

Table 47. Number of threshold exceedances for the natural-origin CHNWR weekly distributed loss thresholds, and number of OMR action response days for the weekly distributed loss thresholds for water years 2010-2022.

Water Year	Weekly Distributed Loss Threshold Exceedances	Weekly Distributed Loss Threshold Action Response Days
2010	18	41
2011	57	75
2012	43	51
2013	9	15
2014	0	0
2015	0	0
2016	1	7
2017	0	0
2018	18	26
2019	23	35
2020	15	27
2021	0	0
2022	0	0
Total	184	277

Applying the rolling 7-day cumulative loss paired with weekly distributed loss thresholds to historical genetically-identified natural-origin CHNWR loss from water years 2010 to 2022 resulted in patterns of multiple threshold exceedances in a row, especially during water years with periods of consecutive days of loss (Figure 65). The highest number of threshold exceedances and action response days would have occurred in water year 2011, which was a wet water year (Table 45) with high loss of genetically-identified natural-origin CHNWR compared to other years between 2010 and 2022 (Figure 15; see Section 5.2.1.2.1 – Historical Loss of Winter-run Chinook Salmon). Zero threshold exceedances would have occurred in water years 2014, 2015, 2017, 2021, and 2022, and zero loss of genetically-identified natural-origin CHNWR occurred in water years 2015, 2017, and 2022 (Figures 65, 66, and 67).

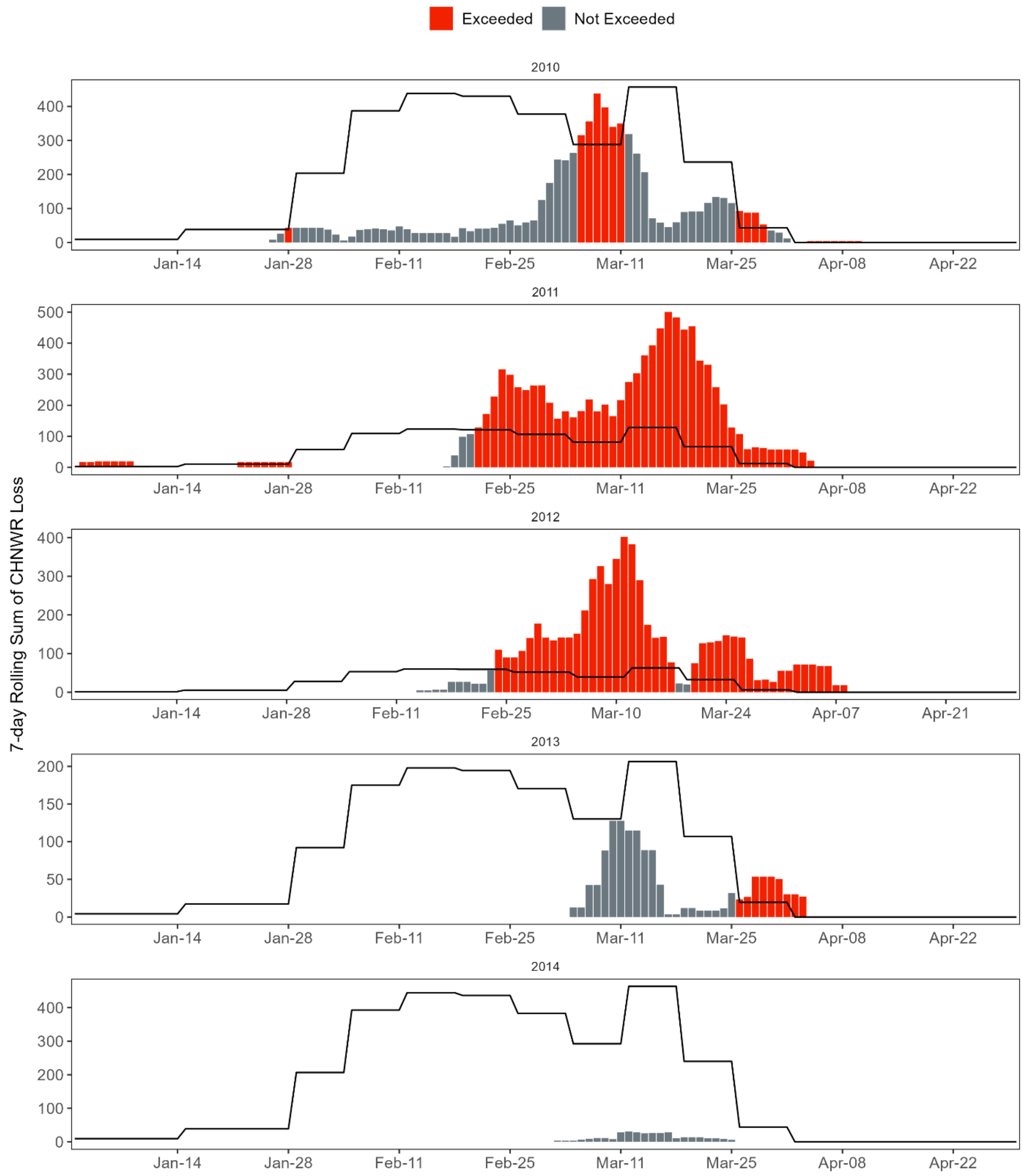

Figure 65. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day from January to April for water years 2010-2014. The black line represents the natural-origin CHNWR weekly distributed loss thresholds. Red bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would have exceeded the natural-origin CHNWR weekly distributed loss threshold. Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR weekly distributed loss threshold.

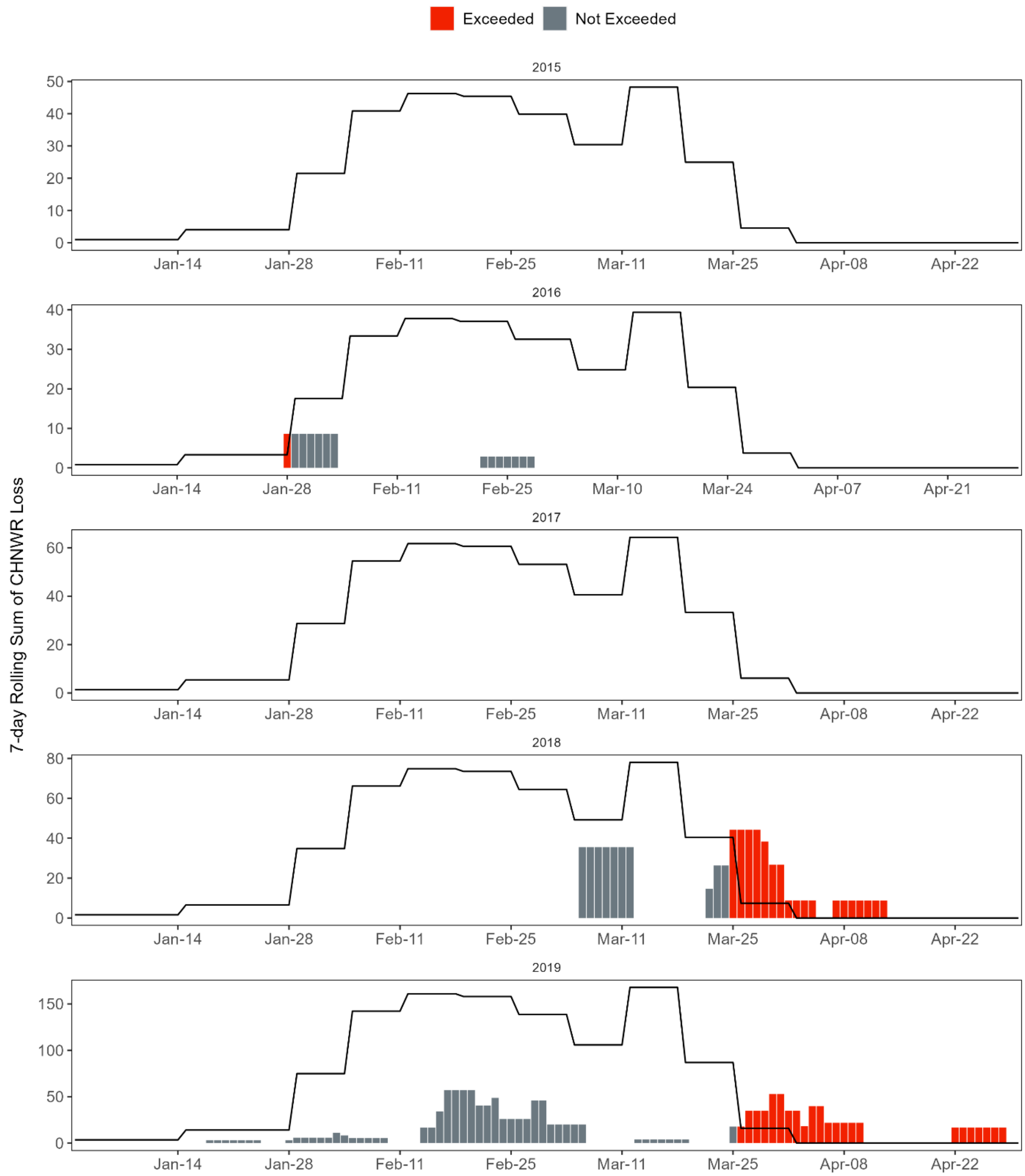

Figure 66. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day from January to April for water years 2015-2019. No genetically-identified natural-origin CHNWR loss occurred in water years 2015 or 2017. The black line represents the natural-origin CHNWR weekly distributed loss thresholds. Red bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would have exceeded the natural-origin CHNWR weekly distributed loss threshold.

Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR weekly distributed loss threshold.

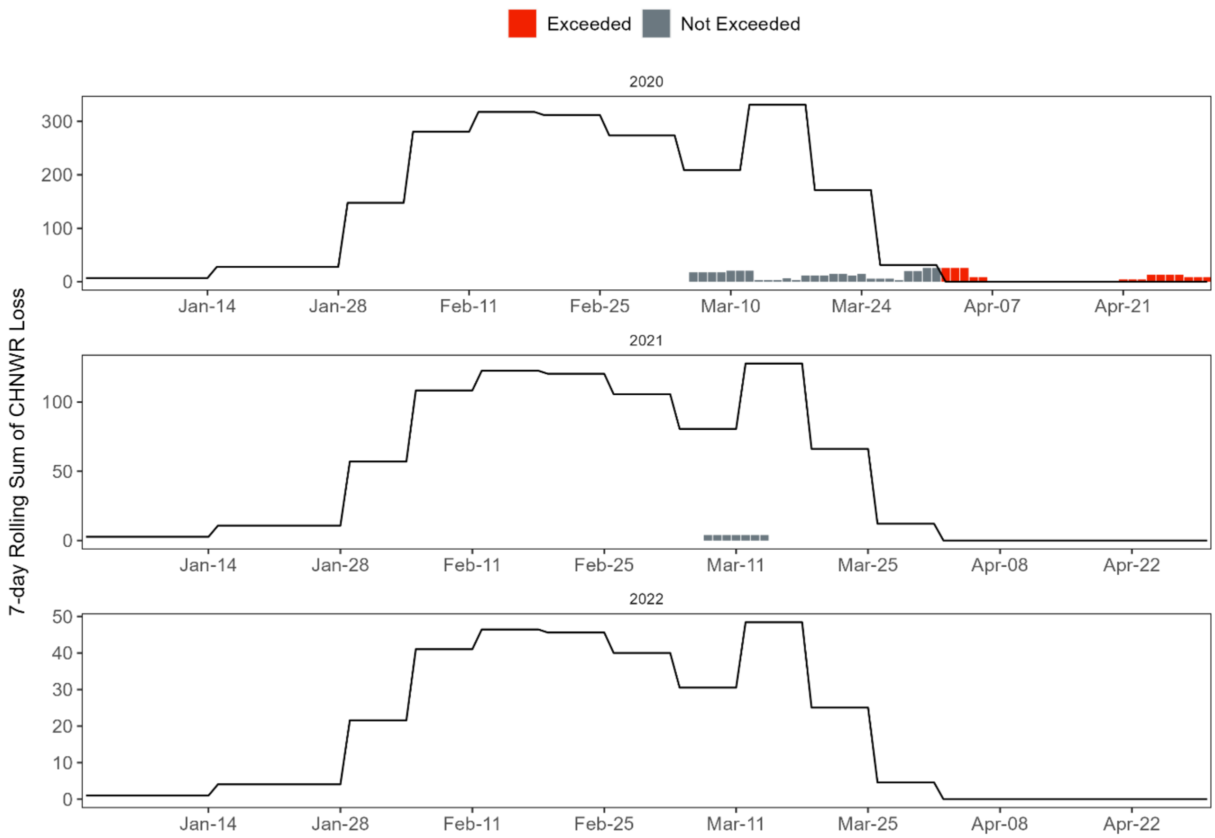

Figure 67. Rolling (7-day) sum of genetically-identified natural-origin CHNWR loss on each day from January to April for water years 2020-2022. No genetically-identified natural-origin CHNWR loss occurred in water year 2022. The black line represents the natural-origin CHNWR weekly distributed loss thresholds. Red bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would have exceeded the natural-origin CHNWR weekly distributed loss threshold. Gray bars indicate that the rolling 7-day sum of genetically-identified natural-origin CHNWR loss would not have exceeded the natural-origin CHNWR weekly distributed loss threshold.

Table 48 shows the monthly distribution of threshold exceedances and action response days for the natural-origin CHNWR weekly distributed loss thresholds. Weekly distributed loss threshold exceedances and action response days were concentrated mostly in March and April (Table 48, Figure 68). Any loss of genetically-identified natural-origin CHNWR often would have exceeded weekly distributed loss thresholds in early April, and any loss that occurred in mid-to-late April would have exceeded the weekly distributed loss thresholds when thresholds dropped to zero (as seen in water years 2010-2013, 2018, and 2020; Figures 65, 66, and 67). Additionally, loss occurring in late March was included in the 7-day rolling sum of loss for the first week of April, thereby contributing to threshold exceedances and action response days in early April. Loss in February comprised between 0% and 51% of total annual genetically-identified natural-origin CHNWR loss; however, loss observed in February in some years with early loss (water years 2010, 2016, and 2019; Figures 65 and 66) was well below weekly distributed loss thresholds. Although there was no loss of genetically-identified natural-origin CHNWR in May of any water year, action response periods initiated by threshold exceedances in late April would have carried over into May in water years 2019 and 2020.

Table 48. Total number of threshold exceedances per month for the natural-origin CHNWR weekly distributed loss thresholds and OMR action response days per month for water years 2010-2022 combined.

Month	Weekly Distributed Loss Threshold Exceedances	Weekly Distributed Loss Threshold Action Response Days
January	16	31
February	14	23
March	89	99
April	65	114
May	0	10

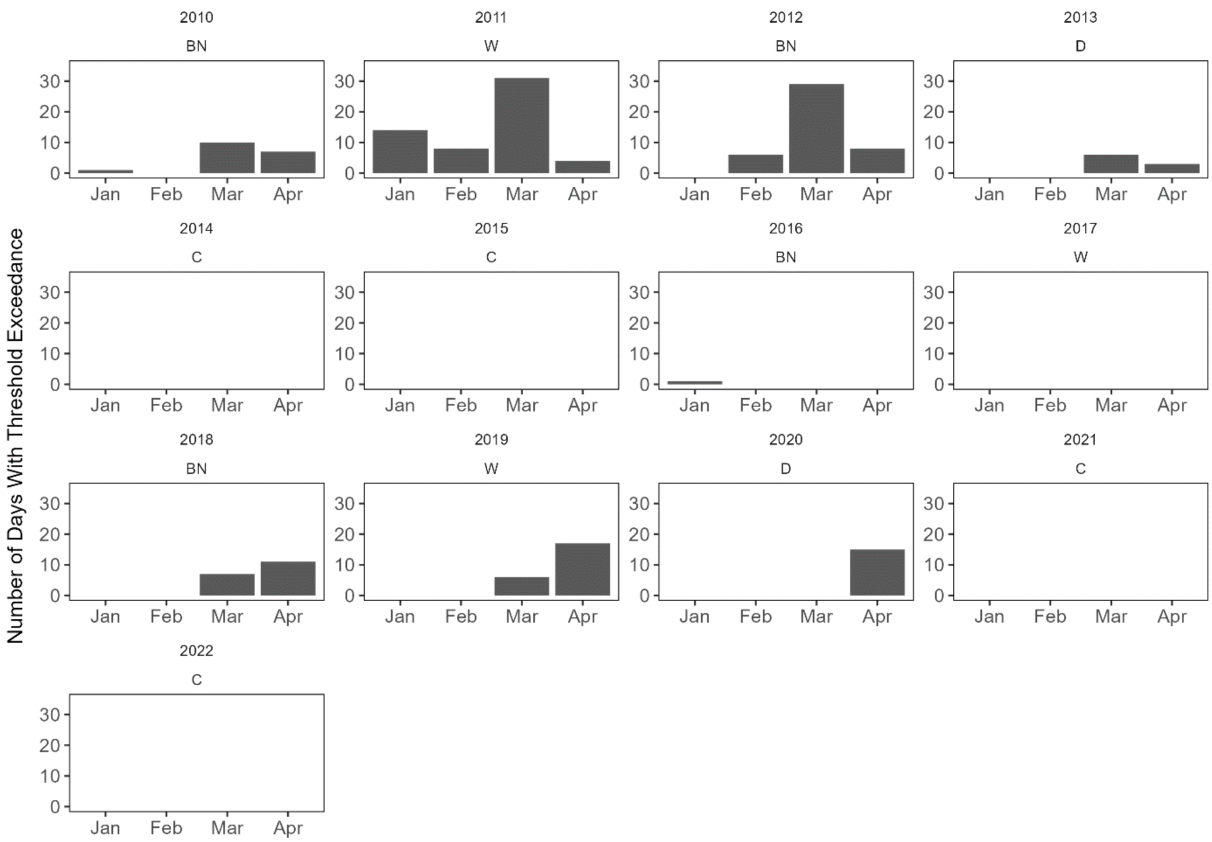

Figure 68. The number of days the natural-origin CHNWR weekly distributed loss thresholds would have been exceeded per month for water years 2010-2022. Water year types are identified below water year labels as follows: Wet (W), Below Normal (BN), Dry (D), and Critical (C). No genetically-identified natural-origin CHNWR loss occurred in water years 2015, 2017, or 2022.

6.2.7.4. Discussion

Natural-origin Winter-run Weekly Distributed Loss Thresholds were developed to minimize take of juvenile natural-origin CHNWR at the CVP and SWP export facilities during OMR Management. Historical analyses of CHNWR loss show that CHNWR weekly distributed loss threshold exceedances and OMR action response days occurred frequently in March and April, especially in water years with high levels of genetically-identified natural-origin CHNWR loss, and to a lesser extent in January and February. Frequent threshold exceedances in March and April, which are likely attributable to the low April weekly distributed loss thresholds resulting from low percentages of CHNWR estimated to be in the Delta during that time (Table 46), will help minimize juvenile CHNWR, and indirectly CHNSR, loss during March and April. Lower numbers of weekly distributed loss threshold exceedances and action response days in January and February compared to March and April may indicate that there would be take of earlier migrating juvenile CHNWR, and potentially CHNSR, at the CVP and SWP export facilities without a minimizing OMR action response, though there are typically low numbers of genetically-identified natural-origin CHNWR observed in salvage in January (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon; Figure 17). Evaluation of and improvements to protections of juvenile CHNWR will be addressed through the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP), which includes the development of a model predicting daily CHNWR migration timing and distribution in the Delta that will be integrated with ECO-PTM to estimate the proportion of the out-migrating CHNWR population that is vulnerable to entrainment into the south Delta (Condition of Approval 7.9.2). These new models will help inform the potential development of modified real-time OMR Management actions that will further minimize entrainment of CHNWR into the south Delta (see Section 6.2.13; Condition of Approval 8.15) and address the challenge of how to best minimize loss of CHNWR when detections are very rare as noted in this section and in Section 6.2.5.

It is unclear if the percentage of natural-origin CHNWR in the Delta, as determined by catch of genetically-identified natural-origin CHNWR at Sherwood Harbor and Chipps Island trawls, is correlated with exposure of juvenile CHNWR to Project operations in the south Delta beyond a presence/absence relationship, though an association between catch of LAD natural-origin CHNWR at Sherwood Harbor trawl and probability of presence in salvage has been identified in the WRCML Model (Gaeta et al. in prep). Day of brood year[10] and the 21-day moving average of LAD natural-origin CHNWR catch at Sherwood Harbor trawl (t – 18 days) were found to be two of the most important features in predicting probability of LAD natural-origin CHNWR presence in salvage. The 21-day moving average of LAD natural-origin CHNWR catch at Sherwood Harbor trawl on an 18-day lag was found to correlate with probability of CHNWR absence in salvage at certain values during the CHNWR outmigration period (Figure 69). LAD natural-origin CHNWR Sherwood Harbor catch values greater than 0.06 in December and values greater than approximately 0.18 for January through May, which are the median minimum values of Sherwood Harbor catch where Shapely Additive Explanations (SHAP)[11] values for absence of CHNWR in salvage ($SHAP_{absent}$) shift from positive to negative, contributed to decreased probability of CHNWR absence in salvage (Figure 70). For example, if the 21-day moving average of Sherwood Harbor catch on a specific day in December was greater than 0.06, then this variable would be contributing to a reduction in the probability of absence in salvage 18 days in the future, i.e., catch of CHNWR at Sherwood Harbor increases the probability of CHNWR salvage. Although a relationship has been detected between the probability of CHNWR presence in salvage and catch of CHNWR at Sherwood Harbor trawl, no relationship between catch of LAD natural-origin CHNWR at Chipps Island trawl and presence in salvage has been established at this time within the WRCML Model. Through the Adaptive Management Program, the WRCML Model Interagency Team will update the WRCML Model to include genetically-identified natural-origin CHNWR which will provide more insight moving forward.

[10] Day of brood year, or brood day of year, for CHNWR is defined as beginning on July 1 and ending on June 30 (Gaeta et al. in prep).

[11] SHAP values are used by Gaeta et al. in prep. to evaluate the contribution of each model feature to WRCML modeling results, i.e., probabilities of CHNWR absence in salvage.

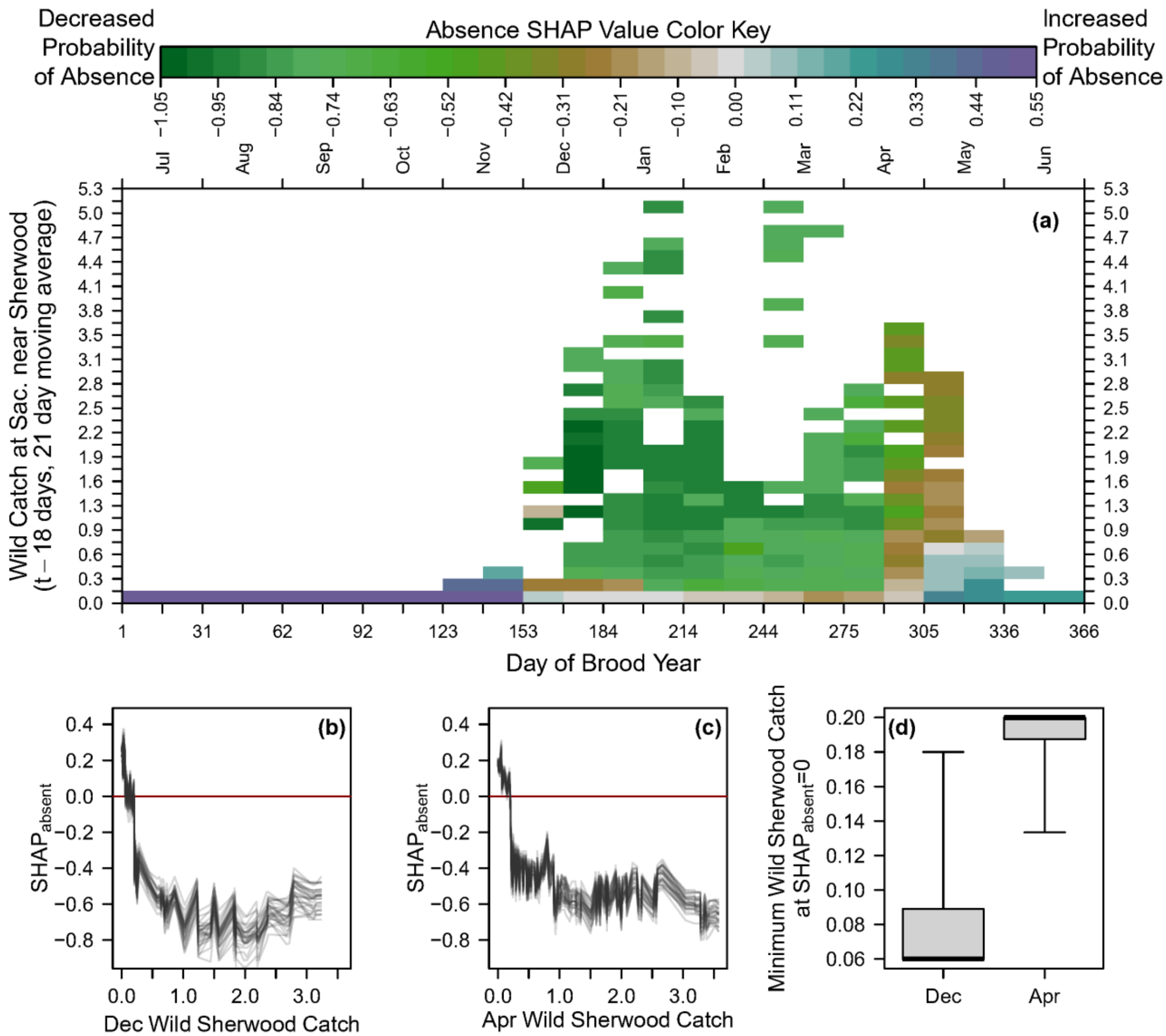

Figure 69. (a) Median LAD natural-origin [wild] CHNWR catch at Sherwood Harbor contribution to $SHAP_{absent}$ throughout the brood year (Jereme Gaeta, personal communication, 7/2024). White cells indicate no observations on a given day of brood year for the given range of Sherwood Harbor catch numbers. (b) Month-specific $SHAP_{absent}$ across LAD natural-origin [wild] CHNWR catch at Sherwood Harbor during December with one line per model run (n=30). (c) Month-specific $SHAP_{absent}$ across LAD natural-origin [wild] CHNWR catch at Sherwood Harbor during April with one line per model run (n=30). (d) The minimum LAD natural-origin [wild] Sherwood Harbor CHNWR catch values in (b) and (c) at which $SHAP_{absent}$ passes the zero line, i.e., Sherwood Harbor CHNWR catch shifts from contributing towards an increase in the probability of CHNWR absence toward a reduction in the probability of CHNWR absence in salvage.

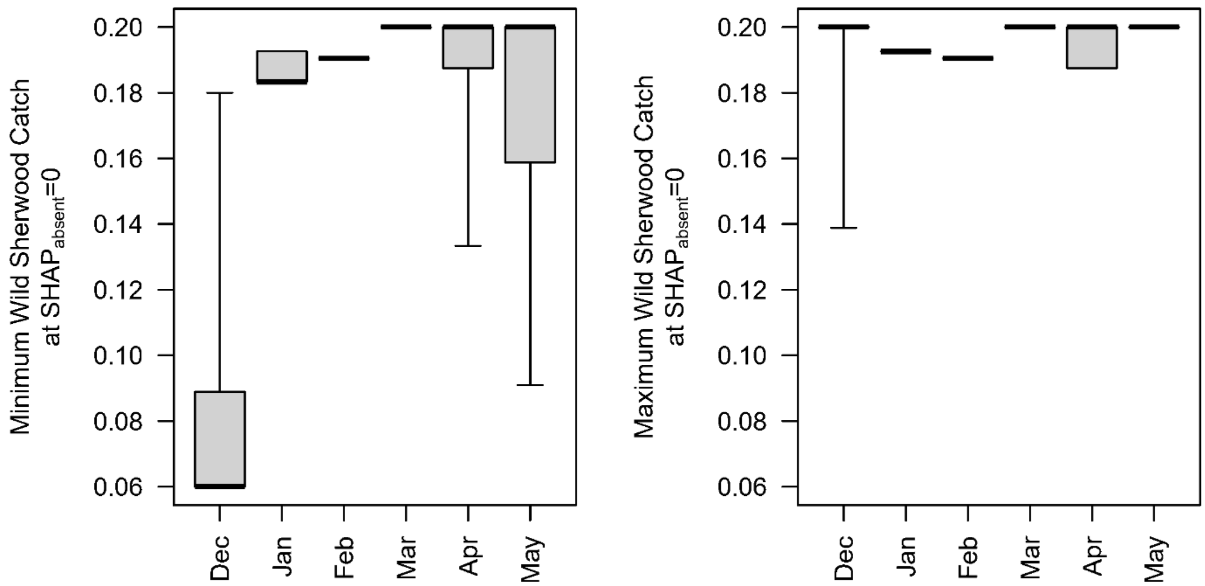

Figure 70. Monthly minimum and maximum LAD natural-origin [wild] Sherwood Harbor CHNWR catch values for December through May at which $SHAP_{absent}$ passes the zero line, i.e., Sherwood Harbor CHNWR catch shifts from contributing towards an increase in the probability of CHNWR absence toward a reduction in the probability of CHNWR absence in salvage. An expanded assessment of Figure 69(d) (Jereme Gaeta, personal communication, 7/2024).

The correlation between LAD natural-origin Sherwood Harbor CHNWR catch and probability of LAD natural-origin CHNWR absence in salvage in the WRCML Model supports the use of Sherwood Harbor monitoring data to inform take and impact minimization for CHNWR exposed to Project operations in the south Delta during OMR Management. Consistent with the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP) and Condition of Approval 7.9.2 (Winter-run Chinook Salmon Machine Learning Model Development), the WRCML Model Interagency Team will develop a model predicting daily CHNWR migration timing and distribution in the Delta that will be used to estimate the proportion of the out-migrating CHNWR population that is vulnerable to entrainment into the south Delta to be used in lieu of historical CHNWR presence in the Delta (Table 46).

Based on historical CHNWR loss data for water years 2010 to 2022, natural-origin CHNWR weekly distributed loss threshold exceedances and action response days would not have been distributed evenly throughout the mid- and late-season juvenile CHNWR outmigration period; instead, there would have been more frequent threshold exceedances and action response days in March and April compared to January and February. Thus, juvenile CHNWR migrating through the Delta in January may experience greater exposure to Project impacts because weekly distributed loss thresholds are rarely exceeded. More frequent threshold exceedances in March and April, which are likely attributed to the low April weekly distributed loss thresholds resulting from low percentages of CHNWR estimated to be in the Delta during that time (Table 46), may minimize juvenile CHNWR, and indirectly CHNSR, loss during April. Although these mismatches exist between the weekly distributed loss thresholds and observations of CHNWR in salvage in earlier months, presence of natural-origin CHNWR in the Delta can serve as an indicator of susceptibility of CHNWR to salvage. Additional minimization of impacts to juvenile CHNWR will be evaluated through the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP), which includes the development of a model predicting daily CHNWR migration timing and distribution in the Delta that will be integrated with ECO-PTM to estimate the proportion of the out-migrating CHNWR population that is vulnerable to entrainment into the south Delta (Condition of Approval 7.9.2). These models in conjunction with the WRCML Model, which can be used to predict probability of juvenile CHNWR presence in salvage, will be used by the SaMT to inform their risk assessments and expert advice to WOMT. Additionally, these new models will help inform potential new real-time OMR Management actions that will further minimize entrainment of CHNWR into the south Delta (see Section 6.2.13; Condition of Approval 8.15).

During OMR Management, if genetic identification is pending or if genetic identification is not possible, OMR action responses will be implemented based on initial Delta Model LAD (USFWS 1997) identification of natural-origin older juvenile Chinook Salmon loss that contributes to a weekly distributed loss threshold exceedance; however, the OMR action response may discontinue if genetic identification confirms CHNWR loss does not exceed the weekly distributed loss threshold. Given the 3-day allowance requested by DWR between a threshold exceedance and implementation of any change to OMR flows, it is likely that genetic analyses will occur prior to initiation of an OMR action response. This will result in only genetically-identified natural-origin CHNWR loss contributing to threshold exceedances and may provide less minimization of impacts for natural-origin older juvenile Chinook Salmon that are present in salvage. In addition to a 3-day allowance for implementing an OMR action response, loss of genetically-identified natural-origin CHNWR has the potential to accumulate up to seven days before triggering an action response due to the 7-day rolling sum of loss, which allows up to a 10-day lag between a daily loss event and an OMR action response.

However, weekly distributed loss thresholds also have the potential to be more reactive to observations of CHNWR in salvage in some situations than a daily loss threshold as was implemented under the 2020 SWP ITP (Condition of Approval 8.6.2; CDFW 2020d). For example, if a daily loss threshold was calculated to be 20 natural-origin older juvenile Chinook Salmon, there could have been multiple days in a row with loss values of 19 natural-origin older juvenile Chinook Salmon or less without any exceedances of the threshold and no OMR action response would occur. Under the weekly distributed loss threshold approach, continuous low-level loss within a 7-day period has the potential to accumulate and exceed the thresholds, which are designed to respond to patterns of continued loss rather than individual days of observed loss. Thus, multiple days of lower loss that would not have exceeded a daily threshold have the potential to accumulate and exceed the weekly loss threshold, which would initiate an OMR action response.

Condition of Approval 8.4.4 provides protections for outmigrating CHNWR during OMR Management. When threshold exceedances occur, the OMR action response of reducing exports to achieve a 7-day average OMR index no more negative than -3,500 cfs for seven consecutive days will minimize take of juvenile CHNWR, and potentially CHNSR, and related impacts of the taking, within the Delta by reducing additional entrainment and loss at the CVP and SWP export facilities.

6.2.8. Condition of Approval 8.4.5 Spring-Run Chinook Salmon Protection Action and Surrogate Annual Loss Thresholds

6.2.8.1. Introduction

Condition of Approval 8.4.5 was developed collaboratively between CDFW, NMFS, DWR, and Reclamation to minimize take and related impacts of the taking to natural-origin and hatchery-origin juvenile CHNSR during OMR Management. The CHNSR hatchery surrogate loss threshold requires DWR to manage exports, each water year between November 1 and the end of OMR Management, in response to the presence of CHNSR hatchery surrogates in salvage to reduce subsequent entrainment and salvage of CHNSR from the Sacramento River and tributaries, including the Feather and Yuba rivers, into the channels of the interior Delta, south Delta, and CVP and SWP export facilities. Each water year, DWR and Reclamation, in coordination with CDFW, NMFS, and USFWS through SaMT, will select three yearling[12] CHNSR surrogate groups and six YOY[13] CHNSR surrogate groups. Yearling CHNSR surrogate groups will be selected from CNFH CHNLFR in-river release groups. YOY CHNSR surrogate groups will be selected from CNFH CHNFR in-river release groups and FRFH CHNSR and CHNFR in-river release groups.

If cumulative loss of any surrogate release group exceeds 0.25% of the CWT release group size, changes in OMR flows will be initiated within three days of an exceedance to reduce the likelihood of additional subsequent entrainment and loss of CHNSR hatchery surrogates at the CVP and SWP export facilities in the south Delta. Specifically, Condition of Approval 8.4.5 requires the DWR to reduce exports to achieve a 7-day average OMR index no more negative than -5,000 cfs for seven consecutive days in November and December (prior to OMR Management), and a 7-day average OMR index no more negative than -3,500 cfs for seven consecutive days beginning January 1 (or whenever OMR Management begins) through the end of OMR Management, or June 30, whichever occurs first.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.4.5 (Spring-run Chinook Salmon Protection Action and Surrogate Annual Loss Thresholds) in minimizing take of juvenile natural-origin and hatchery-origin CHNSR.

6.2.8.2. Methods

6.2.8.2.1. Data Retrieval

For this analysis, salvage data of natural-origin LAD CHNSR at the CVP and SWP export facilities from water years 2010 through 2022 were summarized from the CDFW Bay-Delta Region salvage database (CDFW 2023e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the

[12] Current hatchery practices at CNFH requires 100% Constant Fractional Marking of CHNLFR production for the use of experimental groups (i.e., yearling surrogate groups as determined under the NMFS 2019 Biological Opinion) and production groups.

[13] Current hatchery practices at CNFH and FRFH require 25% Constant Fractional Marking of CHNFR production and FRFH requires 100% Constant Fractional Marking of CHNSR production. Depending on the size of the CHNFR release group, 25% CWT may not be appropriate for a hatchery surrogate release group. CNFH currently releases all CHNFR production in-river and are not constrained by the need to increase their Constant Fractional Marking percentage. In-river releases at FRFH are also not constrained by the need to increase marking. However, FRFH releases CHNFR in net pens in San Pablo Bay when river conditions are not suitable for in-river releases.

2024 SWP ITP; CDFW 2018). The genetically-identified natural-origin CHNSR loss database for water years 2017 to 2022 was consolidated by DWR and CDFW and does not include water years 2010 to 2016 (DWR and CDFW 2023b).

Loss of CWT-confirmed hatchery-origin CHNLFR and CHNFR from CNFH and CHNSR and CHNFR from FRFH for water years 2012 to 2022 were compiled and summarized from SacPAS (2023b) and the CDFW Bay-Delta Region salvage database (CDFW 2023e). For water years 2011 and 2012, salvage data of CWT-confirmed hatchery-origin CHNLFR and CHNFR from CNFH and CHNSR and CHNFR from FRFH were provided by USFWS and then linked to the CDFW Bay-Delta Region salvage database to calculate loss using the Chinook Salmon loss equation (CDFW 2018, 2023e; USFWS 2023b). Hatchery release timing and number of CWT fish released from CNFH and FRFH for water years 2010 through 2022 were obtained from SacPAS (2023b) and confirmed with the Regional Mark Processing Center (RMPC; RMPC 2023).

There are caveats to the salvage database for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss for both the genetic and LAD salvage database is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on salvage data sources and limitations, see CDFW (2024b).

6.2.8.2.2. Development of the CHNSR Hatchery Surrogate Annual Loss Threshold

The hatchery surrogate loss threshold of 0.25% was developed by considering the 0.5% threshold[14] for yearling CHNSR surrogates included in the RPA Action IV.2.3 of the 2009 NMFS BO (NMFS 2009) and incorporating reach-specific survival estimates for YOY and yearling Chinook Salmon emigrating through the upper Sacramento and Feather rivers. The 0.25% threshold considers the number of fish estimated to enter the Delta that are subject to Delta operations (estimated at 50%) rather than solely the number of fish released upstream (i.e., release group size; CDFW 2020e).

Acoustic telemetry studies of CHNSR show variability in juvenile Chinook Salmon outmigration survival. In the Sacramento River, flow is the most important covariate influencing juvenile Chinook Salmon survival (Henderson et al. 2019). Chinook Salmon smolt outmigration slows during low flow drought conditions which can increase smolt exposure to predation and reduce survival. During periods of increased rainfall, high flows result in favorable conditions for out-migrating smolts (YOY surrogates), and survival rates in the Sacramento River greatly improve (Notch et al. 2020). In water year 2017 (wet water year), Notch et al. (2020) reported a survival rate within the Sacramento River of 42.3% (±9.1) for smolts tagged in Mill Creek, increasing from an average survival of 9.9% (±3.2) during the previous critical and dry four study years (2013-2016; range of 0-17%).

In the Feather River, survival of acoustically tagged FRFH CHNSR (YOY surrogates) varies across release groups, with total survival of release groups at Delta entry ranging from 26.8 to 61.5% between water years 2019 through 2021 (CalFishTrack 2023d). In water year 2019, acoustically tagged FRFH CHNSR

[14] NMFS developed the 0.5% threshold to be a proactive response to surrogate loss at the CVP and SWP export facilities prior to exceedance of the CHNSR incidental take limit of 1% as established in the 2009 NMFS BO: "Spring-run loss at the Federal and State fish facilities, combined, is not expected to exceed 1 percent based on marked late fall-run as surrogates that enter the Delta throughout the cohort-year" (NMFS 2009).

released in April 2019 had an estimated 61.5% survival rate from Feather River at Boyd's Pump boat launch to Tower Bridge (CalFishTrack 2023d). In the same water year, acoustically tagged FRFH CHNSR released in April 2019 had an estimated 37.4% survival rate from Feather River at Gridley boat ramp to Tower Bridge (CalFishTrack 2023d). In water year 2020, acoustically tagged FRFH CHNSR released in April 2020 had an estimated 26.8% combined survival rate from Feather River at Boyd's Pump boat launch or Gridley boat ramp to Tower Bridge (CalFishTrack 2023d). In water year 2021, acoustically tagged FRFH CHNSR released in March and April 2021 had an estimated 28.6% survival rate from Feather River at Boyd's Pump boat launch to Tower Bridge (CalFishTrack 2023d).

Acoustic telemetry studies of CHNLFR released from CNFH (yearling surrogates) have also shown variability in juvenile Chinook Salmon outmigration survival. In water year 2019, acoustically tagged CNFH CHNLFR released in November 2018 had an estimated 23.5% survival rate from Battle Creek to Tower Bridge (CalFishTrack 2023d). In water year 2020, acoustically tagged CNFH CHNLFR released in December 2019 had an estimated survival from Battle Creek to Butte City of 76.1% and an estimated survival from Butte City to Tower Bridge of 79.7% (CalFishTrack 2023d). In water year 2021, acoustically tagged CNFH CHNFLR released in January 2021 had an estimated survival from Battle Creek to Butte City of 36.6% and an estimated survival from Butte City to Tower Bridge of 39.1% (CalFishTrack 2023d).

Applying a 50% survival rate for hatchery surrogate releases, as identified in Condition of Approval 8.4.5, assumes that juvenile outmigration survival is comparable to survival reported in Notch et al. (2020) for water year 2017 and not similar to the 2013 to 2016 average or the low survival estimates reported on CalFishTrack (2023d). This assumption is supported by each hatchery's goal of releasing fish during favorable emigration conditions, such as rain events that lead to increased turbidity and river flow, although not all hatchery releases occur during high flow or rainfall events and therefore some hatchery releases may experience lower survival at Delta entry.

6.2.8.2.3. Evaluation of CHNSR Hatchery Surrogate Annual Loss Threshold Exceedances and Action Response Days

The CHNSR hatchery surrogate loss threshold was applied to historical loss of CWT-confirmed hatchery-origin CHNLFR and CHNFR from CNFH and CWT-confirmed hatchery-origin CHNSR and CHNFR from FRFH for water years 2010 through 2022 to evaluate the level of minimization provided by the threshold by determining how often threshold exceedance would occur and how many days of OMR action response would result. Hatchery releases in the San Joaquin River or in the San Francisco or San Pablo bays were not considered for this analysis. Threshold exceedances were recorded when the cumulative loss of each hatchery release group exceeded 0.25% of the total number of CWT fish released. For each threshold exceedance, an OMR action response, whereby south Delta exports are managed to achieve a 7-day average OMR index no more negative than -3,500 cfs (prior to OMR Management) or -5,000 cfs (during OMR Management) is initiated for seven consecutive days.

Historical loss of natural-origin LAD CHNSR from water years 2010 through 2022 was compared to CWT-confirmed hatchery-origin CHNLFR and CHNFR from CNFH and CWT-confirmed hatchery-origin CHNSR and CHNFR from FRFH released in the same years to evaluate the suitability of in-river hatchery production releases as surrogates for the loss of natural-origin CHNSR. A comparison was also made between genetically-identified natural-origin CHNSR loss from water years 2017 through 2022 and hatchery release groups.

6.2.8.3. Results

In water years 2010 to 2022, the CHNSR hatchery surrogate loss threshold of 0.25% of the CWT release group size was exceeded by historical loss of seven release groups of CNFH CHNLFR and never exceeded by historical loss of CNFH or FRFH YOY releases (Table 49). For the seven release groups of CNFH CHNLFR, loss continued to occur after the thresholds were exceeded, although this minimization measure was not in place at the time and as a result, export reductions were not implemented to minimize observed salvage. Loss of yearling and YOY natural-origin CHNSR overlaps with hatchery surrogate group release timing and subsequent loss of CWT hatchery release groups (Figure 71).

Table 49. Summary of hatchery surrogate loss threshold exceedances for CNFH CHNLFR release groups across water years 2010-2022.

Hatchery Release Date	Date of First Loss	Date of Last Loss	CWT Release Group Size	Total Loss	0.25% Loss Threshold	Date of Threshold Exceedance
1/14/2010	1/24/2010	3/9/2010	172,642	976.39	431.61	2/2/2010
12/9/2010	12/20/2010	3/29/2011	766,051	2,436.94	1,915.13	12/28/2010
11/29/2012	12/9/2012	4/21/2013	837,272	3,997.78	2,093.18	12/17/2012
12/22/2015	1/6/2016	3/29/2016	67,700	278.64	169.25	1/30/2016
1/12/2016	1/20/2016	2/12/2016	68,000	188.93	170.00	2/2/2016
12/21/2016	12/30/2016	1/29/2017	81,279	346.77	203.19	1/10/2017
1/4/2019	1/16/2019	2/20/2019	73,952	457.23	184.88	1/21/2019

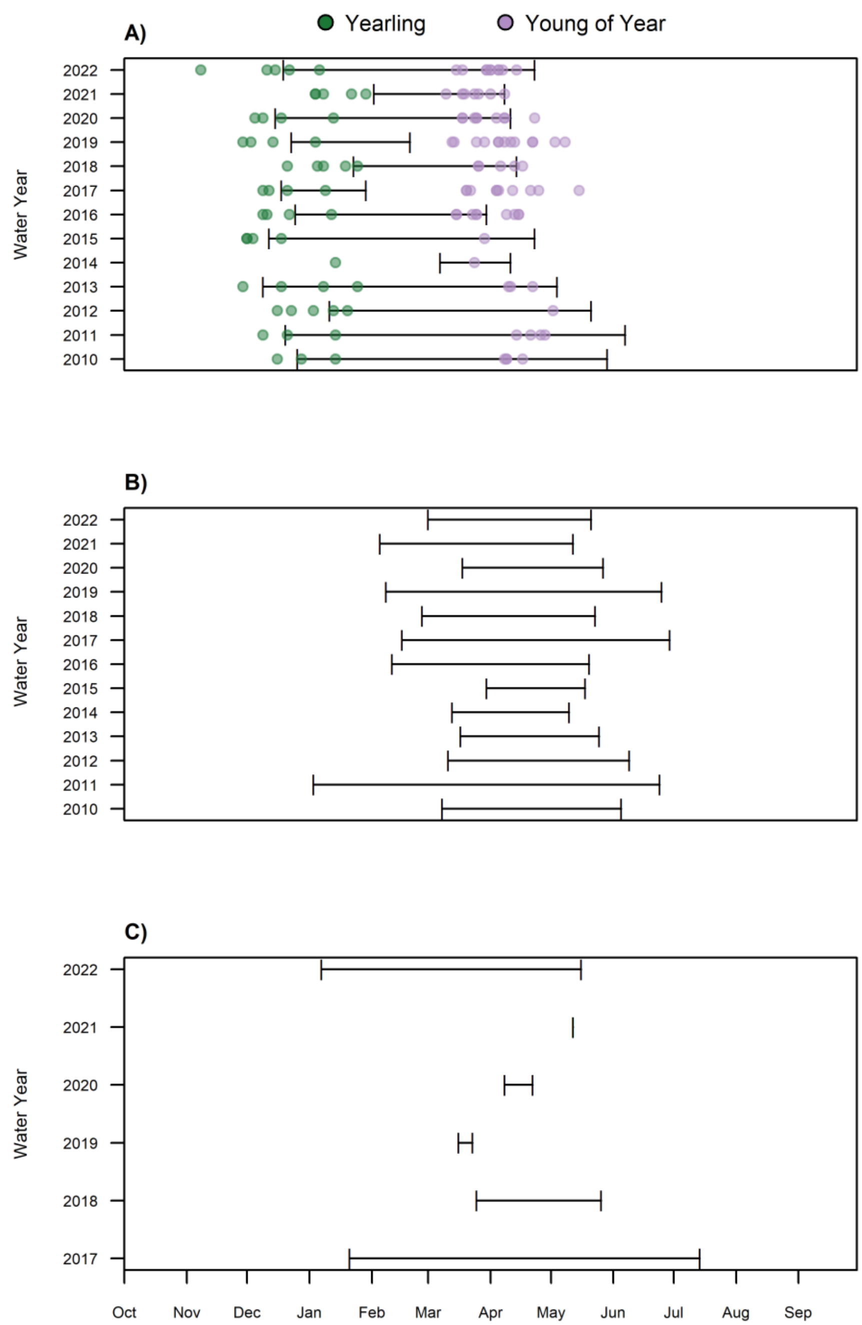

Figure 71. CHNSR hatchery surrogate entrainment period at the CVP and SWP export facilities compared to the entrainment period for LAD natural-origin and genetically-identified natural-origin CHNSR from water years 2010-2022. (A) CWT-confirmed CHNSR hatchery surrogate entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for CHNSR hatchery surrogate release groups for each water year. The green dots indicate the timing of yearling releases of CHNLFR from CNFH. The purple dots indicate the timing of YOY releases of CHNFR from CNFH and CHNSR and CHNFR from FRFH. (B) LAD natural-origin

CHNSR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for LAD natural-origin CHNSR for each water year. (C) Genetically-identified natural-origin CHNSR entrainment period at the CVP and SWP export facilities for water years 2017-2022. The vertical bars on the ends of each line indicate the first and last date of loss for genetically-identified natural-origin CHNSR for each water year.

6.2.8.4. Discussion

Developing specific measures to minimize take of natural-origin CHNSR at the CVP and SWP export facilities is challenging due to the historical lack of genetic testing at the facilities as well as the misidentification of runs based on the Delta Model LAD criteria (Fisher 1992; USFWS 1997) and the absence of an annual abundance estimate (e.g., JPE). Historically, the ability to conduct close to real-time genetic testing at the CVP and SWP export facilities was not feasible; however, DWR, in collaboration with CDFW, developed a database in 2023 for natural-origin CHNSR that includes water years 2017 to 2022 (DWR and CDFW 2023b). For years without genetic confirmation of run, reliance on LAD criteria can lead to false negative and false positive CHNSR identification due to variations in juvenile fish growth associated with food availability and water temperatures. For example, if minimization measures were implemented for CHNSR based on their presence in salvage using the Delta Model LAD criteria (USFWS 1997) rather than genetic confirmation, measures could frequently be triggered by the presence of other runs (mainly CHNFR) that were falsely identified as CHNSR. Conversely, CHNSR may be falsely identified as a different run based on the Delta Model LAD criteria (mainly CHNFR and CHNWR) and, thus, not trigger the minimization measure (Figure 72). In addition, unlike CHNWR, there is currently no JPE for CHNSR, which precludes the development of salvage or loss specific measures natural-origin CHNSR based on estimated abundance of the species entering the Delta.

Due to these known issues associated with identifying juvenile CHNSR in monitoring, Condition of Approval 8.4.5 was developed to provide operational thresholds based on the loss of hatchery-origin CHNSR surrogates at the CVP and SWP export facilities. This Condition of Approval builds off the 2020 SWP ITP Condition of Approval 8.6.4 (Daily Spring-run Chinook Salmon Hatchery Surrogate Loss Threshold) that was implemented in water years 2021 through 2024 and relied exclusively on YOY CHNSR surrogates (i.e., CHNFR from CNFH; CHNSR and CHNFR from FRFH; CHNFR from Nimbus Fish Hatchery (NFH)). The premise of the updated Condition of Approval 8.4.5 is that hatchery releases of CHNLFR, CHNFR, and CHNSR that closely match the timing and size of natural-origin yearling and YOY CHNSR emigration can be utilized as surrogates to indicate emigration timing, route selection, and presence of CHNSR at the CVP and SWP export facilities.

When possible, CNFH times production releases of CHNLFR and CHNFR to coincide with favorable emigration conditions such as rain events that lead to increased turbidity and river flow. Recently, FRFH has also released CHNSR and CHNFR, respectively, during high river flows. The timing of these production releases (historically CHNLFR released between November and January; CHNSR and CHNFR released between March and April; SacPAS 2023a) overlaps the timing of natural-origin yearling and YOY CHNSR emigration triggered by these same environmental cues (see Appendix A – Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta; Johnson and Merrick 2012; CDFW 2020e). Production releases from CNFH and FRFH experience similar hydrology and effects from SWP operations as natural-origin yearling and YOY CHNSR emigrating into and through the Delta (Figure 71; CDFW 2020e).

RMPC (2023) shows that surrogate groups from CNFH and FRFH closely match timing, but also the size of natural-origin CHNSR juvenile emigrating through the Delta. CHNLFR releases from CNFH have fork lengths ranging from 120 to 155 mm (RMPC 2023), which is comparable to the size of genetically-identified yearling CHNSR observed in historical salvage at the CVP and SWP export facilities (yearling CHNSR with a fork length of 130 mm observed on January 7, 2022 and yearling CHNSR with fork lengths ranging from 137 to 185 mm observed in December 2022; see Section 5.2.1.2.2 – Historical Loss of Spring-run Chinook Salmon; DWR 2023d). CHNFR releases from FRFH and CHNSR and CHNFR releases from FRFH are on average approximately 70 to 75 mm as measured by fork length, which align with the Delta Model LAD criteria for YOY CHNSR (USFWS 1997; RMPC 2023).

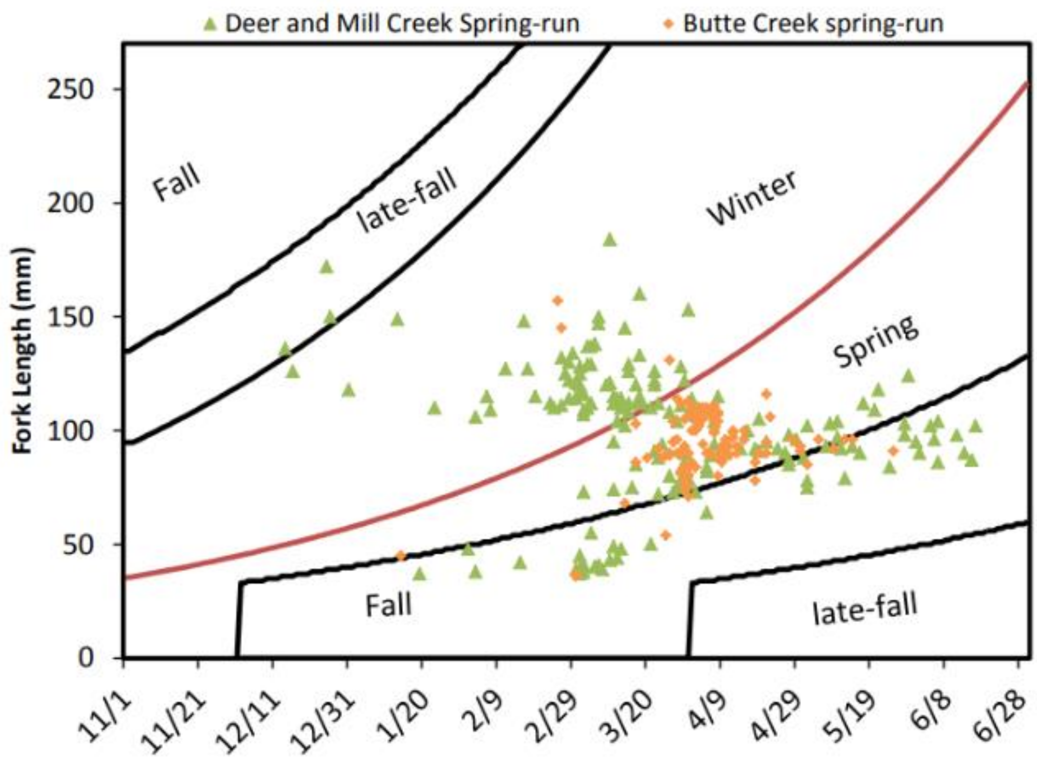

Figure 72. An overview of the genetically-identified natural-origin CHNSR observed in salvage at the CVP and SWP export facilities in relation to the Delta Model LAD criteria from water years 2001 to 2010. CHNSR plotted below the minimum cut off for CHNWR (red line) are considered YOY and those above the red line are considered yearling (figure from Yu [2015]).

Since the implementation of the 2020 SWP ITP Condition of Approval 8.6.4, there have been no exceedances of the 0.25% threshold for YOY CHNSR surrogates. For water years 2021 and 2023, there was no observed loss of CWT-confirmed hatchery-origin YOY CHNSR surrogates (CDFW 2021a, 2023e). In water year 2022, there was a total loss of 4.33 CWT-confirmed hatchery-origin YOY CHNFR from CNFH surrogate group 3 and a total loss of 4.33 CWT-confirmed hatchery-origin YOY CHNFR from CNFH surrogate group 4 in April 2022 (CDFW 2022b; SacPAS 2023b). In water year 2024, there was a total loss of 4.33 CWT-confirmed hatchery-origin YOY CHNSR from FRFH surrogate group 1 in April 2024 (CDFW

2024a). The addition of yearling CHNSR surrogates to Condition of Approval 8.4.5 will extend protections for older juvenile out-migrating CHNSR ensuring that all life history variations are protected. In analyzing the effectiveness of Condition of Approval 8.4.5, zero threshold exceedances occurred for YOY hatchery releases from CNFH and FRFH, whereas seven threshold exceedances occurred for yearling releases of CNFH CHNLFR (Table 49).

In addition to the CHNSR hatchery surrogate loss threshold, Condition of Approval 8.4.5 requires SaMT to conduct a weekly risk assessment from October through June and determine if a more restrictive OMR index is needed to minimize take of juvenile natural-origin CHNSR at the CVP and SWP export facilities. The weekly risk assessment will be informed by real-time monitoring data coupled with new data (e.g., PLAD) gained through ongoing efforts to develop a CHNSR juvenile production estimate and life cycle model (see Section 6.1.4; Conditions of Approval 7.9.3 and 7.9.4).

Condition of Approval 8.4.5 will serve as an interim minimization measure for natural-origin CHNSR until a new minimization measure is developed through coordination with CDFW, DWR, and NMFS through the Adaptive Management Plan (see Attachment 4 to the 2024 SWP ITP). The new minimization measure will be informed by the development of a CHNSR JPE calculation (see Section 6.1.4; Conditions of Approval 7.9.3) and rely on the use of genetic analyses conducted on samples in monitoring programs (see Section 6.2.13; Condition of Approval 8.15).

6.2.9. Condition of Approval 8.5 Storm Flex

Condition of Approval 8.5 may allow DWR to increase exports to capture excess flows in the Delta (hereafter referred to as "Storm Flex") during OMR Management from the onset of OMR Management[15] until the onramp of the Larval and Juvenile Delta Smelt Protective Action (see Section 6.6; Condition of Approval 8.4.1) or the last day of February, whichever occurs first. Prior to initiating Storm Flex operations, Condition of Approval 8.5 requires DWR and Reclamation to submit a risk assessment for Covered Species by evaluating operating to a daily OMR index no more negative than -6,250 cfs if all of the following requirements are met:

1. The Delta is in excess conditions as defined in the 1986 Coordinated Operations Agreement, as amended in 2018,
2. Net flow on the San Joaquin River at Jersey Point (QWEST) is greater than 1,500 cfs,
3. X2 is less than 81 km,
4. The daily average turbidity at Old River at Franks Tract near Terminous (OSJ), Hollands Cut (HOL), and Old River at Bacon Island (OBI) sensors are less than 12 Formazin Nephelometric Units (FNU) at each station,
5. A measurable precipitation event has occurred in the Central Valley,
6. DWR and Reclamation determine that the Delta outflow index indicates a higher level of outflow available for diversion due to peak storm flows,
7. None of the additional real-time OMR index protections are controlling the CVP and SWP operations, and

[15] OMR Management can begin any time after December 1 if a First Flush Action (Condition of Approval 8.3.1) or Adult Longfin Smelt Entrainment Protection Action (Condition of Approval 8.3.3) occur or any time after December 20 if an Adult Delta Smelt Entrainment Protection Action (Condition of Approval 8.3.2) occurs. If none of these actions occur in December, OMR Management begins automatically on January 1.

8. Cumulative loss of the CVP and SWP export facilities of yearling CNFH CHNLFR (yearling CHNSR surrogate) is less than 0.5% within any of the release groups.

If the eight requirements identified above are met, WOMT may require DWR and Reclamation to conduct risk assessments for CHNWR and CHNSR using distribution data from real-time monitoring, particle tracking modeling (e.g., ECO-PTM), and the Winter-run Chinook Salmon Machine Learning Model and associated OMR Conversation Tool comparing risk for OMR index values of -5,000 cfs and -6,250 cfs. If the assessment determines that no additional risk is expected in the upcoming week, DWR and Reclamation may request approval from WOMT to operate to an OMR index no more negative than -6,250 cfs.

If WOMT approves Storm Flex, DWR and Reclamation will continue to monitor CHNWR and CHNSR in real-time, and operate in accordance with any additional real-time OMR index restrictions described in Conditions of Approval 8.2.1, 8.3.1, 8.3.2, 8.3.3, 8.4.1, 8.4.2, 8.4.3, 8.4.4, 8.4.5, and 8.4.7, which include measures that onset OMR Management and other real-time OMR entrainment measures such as CHNWR annual loss thresholds, CHNWR weekly distributed loss thresholds, and CHNSR hatchery surrogate annual loss thresholds.

Exports, and corresponding changes in OMR flows, impact juvenile CHNWR and CHNSR migration and reduce overall survival by routing fish into the interior and south Delta and increasing entrainment into the CVP and SWP export facilities (SST 2017). Although juvenile CHNWR and CHNSR do exhibit some swimming behavior in the Delta, traditional PTM of neutrally buoyant particles can provide some indication of how the CVP and SWP export operations and changes in OMR impact junction routing and entrainment risk into the interior and south Delta. For junctions on both the Sacramento River and San Joaquin River, a -5,000 cfs OMR index provides protection to juvenile CHNWR and CHNSR compared to more negative OMR flows that would exert a larger influence on flow routing at distributary junctions and, thus, on juvenile routing and survival (SST 2017). Based on PTM simulation of particles injected at the confluence of the Mokelumne River and the San Joaquin River conducted to support the 2009 NMFS BO, the risk of particle entrainment doubles from 10 to 20% as net OMR flow increases southward from -2,500 cfs to -3,500 cfs, and quadruples to 40% at -5,000 cfs (NMFS 2009). At OMR flows more negative than -5,000 cfs, the risk of particle entrainment increases at an even greater rate, reaching approximately 90% at -7,000 cfs (see Section 5.2.1.1 – Effects of South Delta Export Operations on Juvenile Chinook Salmon). Recent PTM simulations obtained from DWR's ITP Application (DWR 2023f) and subsequent coordination with DWR show similar correlations between OMR flows and particle fates for both neutrally buoyant and surface-oriented particles. Less negative OMR flows result in greater proportions of particles exiting the Delta past Chipps Island and lower proportions of particles entrained at the CVP and SWP export facilities (see Attachment 5, Appendix A to the 2024 SWP ITP). However, correlations may be less strong than those originally described in the 2009 NMFS BO due to changes in south Delta CVP and SWP operations and OMR Management following the 2009 NMFS BO. Data utilized in PTM analyses included in the 2009 NMFS BO were collected prior to implementation of modern OMR management suggesting that instances of negative OMR flows were likely more frequent and greater in magnitude compared to data collected once OMR management was implemented following the 2009 NMFS BO. Regardless, the risk of entrainment into the south Delta channels is evidenced to increase when OMR flows are more negative (NMFS 2009), as proposed under Storm Flex.

The hydrologic conditions created by high CVP and SWP export rates during Storm Flex operations may create more adverse conditions in south Delta waterways than are currently observed for migrating CHNWR and CHNSR. NMFS (2019a) evaluates Storm Flex operations based on the maximum combined capacity of the Banks Pumping Plant and the Jones Pumping Plant (14,900 cfs), not OMR flows. Impacts associated with Storm Flex vary based on whether high storm flows originate from the Sacramento River or San Joaquin River basins, and to what extent CVP and SWP exports are increased. Given that San Joaquin River flows are more regulated than the Sacramento River, storm events that initiate Storm Flex are more likely to come from the Sacramento River. Storm Flex, and subsequent increased CVP and SWP exports, initiated by Sacramento River flows would alter hydrologic conditions in the south and interior Delta, including the mainstem San Joaquin River downstream to at least Jersey Point (NMFS 2019a). Increased exports during Storm Flex, initiated by Sacramento River flows, will exaggerate the effects of OMR flows on juvenile CHNWR and CHNSR given that water supplying increased exports is predominately originating from the Sacramento River. Low flows entering the Delta from the San Joaquin River would exacerbate altered hydrology, as San Joaquin River flows would not offset the source of increased exports. Conversely, if Storm Flex is initiated by San Joaquin River flows, water supplying increased exports will predominately originate from the San Joaquin River. Flow through Old River via the head of Old River will offset the effects of exports on OMR flows to some extent, depending on the magnitude of combined exports and the volume of flow originating from Old River (NMFS 2019a).

If juvenile CHNWR and CHNSR are present in the vicinity of the CVP and SWP export facilities when exports are increased during Storm Flex operations, it is likely there will be an increase in the number of CHNWR and CHNSR entrained into the CVP and SWP export facilities. Juvenile CHNWR and CHNSR migrate downstream in response to elevated flows in the Sacramento River and San Joaquin River basins (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta); therefore, there is a high probability that juvenile CHNWR and CHNSR presence in the Delta will increase when precipitation events occur in the Central Valley and flows in the Delta increase. In addition to juvenile CHNWR and CHNSR entering the Delta on the elevated storm flows, juvenile CHNWR and CHNSR may already be present in the Delta due to earlier migration (see Sections 4.1.6 and 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta). As indicated above, increased exports can result in increased entrainment of juvenile CHNWR and CHNSR into the south Delta as a result of more negative OMR flows.

The first six requirements for Storm Flex include elevated flows in the Sacramento River or San Joaquin River basins. Positive values of QWEST represent a net positive flow at Jersey Point, indicating a positive inflow westward to the Delta. Negative values at QWEST indicate greater potential for fish entrainment at the CVP and SWP export facilities due to lower inflow into the Delta (see Attachment 5, Appendix A to the 2024 SWP ITP). During wet periods, the San Joaquin River and eastern Delta tributaries (Mokelumne, Consumnes, and Calaveras rivers) may provide sufficient flow to maintain a net positive flow in the lower San Joaquin River (i.e., positive QWEST) despite high exports at the CVP and SWP export facilities. Such flows would tend to transport pelagic organisms in the San Joaquin River toward Suisun Bay. By restricting Storm Flex to only when there are elevated flows in the Delta, Condition of Approval 8.5 minimizes the risk of juvenile CHNWR and CHNSR entraining into the south Delta and experiencing loss at the CVP and SWP export facilities.

During Storm Flex, if either of the last two requirements for Storm Flex are no longer being met or a risk assessment by DWR or Reclamation determines there is an increased risk of exceeding real-time OMR

Conditions of Approval, Condition of Approval 8.5 requires DWR to end Storm Flex by reducing exports to achieve an average OMR index no more negative than -5,000 cfs on a 14-day average, unless further reduction in exports is required by a specific Condition of Approval. Ending Storm Flex operations, driven by risk assessments, is essential to reducing take of CHNWR and CHNSR when real-time data indicate increased entrainment of CHNWR and CHNSR into the CVP and/or SWP export facilities.

Condition of Approval 8.5 will minimize loss of CHNWR and CHNSR by only allowing Storm Flex during times when the Delta is in excess conditions with positive Delta inflow, a measurable precipitation event has occurred, there are no controlling real-time OMR Conditions of Approval[16], and the risk of exceeding real-time OMR Conditions of Approval is low.

6.2.10. Condition of Approval 8.6 End of OMR Management

6.2.10.1. Introduction

Condition of Approval 8.6 allows OMR Management for CHNWR and CHNSR to end June 30 unless specific water temperature threshold exceedances occur earlier. Specifically, DWR will conclude OMR Management for CHNWR and CHNSR on June 30 or when the following conditions have occurred, whichever occurs first:

- Daily average water temperature at Mossdale (MSD) exceeds 22.2°C for seven days (does not have to be consecutive) in June, and
- Daily average water temperature at Prisoner's Point (PPT) exceeds 22.2°C for seven days (does not have to be consecutive) in June.

Water temperatures above 22°C are shown to cause decreased growth, impair smoltification, increase predation, and generally deter salmonids from the area (Carter 2008). Ending OMR Management when water temperatures in the Delta exceed 22.2°C for seven non-consecutive days in June assumes juvenile CHNWR and CHNSR are no longer present in the Delta due to the detrimental impacts from remaining in water temperatures above 22°C. However, if juvenile CHNWR and CHNSR are observed in salvage at the CVP or SWP export facilities then it is assumed they are still present in the interior Delta. Therefore, it is important to understand the relationship between ending OMR Management earlier than June 30 (based on water temperatures in the Delta) and the potential for subsequent entrainment of CHNWR and CHNSR.

CDFW conducted the following analysis to evaluate the effectiveness of Condition of Approval 8.6 (End of OMR Management) in minimizing take of juvenile natural-origin and hatchery-origin CHNWR and CHNSR.

6.2.10.2. Methods

6.2.10.2.1. Data Retrieval

For this analysis, salvage data for juvenile natural-origin and hatchery-origin CHNWR and CHNSR collected at the CVP and SWP export facilities from water years 2010 to 2022 were summarized from

[16] Controlling Conditions of Approval include 8.2.1, 8.3.1, 8.3.2, 8.3.3, 8.4.1, 8.4.2, 8.4.3, 8.4.4, 8.4.5, and 8.4.7.

the CDFW Bay-Delta Region salvage database (CDFW 2022e) and loss was calculated using the Chinook Salmon loss equation (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Natural-origin LAD and genetic salvage data, as well as hatchery-origin LAD and CWT-confirmed salvage data were used to bolster analyses and minimize any data gaps.

The Delta Model LAD criteria (USFWS 1997) were used to identify juvenile LAD CHNWR and CHNSR at the CVP and SWP export facilities. For LAD-identified juvenile CHNWR and CHNSR, natural-origin and hatchery-origin were differentiated based on the presence or absence of an adipose fin ("unclipped" versus "clipped") as documented in the salvage database. Clipped LAD CHNWR and CHNSR were characterized as hatchery-origin and unclipped LAD CHNWR and CHNSR were characterized as natural-origin. CWT-confirmed hatchery-origin CHNWR and CHNSR salvage data were obtained from USFWS (USFWS 2023b, 2023c) for water years 2010 and 2011, and from SacPAS for water years 2012 through 2022 (SacPAS 2023).

The genetically-identified natural-origin CHNWR loss database for water years 2010 to 2022 was consolidated by DWR, Reclamation, and CDFW (DWR et al. 2023). A collaborative QA/QC process was conducted by DWR, Reclamation, and CDFW to prepare the genetic database for use in the development of the natural-origin CHNWR annual loss threshold (see Section 6.2.6; Condition of Approval 8.4.3) and natural-origin CHNWR weekly distributed loss thresholds for OMR Management (see Section 6.2.7; Condition of Approval 8.4.4). However, there are caveats to the database for water years 2016 and 2019. Water year 2016 observed loss is potentially inaccurate given unprocessed Chinook Salmon genetic samples of unknown sample size. Water year 2019 observed loss for both the genetic and LAD database is also potentially inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. The genetically-identified natural-origin CHNSR loss database for water years 2017 to 2022 was consolidated by DWR and CDFW and does not include water years 2010 to 2016 (DWR and CDFW 2023b). As indicated above, water year 2019 observed loss is inaccurate due to Chinook Salmon enumeration issues at the Tracy Fish Collection Facility. For additional information on salvage data sources and limitations, see CDFW (2024b).

Daily water temperature data for the month of June for water years 2010 to 2022 were obtained from the California Data Exchange Center (CDEC) for 13 water temperature stations across the interior Delta, including MSD and PPT (CDEC 2023; Figure 73 and Table 50).

Table 50. Water temperature stations in the interior Delta listed south to north by location.

Water Temperature Station (ordered from south to north)	**Location**
MSD	San Joaquin River at Mossdale Bridge
CLC	Clifton Court Forebay
BDT	San Joaquin River at Brandt Bridge
MHO	Middle River near Howard Road Bridge
OH4	Old River at Highway 4
SJG	San Joaquin River at Garwood Bridge
OBI	Old River at Bacon Island
TRN	Turner Cut near Holt
HLT	Middle River near Holt
ORQ	Old River at Quimby Island near Bethel Island
BET	Bethel Island
PPT	San Joaquin River at Prisoner's Point near Terminous
BLP	Blind Point

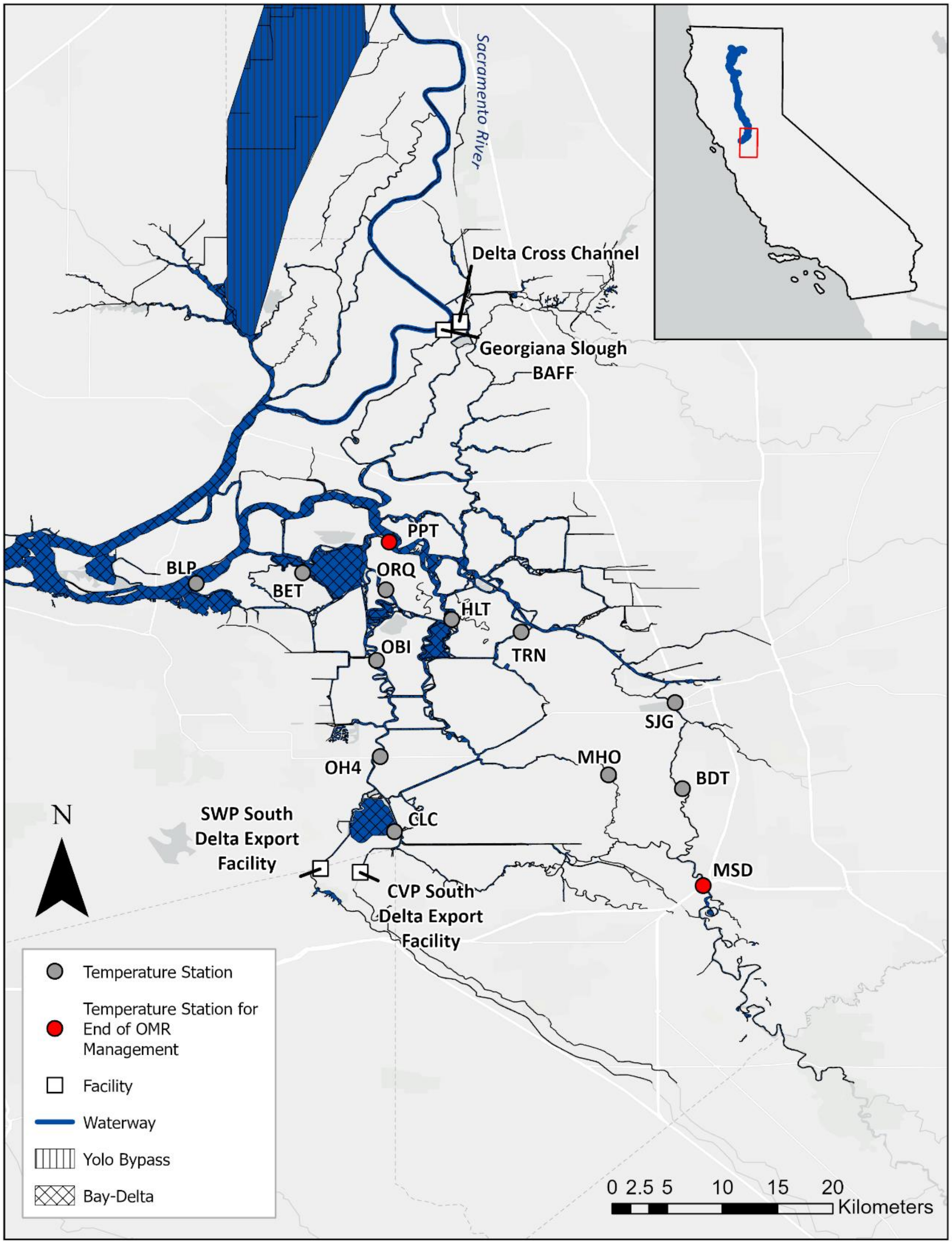

Figure 73. Locations of 13 water temperature stations within the interior Delta. The MSD and PPT temperature stations that are monitored to end OMR Management, as described in Condition of Approval 8.6, are indicated with red dots.

6.2.10.2.2. Evaluation of Juvenile CHNWR and CHNSR Entrainment Period

The first date and last date of loss for juvenile CHNWR and CHNSR at the CVP and SWP export facilities across water years 2010 through 2022 were determined to summarize the historical entrainment period for each species. Historical entrainment periods of juvenile CHNWR were consolidated for LAD natural-origin CHNWR (unclipped) and hatchery-origin CHNWR (clipped). Historical entrainment periods of genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR were also summarized.

Historical entrainment periods of juvenile CHNSR were consolidated similarly to CHNWR with two modifications. Natural-origin juvenile CHNSR identified to run by the Delta Model LAD criteria (USFWS 1997) only includes the YOY size class and not a yearling size class; therefore, the entrainment period of LAD CHNSR is limited to YOY CHNSR. For genetically-identified natural-origin CHNSR, juvenile CHNSR include both YOY and yearling size classes, whereby the yearling size class includes fish sized greater than the maximum Delta Model LAD criteria (USFWS 1997) for CHNSR. In addition to differences in size classes for CHNSR, the historical entrainment periods for genetically-identified natural-origin CHNSR were limited to water years 2017 to 2022 based on data availability. None of the CWT-confirmed hatchery-origin CHNSR were considered yearlings based on size between water years 2010 and 2022.

6.2.10.2.3. Evaluation of Water Temperature Threshold Exceedances

Water temperature data from the thirteen temperature stations were calculated as daily averages for June across water years 2010 through 2022. To better understand historical water temperature dynamics in the interior Delta, the June temperature dataset was visually analyzed by plotting individual box plots for each station within each water year against the CHNWR and CHNSR water temperature threshold of 22.2°C.

Daily average water temperatures for MSD and PPT were filtered to include dates with daily average temperatures greater than 22.2°C in June to evaluate the level of minimization provided by the water temperature thresholds by determining on which date, if any, in each water year that both stations exceeded the threshold for seven days (consecutive or non-consecutive) in June.

6.2.10.3. Results

6.2.10.3.1. Juvenile CHNWR Entrainment Period

For water years 2010 to 2022, the average last dates of loss for LAD and genetically-identified natural-origin CHNWR combined at the CVP and SWP export facilities were April 18 and March 29, respectively (Table 51). For water years 2010 to 2022, the average last date of loss for LAD hatchery-origin and CWT-confirmed hatchery-origin CHNWR combined at the CVP and SWP export facilities were April 11 and March 27, respectively (Table 51). Historically, LAD natural- and hatchery-origin CHNWR have been observed in salvage at the CVP and SWP export facilities from December through May (Figure 74). Genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR have been observed in salvage from December through April (Figure 75). Historically, peak loss of LAD natural- and hatchery-origin CHNWR occurred from January through March (see Section 5.2.1.2.1 – Historical Loss of Winter-run Chinook Salmon; Figures 9-12). Loss of LAD natural- and hatchery-origin CHNWR in May has only occurred in 5 of the 13 water years analyzed, specifically water years 2011, 2012, 2017, 2018, and 2020. For LAD natural-origin CHNWR, loss in May for water years 2012, 2017, and 2018 totaled 58.05, 6.80, and 8.66 fish, respectively. For LAD hatchery-origin CHNWR, loss in May for water years 2011, 2012, 2017, and 2020 totaled 4.33, 17.94, 29.96, and 4.33, respectively. For water years 2010 to 2022, no loss of natural-origin or hatchery-origin CHNWR, identified by LAD, genetics, or CWT has occurred in June (Figures 74 and 75).

Table 51. Latest date of observed loss for LAD natural-origin, LAD hatchery-origin, genetically-identified natural-origin, and CWT-confirmed hatchery-origin CHNWR at the CVP and SWP export facilities for water years 2010-2022, as well as the average and median date of last loss. Table cells represented with "N/A" indicate historical loss was not observed. Table cells represented with "-" indicate genetic analyses were not conducted.

Water Year	LAD Natural-Origin CHNWR Date of Last Loss	LAD Hatchery-Origin CHNWR Date of Last Loss	Genetic Natural-Origin CHNWR Date of Last Loss	CWT-Confirmed Hatchery-Origin CHNWR Date of Last Loss
Average	18-Apr	11-Apr	29-Mar	27-Mar
Median	20-Apr	14-Apr	31-Mar	25-Mar
2010	20-Apr	19-Mar	4-Apr	24-Mar
2011	13-Apr	10-May	29-Mar	-
2012	29-May	7-May	2-Apr	31-Mar
2013	6-Apr	21-Apr	28-Mar	25-Mar
2014	14-Apr	20-Mar	19-Mar	-
2015	31-Mar	25-Feb	N/A	25-Feb
2016	22-Mar	29-Mar	22-Feb	14-Mar
2017	5-May	8-May	N/A	-
2018	15-May	14-Apr	7-Apr	9-Apr
2019	20-Apr	30-Mar	7-Apr	-
2020	30-Apr	6-May	24-Apr	-
2021	9-Mar	14-Apr	8-Mar	-
2022	27-Apr	5-Apr	N/A	30-Mar

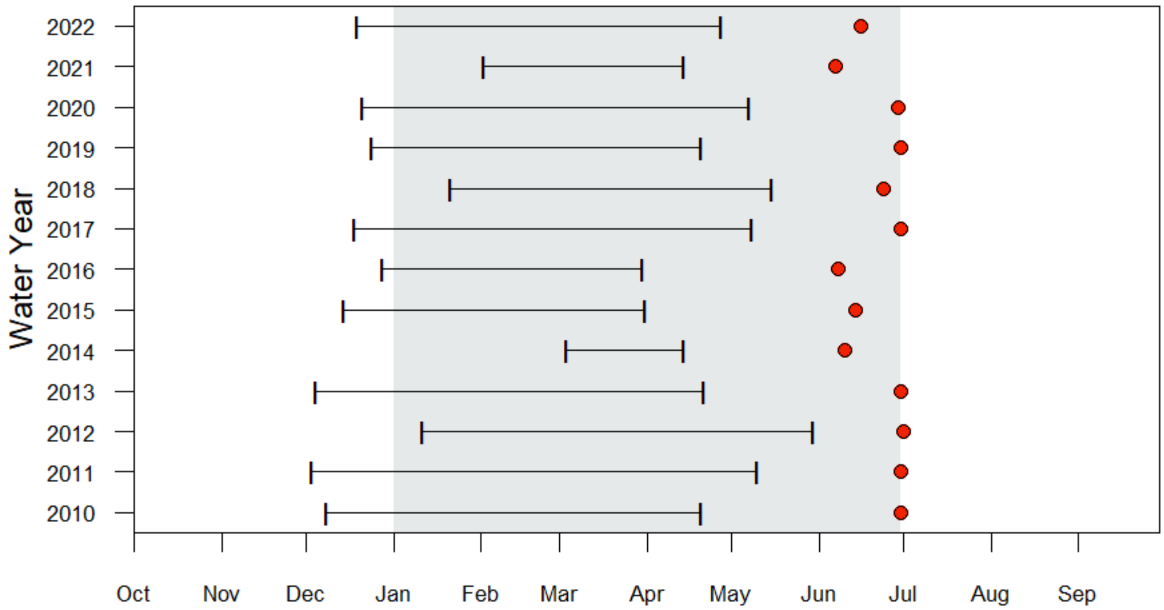

Figure 74. LAD natural-origin and hatchery-origin CHNWR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for LAD natural-origin and hatchery-origin CHNWR each water year. The red dots indicate when the water temperature station data at MSD and PPT would trigger an end to OMR Management for CHNWR and CHNSR each water year. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively.

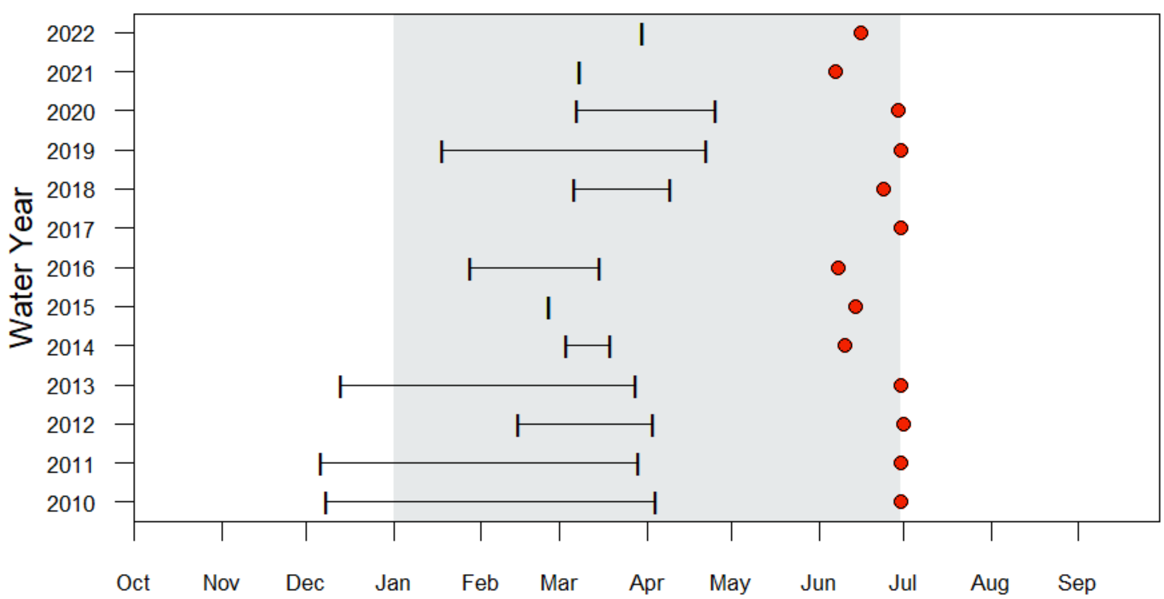

Figure 75. Genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNWR each water year. The red dots indicate when the water temperature

station data at MSD and PPT would trigger an end to OMR Management for CHNWR and CHNSR each water year. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively. For water year 2015 CWT-confirmed hatchery-origin CHNWR loss occurred only on 2/25/2015. For water year 2021, genetically-identified natural-origin CHNWR loss occurred only on 3/8/2021. For water year 2022 CWT-confirmed hatchery-origin CHNWR loss occurred only on 3/26/2022 and 3/30/2022. No loss of genetically-identified natural-origin or CWT-confirmed hatchery-origin CHNWR occurred in water year 2017.

6.2.10.3.2. Juvenile CHNSR Entrainment Period

For water years 2010 to 2022, the average last dates of loss for LAD and genetically-identified natural-origin CHNSR combined at the CVP and SWP export facilities were May 30 and May 13, respectively (Table 52). For water years 2010 to 2022, the average last date of loss for LAD and CWT-confirmed hatchery-origin CHNSR combined at the CVP and SWP export facilities was May 14 (Table 52). Historically, LAD natural- and hatchery-origin CHNSR have been observed in salvage at the CVP and SWP export facilities from January through June (Figure 76). Genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNSR have been observed in salvage from January through July (Figure 77). Historically, peak loss of LAD natural- and hatchery-origin CHNSR occurred from March through May (see Section 5.2.1.2.2 – Historical Loss of Spring-run Chinook Salmon; Figures 25-27). Loss of LAD natural- and hatchery-origin CHNSR in June occurred in 5 of the 13 water years analyzed, specifically water years 2010, 2011, 2012, 2017, and 2019. For LAD natural-origin CHNSR, loss in June for water years 2010, 2011, 2012, 2017 and 2019 totaled 159.81, 5,033.41, 3.19, 5,478.57 and 28.63 fish, respectively. For LAD hatchery-origin CHNSR, loss in June for water years 2011 and 2017 totaled 647.22 and 25.71, respectively. For LAD natural- and hatchery-origin CHNSR, loss did not occur after June 30. Historically, peak loss of genetically-identified natural-origin CHNSR occurred from April through May; however, data were only available for water years 2017 to 2022 (see Section 5.2.1.2.2 – Historical Loss of Spring-run Chinook Salmon; Figures 34 and 35). For genetically-identified natural-origin CHNSR, loss observed after June only occurred during one of the six water years analyzed, specifically water year 2017. In water year 2017, loss of genetically-identified natural-origin CHNSR totaled 5,467.17 fish in June and loss of 2.33 fish extending into July. Across water years 2010 to 2022, only one genetically-identified natural-origin yearling CHNSR was observed in salvage, specifically on January 7, 2022. Only five CWT-confirmed hatchery-origin CHNSR were observed in salvage between water year 2010 and 2022. Loss of CWT-confirmed hatchery-origin CHNSR totaled 4.33 in water year 2013 and 18.98 in water year 2018. Zero loss of CWT-confirmed hatchery-origin CHNSR occurred in June.

Table 52. Latest date of observed loss for LAD natural-origin, LAD hatchery-origin, genetically-identified natural-origin, and CWT-confirmed hatchery-origin CHNSR at the CVP and SWP export facilities for water years 2010-2022, as well as the average and median date of last loss. Table cells represented with “N/A” indicate historical loss was not observed. Table cells represented with “-” indicate genetic analyses were not conducted.

Water Year	LAD Natural-Origin CHNSR Date of Last Loss	LAD Hatchery-Origin CHNSR Date of Last Loss	Genetic Natural-Origin CHNSR Date of Last Loss	CWT-Confirmed Hatchery-Origin CHNSR Date of Last Loss
Average	30-May	14-May	13-May	21-Apr
Median	25-May	15-May	14-May	21-Apr
2010	5-Jun	30-May	-	-
2011	24-Jun	20-Jun	-	-
2012	8-Jun	26-May	-	-
2013	25-May	2-May	-	3-May
2014	10-May	18-Apr	-	-
2015	18-May	30-Apr	-	-
2016	19-May	7-Apr	-	-
2017	29-Jun	8-Jun	14-Jul	-
2018	23-May	21-May	27-May	10-Apr
2019	25-Jun	27-May	23-Mar	-
2020	26-May	5-May	21-Apr	-
2021	12-May	11-May	12-May	-
2022	21-May	15-May	16-May	-

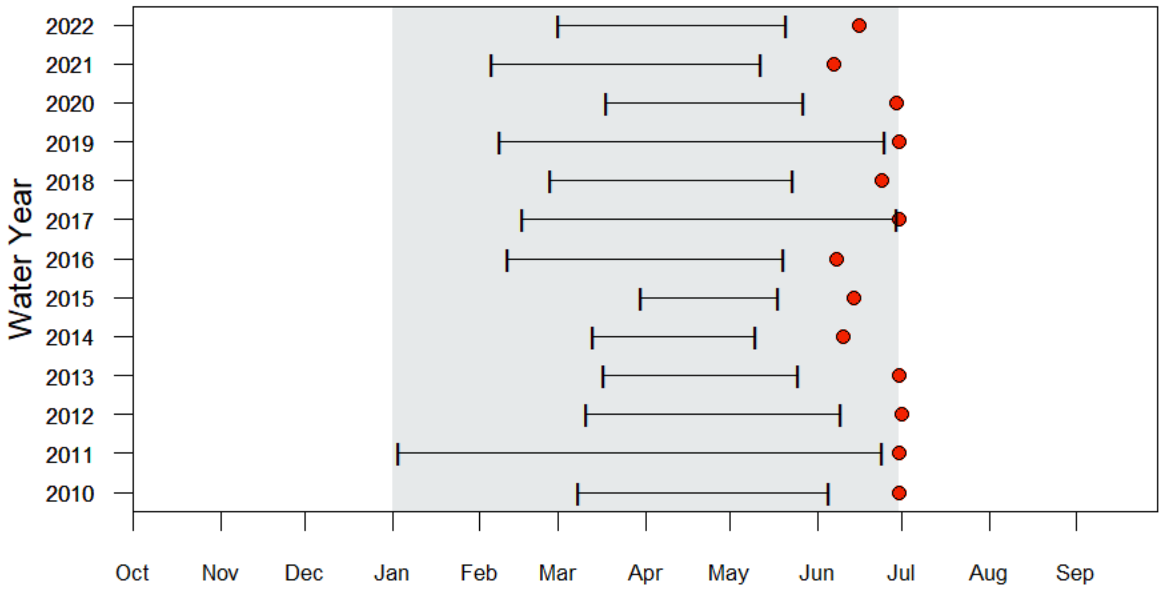

Figure 76. YOY LAD natural-origin and hatchery-origin CHNSR entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for YOY LAD natural-origin and hatchery-origin CHNSR each water year. The red dots indicate when the water temperature station data at MSD and PPT would trigger an end to OMR Management for CHNWR and CHNSR each water year. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively. For water year 2017, the last date of loss and the temperature threshold exceedance occurred on 6/29/2017 and 6/30/2017, respectively, which is why the vertical line and the red dot appear overlapping.

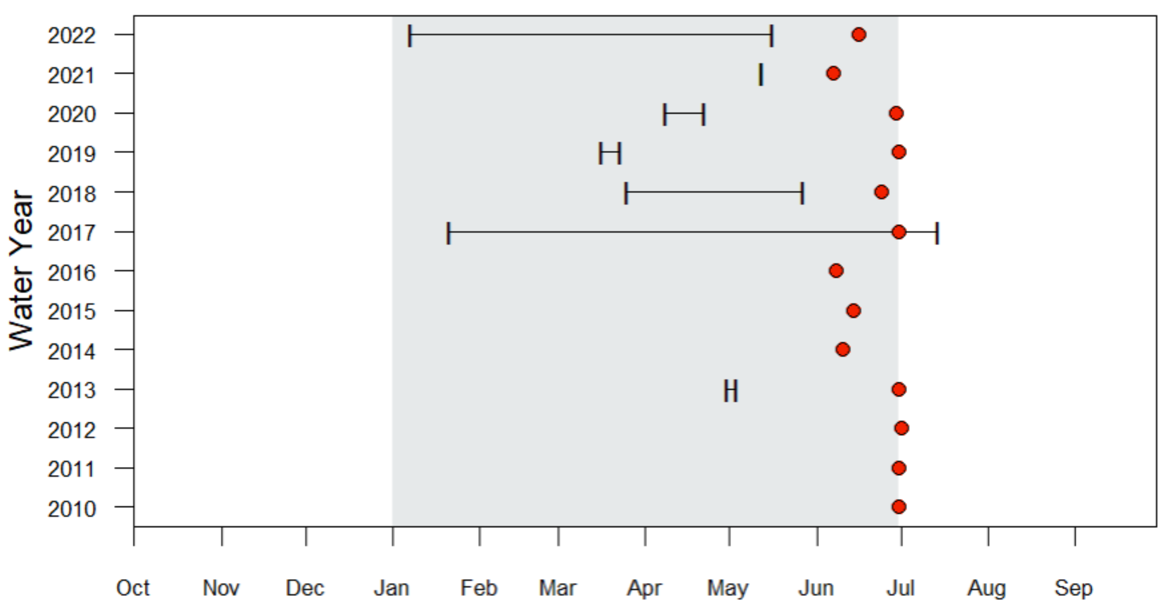

Figure 77. Genetically-identified natural-origin YOY and yearling CHNSR entrainment period at the CVP and SWP export facilities for water years 2017-2022 and CWT-confirmed hatchery-origin CHNSR

entrainment period at the CVP and SWP export facilities for water years 2010-2022. The vertical bars on the ends of each line indicate the first and last date of loss for genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNSR each water year. The red dots indicate when the water temperature station data at MSD and PPT would trigger an end to OMR Management for CHNWR and CHNSR each water year. The shaded gray box indicates the OMR Management period with the latest potential start and end dates of January 1 and June 30, respectively. For water year 2021, genetically-identified natural-origin CHNSR loss occurred only on 5/12/2021. The first date of the entrainment period for water year 2022 represents the only genetically-identified natural-origin yearling CHNSR observed in salvage across water years 2017-2022. Zero CWT-confirmed hatchery-origin CHNSR were observed in salvage in water years 2010-2012, 2014-2017, and 2019-2022.

6.2.10.3.3. Water Temperature Variability and Threshold Exceedances

In most water years (2012 to 2016, 2018, 2021, and 2022), water temperature variability across the interior Delta shows a decreasing trend in the south Delta from MSD to PPT (Figure 78). However, in wetter water years (2011, 2017, and 2019), the trend reverses and shows water temperatures increasing from CLC to PPT. For water years 2010 (below normal water year) and 2020 (dry water year), water temperatures across the Delta were relatively uniform.

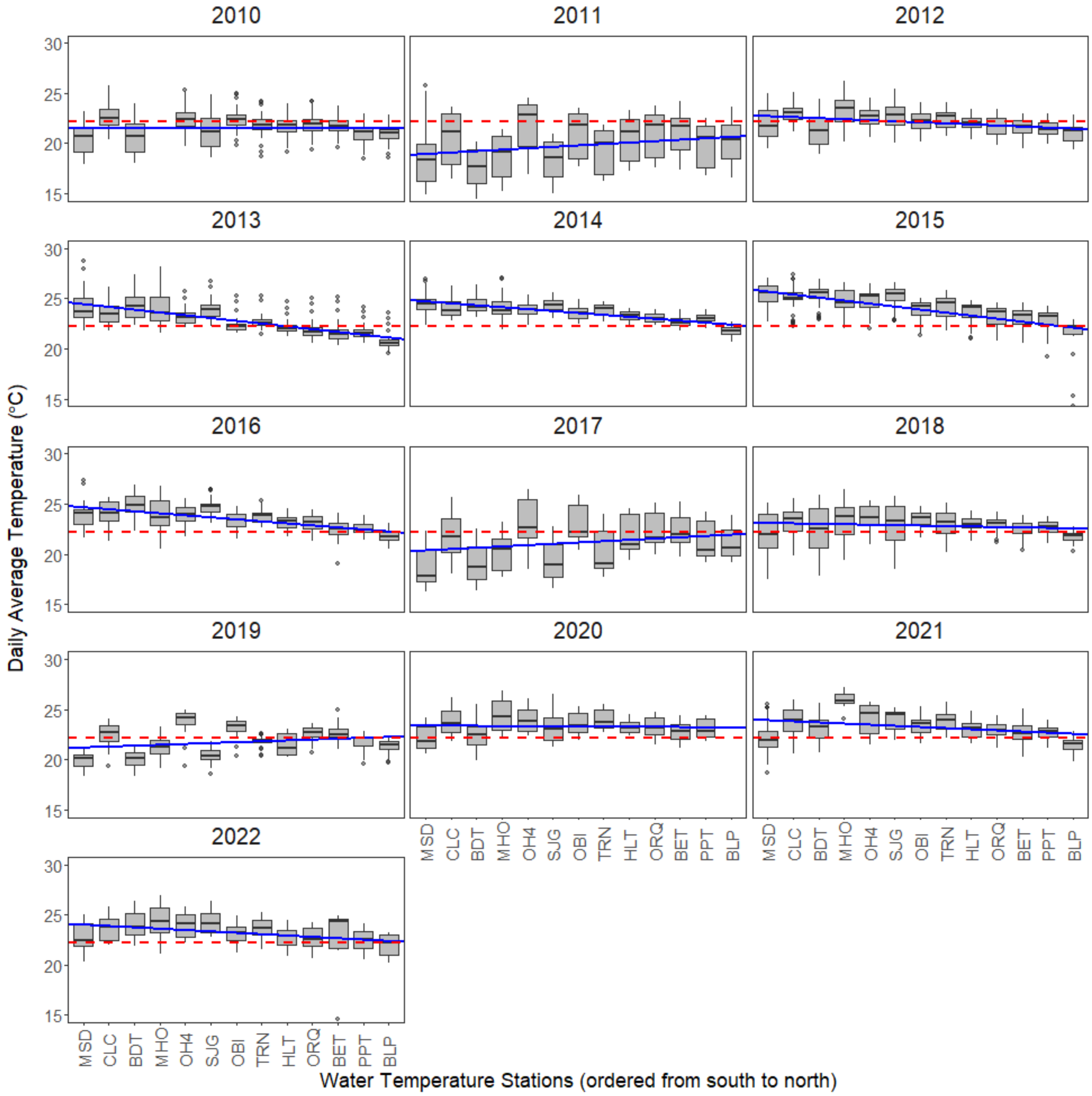

Figure 78. Box plots showing average daily water temperature trends in June for thirteen water temperatures stations in the interior Delta across water years 2010-2022. Water temperature stations are listed on the x-axis in order from south (MSD) to north (BLP). The blue trendlines, which represent a linear regression between water temperature stations (ordered south to north) and daily average water temperatures, indicate the direction of water temperature change across the interior Delta. The black horizontal line in each box plot indicates the median water temperature for each temperature station. The CHNWR and CHNSR OMR Management temperature threshold of 22.2°C is represented by the dotted red line.

Table 53 includes historical dates when water temperature threshold exceedances, monitored at MSD and PPT, would trigger an end to OMR Management for water years 2010 through 2022. Both temperature stations need to exceed 22.2°C for seven days (consecutive or non-consecutive) in June to conclude OMR Management prior to June 30. Therefore, Table 53 highlights in red the second temperature station to exceed the threshold as the station responsible for ending OMR Management. In 2 of the 13 water years evaluated, temperatures exceeding the threshold would have ended OMR Management for CHNWR and CHNSR on the same day for both the MSD and PPT temperature stations. Temperatures exceeding the threshold at the MSD temperature station would have ended OMR Management for CHNWR and CHNSR in 2 of the 13 water years analyzed. Temperatures exceeding the threshold at the PPT temperature station would have ended OMR Management for CHNWR and CHNSR in 3 of the 13 water years analyzed. In six water years, OMR Management for CHNWR and CHNSR would have ended on June 30 prior to temperatures exceeding 22.2°C for seven days (consecutive or non-consecutive) at both the MSD and PPT stations. Figures 74, 75, and 76 show water temperature threshold exceedances occurring after the historical entrainment period of LAD natural-origin and hatchery-origin CHNWR and CHNSR, and genetically-identified natural-origin CHNWR, and CWT-confirmed hatchery-origin CHNWR. Figure 77 shows water temperature threshold exceedances occurring after the historical entrainment period of genetically-identified natural-origin and CWT-confirmed hatchery-origin CHNSR in all years except water year 2017 when loss extended through July.

Table 53. Water temperature threshold exceedance dates, as monitored by the MSD and PPT stations, to end OMR Management for CHNWR and CHNSR in June for water years 2010-2022. Water temperature exceedance dates for each station indicate the date when historical daily average water temperatures exceeded 22.2°C for 7 days (consecutive or non-consecutive) in June. Table cells highlighted in red indicate which temperature station and on which date OMR Management for CHNWR and CHNSR would conclude prior to June 30. Table cells represented with "-" indicate that there was not a temperature threshold exceedance prior to June 30.

Water Year	MSD Date of Water Temperature Threshold Exceedance	PPT Date of Water Temperature Threshold Exceedance
2010	-	-
2011	-	-
2012	June 15	-
2013	June 7	-
2014	June 7	June 10
2015	June 7	June 14
2016	June 7	June 7
2017	-	June 26
2018	June 24	June 16
2019	-	June 23
2020	June 28	June 8
2021	June 7	June 7
2022	June 15	June 16

6.2.10.4. Discussion

The MSD temperature station is located in the southern portion of the interior Delta and represents water temperatures CHNWR and CHNSR experience while emigrating through the south Delta. Based on historical entrainment periods, CHNWR are not expected to be present in the south Delta in June, while CHNSR may still be emigrating and present in the vicinity during this time. The PPT temperature station is located in the northern portion of the interior Delta near the junctions of the San Joaquin River, Middle River, and Mokelumne River. Monitoring water temperatures at this location is critical because emigrating juvenile CHNWR or CHNSR entrained into Georgianna Slough or the DCC will pass through the area. In most years, the MSD and PPT temperature stations record different water temperature patterns, with potential regional temperature stratification in the south Delta influenced by San Joaquin River inflow. Pairing of water temperatures measured at the MSD and PPT temperatures stations in Condition of Approval 8.6 will adequately represent the scope of thermal conditions experienced by juvenile CHNWR and CHNSR across the Delta.

The entrainment period for LAD natural-origin and hatchery-origin CHNWR and CHNSR, as well as genetically-identified natural-origin CHNWR and CWT-confirmed hatchery-origin CHNWR and CHNSR, did not extend past the end of OMR management for water years 2010 to 2022. However, in water year 2017, one genetically-identified natural-origin CHNSR was observed in salvage on July 14, which was later than the end of OMR Management (June 30 in water year 2017). Even though one natural-origin CHNSR was observed in salvage after June 30, the temperature thresholds specified in Condition of Approval 8.6 minimize take of CHNSR as OMR Management has extended several days after the last date of natural-origin CHNSR loss for most water years analyzed. Thus, ending OMR management prior to June 30 based on temperature exceedance criteria minimizes entrainment and take of juvenile CHNSR based on historical data.

Adhering to temperature criteria at both the MSD and PPT stations minimizes the risk of entrainment of juvenile CHNWR and CHNSR by limiting the end of OMR Management to occur only after temperatures have exceeded core (16°C) and non-core (18°C) rearing temperatures as documented by USEPA (2003), which has historically occurred no earlier than June 7. When temperatures at the MSD and PPT temperature stations exceed the UESPA (2003) approved rearing temperatures, it is unlikely that juvenile CHNWR and CHNSR are using this area to rear, indicating that juveniles are at low risk of being entrained at the CVP and SWP export facilities.

6.2.11. Condition of Approval 7.5.2 Skinner Delta Fish Protective Facility Improvement Process, Condition of Approval 7.5.1 Facility Outages Reporting, and Condition of Approval 8.13 Skinner Fish Protective Facility CDFW Staff

Condition of Approval 7.5.2 requires DWR to continue to refine and improve Skinner Fish Protective Facility fish sampling procedures and infrastructure to improve accuracy and reliability of data and fish survival. The Skinner Fish Protective Facility minimizes losses resulting from fish entrainment at Banks Pumping Plant through the salvage process. DWR operates the facility to capture fish entrained by Banks Pumping Plant into CCF. Salvage of fish occurs at the Skinner Fish Protective Facility whenever Banks

Pumping Plant is actively pumping. Fish are salvaged in the Skinner Fish Protective Facility every 120 minutes and monitored during a 30-minute fish count. Salvaged fish are transported by truck to release sites near the confluence of the Sacramento and San Joaquin rivers. Under the 2024 SWP ITP, DWR commits to making improvements to the Skinner Fish Protective Facility including implementation of updated training curricula and salvage release site improvements.

Condition of Approval 7.5.2 requires DWR to continue to refine and improve Skinner Fish Protective Facility fish sampling procedures and infrastructure to improve accuracy and reliability of data and fish survival. Specifically, Condition of Approval 7.5.2 requires DWR to minimize impacts from excessive debris, such as reduced counts resulting from required maintenance activities, through continued implementation of fall herbicide application to CCF and completion of a Debris Management Effectiveness Study to analyze the effectiveness of CCF herbicide application on debris management procedures. If the results of the Debris Management Effectiveness Study identify feasible additional improvements that require further development and/or prioritization, an SDM process may be utilized to develop improvement requirements including design criteria and/or procedures to implement the study recommendations (e.g. alternative methods of managing fish counts during periods of heavy debris and/or large numbers of fish). Within one year from issuance of the ITP, DWR will submit a draft Debris Management Effectiveness Study Plan to CDFW for approval. The Debris Management Effectiveness Study Plan will include a timeline for study completion, and an SDM process for alternatives development, and design criteria development with participation from DWR, CDFW, NFMS and USFWS. At the conclusion of the SDM process, DWR will submit the SDM recommendations to CDFW for approval and will implement recommendations within two years. In the interim, DWR and CDFW will use the historical count length reduction procedures for managing heavy debris/and or large numbers of fish. Facility improvement evaluations informed by the Debris Management Effectiveness Study and SDM process will be performed concurrently with the Alternative Loss Pilot Study Implementation Plan effort (see Section 6.2.12; Condition of Approval 7.9.1). DWR is committed to implementing the Alternative Loss Pilot Study Implementation Plan which would include continued coordination with Reclamation to incorporate flexibility with salvage release site operations to improve fish survival.

Instances of reduced counts due to high aquatic weed debris at Skinner Fish Protective Facility have decreased since the fall herbicide treatment in CCF has been implemented beginning fall 2020 with CDFW annual approval. From calendar years 2020 to 2023, there have been five documented notes of reduced fish counts due to high aquatic weed debris documented in the CDFW Bay-Delta Region salvage database (Kyle Griffiths, personal communication, 5/2024). In calendar year 2019, there were 166 documented notes of reduced fish counts due to high weed debris between the months of July and December in the salvage database (Kyle Griffiths, personal communication, 5/2024). One database note may refer to multiple reduced counts within the same day, so it is likely there were more than 166 instances of reduced counts in calendar year 2019. Continuation of CCF herbicide treatment in the fall, if approved by CDFW on an annual basis, will likely continue to moderate the number of reduced counts at the Skinner Fish Protective Facility and may reduce further take of CHNWR and CHNSR within CCF.

Under Condition of Approval 7.5.1, DWR will provide Reclamation, CDFW, USFWS, and NMFS notice of salvage disruptions due to planned facility maintenance (planned outages) at least two weeks in advance. For unplanned facility maintenance, notice will be provided as soon as practicable. In the event of an unplanned outage (e.g., power disruption) extending beyond one hour, DWR will stop pumping, but may continue to operate the CCF radial gates.

Under Condition of Approval 8.13, DWR will fund two full-time Environmental Scientist and one Senior Environmental Scientist, Specialist positions in CDFW's Fish Facility and Entrainment Unit to work collaboratively with DWR's Skinner Fish Protective Facility staff. Duties of the CDFW's Fish Facility and Entrainment Unit staff include, but are not limited to: receiving daily salvage data from the Tracy Fish Collection Facility and Skinner Fish Protective Facility, conducting QA/QC on salvage data and on the salvage database, training DWR's Skinner Fish Protective Facility staff, overseeing salvage facility operations, working with DWR annually to review and revise the Skinner Delta Fish Protective Facility Operations Manual, reviewing annual salvage reports, receiving notifications regarding inspections or maintenance of fish protective equipment, engaging in real-time decision making to determine whether reduced fish count times (reduced counts) at the Skinner Fish Protective Facility are appropriate, and participating in the Alternative Loss Estimation Pilot Study and the Debris Management Effectiveness Study.

The salvage process at the Skinner Fish Protective Facility generates one of the largest data sources characterizing entrainment and take of CHNWR and CHNSR with a high amount of sampling effort. The duties performed by CDFW's Fish Facility and Entrainment Unit staff will ensure proper identification of State and federally listed salmonids at the Skinner Fish Protective Facility, which allows for an accurate calculation of loss used to assess threshold exceedances for OMR Management. These staff members will also maintain consistency in operating to the established protocols to ensure continued generation of a robust dataset that has undergone QA/QC.

DWR, in collaboration with CDFW's Fish Facilities and Entrainment Unit, will develop and implement a revised written training curriculum for implementation in water year 2025 as identified in Section IV: Fish Identification of the 2021 DWR/CDFW Interagency Agreement for Fish Facilities Operation (DWR and CDFW 2021). Skinner Fish Protective Facility will have access to a staff biologist from CDFW's Fish Facilities and Entrainment Unit for consultation to support Skinner Fish Protective Facility staff, research studies, and special handling of tagged fish.

Conditions of Approval 7.5.2, 7.5.1, and 8.13 will minimize take of Covered Species including CHNWR and CHNSR by improving accuracy of species identification and data collection during the salvage process, improving salvage database management to provide a robust and reliable dataset for informing management decisions, and improving fish survival through updated Skinner Fish Protective Facility operations.

6.2.12. Condition of Approval 7.9.1 Alternative Loss Estimation Pilot Study

Condition of Approval 7.9.1 requires DWR to fund and support the continued development of an alternative loss equation to estimate juvenile CHNWR, CHNSR, and steelhead loss at the CVP and SWP export facilities. This ongoing effort builds upon the 2020 SWP ITP Condition of Approval 7.4.3 that required DWR to refine the Chinook Salmon loss equation through annual performance evaluation studies for each component of the equation, pertaining to CHNWR and CHNSR loss (CDFW 2020d). The current loss equation used to estimate loss of CHNWR and CHNSR at the CVP and SWP export facilities is comprised of four main components, each associated with mortality: pre-screen loss, screening (louver) efficiency, salvage, and handling and trucking loss (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). These components are based off studies utilizing juvenile Chinook Salmon and steelhead loss and have not been updated since 2003, thus additional studies are needed to better understand how each component contributes to juvenile CHNWR and CHNSR loss under different environmental parameters and spatiotemporal variation.

DWR and Reclamation have conducted performance evaluation studies historically; however, results of these studies have not been incorporated into the loss equation. For example, the loss equation currently calculates pre-screen loss at the Skinner Fish Protective Facility as 75% based on the average of historical studies conducted in CCF (CDFW 2018). However, studies since 2009 have indicated that pre-screen loss varies among release groups within individual studies. Clark et al. (2009) calculated pre-screen loss from PIT tagged and acoustic tagged juvenile steelhead released at the CCF radial gates ranging from 78±4 to 82±3%. The lower estimate considers steelhead emigration from CCF into Old River and may underestimate pre-screen loss given uncertainty in telemetry results (e.g., predation). Wunderlich (2015) conducted pre-screen evaluation studies for PIT tagged CHNFR released at the CCF radial gates and determined a pre-screen loss rate of 81.14±0.19% for all release groups combined. However, prescreen loss ranged from 41 to 100% across different release groups. Miranda (2016) conducted pre-screen evaluation studies for PIT tagged CHNFR and CHNLFR released at the CCF radial gates from January to May of 2016 and determined monthly pre-screen loss ranged from 75 to 97%, with a season average estimate of 91%. Additional releases conducted by Miranda (2019) using PIT and acoustic tagged CHNFR and CHNLFR released at the CCF radial gates and at the head of the Skinner Fish Protective Facility calculated pre-screen loss as 77.16% for all runs combined. Pre-screen loss was estimated as 56.07% (26.1-88.5%) for CHNLFR and 92.1% (92.1-98.5%) for CHNFR. An additional 12,574 PIT tagged CHNLFR, CHNFR, and steelhead have been released at the radial gates from 2017 through 2020 with an estimate of pre-screen loss of 74.4% (DWR 2021b) for all releases.

Pre-screen loss at the Tracy Fish Collection Facility is largely unstudied but is assumed to be 15% (CDFW 2018; NMFS 2019a). This value likely underestimates pre-screen loss at the Tracy Fish Collection Facility because it only incorporates assumed loss between the trash rack and the primary louvers and does not consider observed loss in front of the trash rack. NMFS (2019a) speculates that pre-screen loss may be inversely correlated with pumping rates (water velocity) and turbidity, but further investigation is warranted.

This variation in pre-screen loss is also found in screening (louver) efficiency at the Skinner Fish Protective Facility, which has been documented to range from 17 to 100% (Clark 2009; Wunderlich 2015; Miranda 2019). Clark et al. (2009) conducted louver efficiency studies for PIT tagged hatchery steelhead released at the Skinner Fish Protective Facility trash rack and estimated two efficiency rates based on fish movement. For PIT tagged steelhead detections, louver efficiency was estimated as 74±7% (17-100%). For PIT tagged and acoustic tagged steelhead detections, louver efficiency was estimated as 82±7% (19-100%). The higher estimate considers steelhead emigration out of the primary louver bay and into the CCF and may be a liberal estimate due to small sample size (i.e., error associated with emigration may be large). Wunderlich (2015) released PIT tagged CHNFR in front of the Skinner Fish Protective Facility in April and May of 2013 and estimated louver efficiency as 74% (71-76%). Additional releases conducted by Miranda (2019) using PIT and acoustic tagged CHNFR and CHNLFR released at the Skinner Fish Protective Facility trash rack and estimated louver efficiency as 81.7% (77.9-86.2%) while operating under SWRCB Decision 1485 requirements for salmon and 55.0% (54.3-55.7%) while operating for striped bass criteria. An additional 1,054 PIT tagged CHNLFR, CHNFR, and steelhead have been released at the trash rack from 2017 through 2020 with an estimate of louver efficiency of 85.1% (DWR 2021b) for all releases.

In addition to pre-screen and screening (louver) loss, loss of Chinook Salmon occurs at the Tracy Fish Collection Facility during louver cleaning. During cleaning, louvers are lifted out of the facility, allowing fish to freely pass through the channel leading to the Jones Pumping Plant. At the Skinner Fish Protective Facility, bays are closed prior to louver cleaning, which prevents fish from passing through the channel leading to the Banks Pumping Plant. Studies at the Tracy Fish Collection Facility have demonstrated that approximately 6.7% of juvenile Chinook Salmon that encounter the louvers are lost through the louvers during regular cleaning (Karp et al. 2017). This value is preliminary and currently not incorporated into the loss equation.

Another component of the loss equation that could be updated is the mortality associated with handling and trucking Chinook Salmon. The handling and trucking loss component assumes 2% loss for Chinook Salmon less than or equal to 100 mm as measured by fork length and 0% loss for Chinook Salmon greater than 100 mm as measured by fork length. These estimates are based on a study conducted between 1984 and 1985 that determined survival rates for transporting Chinook Salmon were never less than 98% (Raquel 1989). Since handling and trucking conditions have changed since that study, it is possible that 2% may not accurately depict the loss attributed to handling and trucking and new investigations are warranted.

Additionally, the loss equation does not consider the condition and survival of salvaged fish at either the Tracy Fish Collection Facility or Skinner Fish Protective Facility once they are returned to the Sacramento and San Joaquin rivers. Past studies have documented predation by piscivorous fish and birds at release sites; however, predation and other post-release stressors have not been well quantified (Miranda et al. 2010). Orsi (1968) estimated that up to one third of the fish released per day experience predation; and in the absence of large numbers of predatory striped bass, less than 10% of released fish experience predation. NMFS (2019a) speculates that predation may be the main source of post-release mortality; however, mortality is likely to fluctuate based on other factors, including the number of fish released, season, and frequency of release. A predation study using tethered Golden Shiner (*Notemigonus crysoleucas*) at Curtis Landing, a release site for the Skinner Fish Protective Facility, found that waiting 5 days between releases did not decrease predation (Hammen et al. 2021). Several other measured environmental variables were analyzed for potential impact on predation, and water depth and time of day were found to have the greatest influence on predation rates. Additional studies are warranted to estimate post-release loss of salvaged Chinook Salmon attributed to predation and other post release stressors.

Under Condition of Approval 7.9.1, DWR will develop a refined alternative loss equation to use in parallel with the current loss equation and incorporate SDM to prioritize loss component studies and performance evaluation studies. The goal of Condition of Approval 7.9.1 is to provide a more accurate estimate of CHNWR, CHNSR, and steelhead loss, and loss components at the CVP and SWP export facilities by assembling an Alternative Loss Equation Technical Team with representatives from DWR, CDFW, NMFS, Reclamation, and USFWS to develop refined protocols for daily estimation of salvage and loss, including relevant calculations and models, data, and information sources necessary to estimate salvage and loss. DWR has developed an initial loss model, the Alternative Loss Equation software tool, and will continue to refine the model through feedback from the Alternative Loss Equation Technical Team. The Alternative Loss Equation software tool employs a Partially Observed Markov Process (POMP) model to estimate loss using random parameters to analyze time series data (Simonis et al. 2016). Within a year of issuance of the 2024 SWP ITP, DWR and Reclamation will take feedback from the Alternative Loss Equation Technical Team to develop a draft Alternative Loss Pilot Study Implementation Plan for review and approval by the technical team, SaMT, and CDFW. Following CDFW approval of the draft plan, DWR will finalize the Alternative Loss Pilot Study Implementation Plan for implementation. Within of one and a half years of CDFW approval on the final Alternative Loss Pilot Study Implementation Plan, the Alternative Loss Equation Technical Team will complete a SDM process to establish priorities (e.g., loss component studies/pilot study recommendations) for further implementation by DWR. Within seven years of issuance of the 2024 SWP ITP, DWR will update the loss equation with the refined loss equation components for approval by CDFW.

The loss equation is essential for determining impacts to juvenile CHNWR and CHNSR associated with operations at the CVP and SWP export facilities and is applied to loss thresholds designed to curtail OMR flows (Conditions of Approval 8.2.1, 8.4.3, 8.4.4, 8.4.5, and 8.5). A refined loss equation, incorporating best available science, will better estimate loss of juvenile Chinook Salmon observed at the south Delta CVP and SWP export facilities.

6.2.13. Condition of Approval 8.15 Relationship Between the Adaptive Management Program and the 2024 SWP ITP

Condition of Approval 8.15 establishes the relationship between the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP) and the 2024 SWP ITP. The goal of the Adaptive Management Program is to support existing and new monitoring and science to improve understanding of CHNWR and CHNSR ecology. The following actions described in the Adaptive Management Program will serve to minimize take of CHNWR and CHNSR by filling many information gaps identified in this Effects Analysis and improving species management:

- Development of a model to predict daily CHNWR migration timing through the Delta using long-term monitoring and environmental data as a real-time assessment tool for SaMT (Condition of Approval 7.9.2);
- Development of a new modeling framework integrating the CHNWR distribution model (mentioned above) with particle tracking modeling to estimate daily proportion of the outmigrating CHNWR population that is at risk of entrainment into the south Delta as a real-time assessment tool for SaMT (Condition of Approval 7.9.2);
- Continued development of a CHNSR JPE (Condition of Approval 7.9.3);
- Continued development of a CHNSR life cycle model (Condition of Approval 7.9.4);
- Evaluation of the CHNSR hatchery surrogate threshold (Condition of Approval 7.9.3) and development of a new OMR real-time threshold informed by the CHNSR JPE and CHNSR life cycle model;
- Acoustic telemetry studies and analysis to better estimate CHNWR through-Delta survival and loss due to CVP and SWP operations and inform the NMFS Southwest Fisheries Science Center Winter-run Chinook Salmon Lifecycle Model to identify a target through-Delta survival value;

- Refinement and finalization of the Alternative Loss Equation to provide a more accurate estimate of salmonid loss and loss parameters at the CVP and SWP export facilities (Condition of Approval 7.9.1);
- Continued effectiveness monitoring of the Georgiana Slough Salmonid Migratory Barrier during annual operation (Condition of Approval 7.9.6); and
- Supplementation of Delta outflow during spring months (March – May) through CVP and SWP contribution towards the HRL to benefit juvenile Chinook Salmon growth and survival in tributaries and the Delta (SWP share provided by Condition of Approval 8.12).

These additional monitoring, science, and management actions will elucidate impacts of the Project and may result in measures to further minimize take of CHNWR and CHNSR associated with Project impacts through the Adaptive Management Program[17]. Each action will have a dedicated Adaptive Management Technical Team comprised of technical staff representing DWR, CDFW, Reclamation, USFWS, and NMFS. The Adaptive Management Steering Committee will be responsible for support, coordination, and implementation of the Adaptive Management Program, and will be comprised of manager-level representatives from DWR, CDFW, Reclamation, USFWS, and NMFS. Adaptive management changes will be decided on collaboratively by the Adaptive Management Technical Teams and Adaptive Management Steering Committee to the maximum extent possible and may include changes to Project operations or other changes to the 2024 SWP ITP through major or minor amendments requested by DWR (California Code of Regulations, Title 14, § 783.6, subdivision (c)), consistent with Condition of Approval 5 (Consultation Regarding Amendment).

6.3. Minimization of Effects of Maintenance at Clifton Court Forebay

DWR will conduct maintenance activities in CCF, according to Condition of Approval 7.5.1 – Maintenance, Outages, and Inspection Reporting, Condition of Approval 8.14 – Clifton Court Forebay Maintenance, Outages, and Inspection Procedures (see Section 6.2.11), and DWR's Clifton Court Forebay Aquatic Weed Management Standard Operating Procedures (DWR 2023j) for the duration of the 2024 SWP ITP (see Section 5.3 – Effects of Maintenance at Clifton Court Forebay on Chinook Salmon). DWR will employ specific practices to minimize impacts of CCF maintenance activities on Covered Species, including CHNWR and CHNSR.

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[17] Additional actions listed below are included in the Adaptive Management Program (see Attachment 4 to the 2024 SWP ITP) but were identified in the ITP Application (DWR 2023f) as elements that will not be DWR's responsibility (*) or were not included in the ITP Application (**):

- Effectiveness monitoring for the Upper Sacramento River Anadromous Fish Habitat Restoration Project in providing spawning and refuge habitat for Chinook Salmon in the Sacramento River watershed*;
- Evaluation of the effectiveness of Upper Sacramento River Spring Pulse Flow Study on Chinook Salmon in the Sacramento River watershed*;
- Winter-run Chinook Salmon Action Plan*;
- Shasta Reservoir coldwater pool management**; and
- Adaptive management and monitoring of a new Clear Creek flow regime and/or temperature criteria**.

DWR will strive to limit aquatic weed treatments to only two times per year. Aquatic algae treatments are anticipated to occur twice per year or less, but as-needed if using peroxide-based algaecides. DWR will only use aquatic herbicides and algaecides that cause as little harm as possible to Covered Species such as Aquathol K, which has low toxicity to fish, and peroxide-based algaecides, which are non-toxic. Copper-based compounds will also be used for management of aquatic weeds and algae. Although copper-based herbicides and algaecides can be acutely toxic to fish, DWR will apply these products at a concentration of 1 ppm or less to minimize impacts on Covered Species.

DWR will aim to avoid application of herbicide and algaecide treatments (i.e., Aquathol K and copper-based compounds) during times when Covered Species are present in CCF and anticipates these activities to occur between early summer (late June) and fall (late October). There is a low probability that CHNWR and CHNSR are present in the Delta during this time, although CHNWR have been observed in monitoring at Knights Landing RST as early as August (CalFish 2023c). However, according to Condition of Approval 8.14.2 (Herbicide and Algaecide Treatment), if any Covered Species is observed at the Skinner Fish Protection Facility prior to application, DWR will confer with CDFW prior to initiating herbicide or algaecide treatments. Condition of Approval 8.14.2 requires that if herbicide and algaecide treatments occur outside of summer and fall months, average daily water temperatures within CCF must be greater than or equal to 25°C and treatment must be approved by CDFW. Additionally, CCF radial gates will remain closed during treatments to reduce seepage outside of CCF and minimize impacts to fish that may be in the vicinity. Prior to herbicide or algaecide application, water in CCF will be drawn down to increase fish movement towards the Skinner Fish Protective Facility so they can be salvaged rather than remaining in CCF and be exposed to chemical treatment. Additional measures in Condition of Approval 8.14.2 to help minimize take of CHNWR and CHNSR include collecting water quality samples before, during, and after treatment to avoid exceeding concentrations permissible under the National Pollutant Discharge Elimination System (NPDES) permit, only conducting aerial spray applications in wind speeds less than 15 miles per hour (mph) to lessen any spray wafting outside the immediate area, and implementation of a spill prevention plan should an accidental spill occur (Condition of Approval 6.7 – Hazardous Waste). Any deviations from typical treatment conditions will require approval by CDFW, NMFS, and USFWS.

Under Condition of Approval 8.14.3 (Clifton Court Forebay Aquatic Weed Harvesting), mechanical boat-mounted aquatic weed harvesters will be utilized on an as-needed basis year-round, though harvesting will occur most frequently during the late summer and fall. Environmental awareness training will be conducted for all personnel involved (Condition of Approval 6.4 – Education Program) and harvesting will stop immediately if any wildlife is observed in the vicinity to allow wildlife to volitionally exit the area.

6.4. Minimization of Effects of Operations and Maintenance at Barker Slough Pumping Plant

DWR will operate and maintain the BSPP, according to Condition of Approval 7.6 – Barker Slough Pumping Plant Maintenance, Condition of Approval 8.10 – Barker Slough Pumping Plant Delta Smelt and Longfin Smelt Protections (see Section 6.4.1; Conditions of Approval 8.10.1 and 8.10.2), and DWR's North Bay Aqueduct Fish Screen Sediment and Aquatic Weed Removal Standard Operating Procedures (DWR 2023i) for the duration of the 2024 SWP ITP (see Section 5.4 – Effects of Operations and

Maintenance at Barker Slough Pumping Plant on Chinook Salmon). BSPP fish screens are designed using NMFS fish screen criteria for salmonids to prevent entrainment and minimize impingement of juvenile salmonids larger than 25 mm (NMFS 2023b). BSPP maintenance activities include fish screen cleaning, sediment removal, and aquatic weed removal. Fish screen cleaning occurs monthly, as needed, where pumping operations cease to prevent fish entrainment into the BSPP. Sediment removal occurs year-round in the trap and concrete apron in front of the BSPP fish screens and in the pump wells behind the BSPP fish screens. To better understand impacts from sediment removal, salmonid biological monitoring may be required based on the collection of juvenile Chinook Salmon and steelhead in the Yolo Bypass Fish Monitoring Program (YBFMP) sampling between November and June (Condition of Approval 7.6.1 – Biological Monitoring of Maintenance Activities and Condition of Approval 7.6.4 – Sediment Removal). Biological monitoring can take the form of having a CDFW-approved biological monitor on site to record fish observed in removed sediment or the use of environmental DNA for water samples taken in the BSPP forebay or at the intakes. The biological requirement for salmonid monitoring from November through December is the collection of juvenile Chinook Salmon or steelhead in the most recent seining at YBFMP sites BL 1-5 (Lower Yolo Bypass Toe Drain). The biological requirement for salmonid monitoring from January through June is the collection of juvenile Chinook Salmon or steelhead within the past five days in the YBFMP RST (Lower Yolo Bypass Toe Drain). From July through October, there is no biological trigger to do additional biological monitoring. DWR will provide an annual summary to CDFW reporting BSPP sediment removal activities and results from salmonid monitoring data provided by the biological monitor.

Aquatic weed removal, via weed raking or weed harvesting, occurs year-round at the fish screens and BSPP forebay. To better understand impacts from high volumes of aquatic weed removal (over 3 cubic yards removed per day), salmonid biological monitoring may be required consistent with the criteria for biological monitoring identified for sediment removal activities (Condition of Approval 7.6.1 – Biological Monitoring of Maintenance Activities, Condition of Approval 7.6.2 – Fish Screen Aquatic Weed Raking, and Condition of Approval 7.6.3 – Aquatic Weed Harvesting). Biological monitoring can take the form of having a CDFW-approved biological monitor on site to record fish observed in removed aquatic weeds or the use of environmental DNA for water samples taken in the BSPP forebay or at the intakes. DWR will provide an annual summary to CDFW reporting BSPP aquatic weed removal activities and results from salmonid monitoring data provided by the biological monitor.

6.4.1. Condition of Approval 8.10.1 Barker Slough Pumping Plant Larval Delta Smelt Protection and Condition of Approval 8.10.2 Barker Slough Pumping Plant Larval Longfin Smelt Protection

Conditions of Approval 8.10.1 and 8.10.2 require DWR to reduce BSPP diversions during spring months to protect larval DS and LFS during dry and critical water year types. Condition of Approval 8.10.1 requires DWR to reduce the maximum 7-day average diversion rate at the BSPP to less than 100 cfs between May 1 and June 30 of dry and critical water years if catch of larval DS in 20-mm survey at station 716 exceeds 5% of the total catch of larval DS across the north Delta. DWR will further reduce the 7-day average diversion rate at the BSPP to less than 60 cfs between March 1 and April 30 of dry and critical water years if catch of larval DS in 20-mm survey at station 716 exceeds 14% of the total catch of larval DS across the north Delta. Condition of Approval 8.10.2 requires DWR to reduce the maximum 7-

day average diversion rate at the BSPP to less than 100 cfs between January 1 and March 31 of dry and critical water years to minimize entrainment of larval LFS.

Reducing the BSPP diversions during the spring months will reduce the potential entrainment of juvenile CHNWR and CHNSR into the BSPP forebay and will have a beneficial impact on food web dynamics in the greater Yolo Bypass region by reducing the amount of prey items removed from the system through exports (see Attachment 5, Sections 6.4.2 and 9.4.2 to the 2024 SWP ITP; Conditions of Approval 8.10.1 and 8.10.2).

6.5. Minimization of Effects of South Delta Temporary Barriers Project

DWR will operate the South Delta Temporary Barriers Project, according to Condition of Approval 7.7 – South Delta Temporary Barriers Project Reporting and DWR's Annual Construction and Operations Flow Chart for Calendar Years 2023-2027 (DWR 2023k) for the duration of the 2024 SWP ITP, or until such time as permanent operable gates are constructed (see Section 5.5 – Effects of South Delta Temporary Barriers Project on Chinook Salmon). Timing of barrier construction and removal, as well as barrier flap gate operations, will minimize take of CHNWR and CHNSR. Historical data show that CHNWR juveniles enter the Delta as early as August and exit the Delta by May, overlapping the beginning of annual May construction of the South Delta Temporary Barriers Project (see Section 4.1.6 – Rearing and Outmigrating Juveniles in the Bay-Delta and Section 4.1.7 – Juvenile Ocean Entry; CalFish 2023c; SacPAS 2023a). CHNSR have a greater risk of exposure to the barriers, during construction and operation, than CHNWR due to variable life histories and outmigration timing. Historical data show that YOY CHNSR juveniles enter the Delta as early as November and exit the Delta by June (see Section 4.2.6 – Rearing and Outmigrating Juveniles in the Bay-Delta and Section 4.2.7 – Juvenile Ocean Entry; Buttermore et al. 2021a; CalFish 2023c). Yearling CHNSR Delta entry and exit timing are more variable and difficult to determine based on current monitoring in the Delta. In addition to Delta entry and exit monitoring, historical salvage shows that juvenile CHNWR and CHNSR are present in the south Delta in the vicinity of the CVP and SWP export facilities during spring operations of the south Delta temporary barriers (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon at the CVP and SWP Export Facilities). Historically, juvenile LAD CHNWR have been observed in salvage from December through June, with most loss occurring between December and April. Historically, juvenile LAD CHNSR have been observed in salvage from January through June with loss observed once in October of water year 1998 and once in September of water year 2000. Genetically-identified natural-origin CHNSR loss was also observed once in July of water year 2017. CHNWR and CHNSR present in the south Delta in May will be exposed to constructed-related impacts and intermediate culvert operations. CHNWR and CHNSR present in the south Delta in June will be exposed to intermediate and full culvert operations.

To minimize impacts to outmigrating CHNWR and CHNSR, DWR will keep all barrier flap gates tied open during barrier construction and will keep the Grant Line Canal Barrier flashboard structure open to allow for volitional fish passage. DWR (2018) evaluated the effects of the barriers and determined that juvenile survival improved during intermediate culvert operations (i.e., barriers installed with flap gates tied open) and declined during full operations. Following construction and approval from CDFW, NMFS, and USFWS, DWR can begin intermediate culvert operations after May 15 where all but one flap gate is untied at each barrier. The untied flap gates are set to operate tidally allowing passage for juvenile

CHNWR and CHNSR during flap gate openings. Passage however is limited at the Grant Line Canal Barrier during intermediate culvert operation by closing the flashboard structure. On June 1 or when the average daily water temperature measured at the Mossdale (MSD) station has reached 71.6°F (22°C) full operation can begin where all flap gates are tidally operated. Water temperatures above 22°C are shown to cause decreased growth, impair smoltification, increase predation, and generally deter salmonids from the area (Carter 2008). It is unlikely that juvenile CHNWR and CHNSR are using areas near the south Delta temporary barriers to rear when water temperatures exceed the core (16°C) and non-core (18°C) rearing temperatures as documented by USEPA (2003). Initiating full operation only after water temperatures become uninhabitable for salmonids will minimize the take of the barriers on CHNWR and CHNSR.

Condition of Approval 7.7 requires DWR to seek written approval from CDFW prior to full operations of the barriers, and without approval DWR must continue to operate at intermediate operations. Condition of Approval 7.7 also requires DWR to seek written approval before raising the weir elevation of the barriers by 1 ft on or after June 15.

By September 15, DWR must remove a section of the Old River at Tracy and the Middle River barriers (i.e., notch the weir) and remove the flashboard structure at the Grant Line Canal Barrier to provide passage for up-migrating adult salmonids and minimize the negative effects of delayed migration timing (DWR 2023k).

6.6. Additional Old and Middle River Management Minimization

Additional OMR Management minimization measures are those Conditions of Approval included in the 2024 SWP ITP which are intended to minimize take and impacts of the taking to a Covered Species other than CHNWR and CHNSR, but may provide ancillary protections to CHNWR and CHNSR when implemented. The following briefly summarizes these additional Conditions of Approval and how they provide additional OMR Management minimization for CHNWR and CHNSR.

Condition of Approval 8.3.1 – First Flush Action

Condition of Approval 8.3.1 limits south Delta exports for 14 consecutive days between December 1 and the last day of February to achieve a 14-day average OMR index no more negative than -2,000 cfs within three days of when the following criteria are met:

- 3-day running average of daily flows at Freeport is greater than, or equal to, 25,000 cfs, and
- 3-day running average of daily turbidity at Freeport is greater than, or equal to, 50 FNU.

Following the implementation of Condition of Approval 8.3.1, OMR Management initiates which limits south Delta exports to achieve a 14-day average OMR index no more negative than -5,000 cfs.

If Condition of Approval 8.3.1 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR (Grimaldo et al. 2009).

Condition of Approval 8.3.2 – Adult Delta Smelt Entrainment Protection Action

Condition of Approval 8.3.2 limits south Delta exports after a First Flush Action or after December 20, whichever occurs first, to achieve a 5-day average OMR index that is no more negative than -3,500 cfs within three days of when any of the following criterion are met:

- Daily average turbidity at Old River at Franks Tract near Terminous is greater than, or equal to, 12 FNU, or
- Daily average turbidity at Holland Cut is greater than, or equal to, 12 FNU, or
- Daily average turbidity at Old River at Bacon Island is greater than, or equal to, 12 FNU.

Condition of Approval 8.3.2 can off-ramp when daily average turbidity in at least one of the three turbidity stations is less than 12 FNU for two consecutive days. Condition of Approval 8.3.2 can also off-ramp when the 3-day continuous average water temperatures at Jersey Point or Rio Vista reach 12°C (53.6°F) or if a high-flow off-ramp occurs, whereby daily average San Joaquin River flow at Vernalis is greater than 10,000 cfs. If daily average San Joaquin River flow at Vernalis drops below 8,000 cfs, Condition of Approval 8.3.2 goes back into effect.

Following the implementation of Condition of Approval 8.3.2, OMR Management initiates which limits south Delta exports to achieve a 14-day average OMR index no more negative than -5,000 cfs.

If Condition of Approval 8.3.2 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR and CHNSR (Grimaldo et al. 2009).

Condition of Approval 8.3.3 – Adult Longfin Smelt Entrainment Protection Action

Condition of Approval 8.3.3 limits south Delta exports for seven consecutive days between December 1 and the start of OMR Management to achieve a 7-day average OMR index no more negative than -5,000 cfs within three days of when the following criterion is met:

- Cumulative water year salvage of LFS with fork length greater than, or equal to, 60 mm exceeds the salvage threshold defined in the 2024 SWP ITP.

Following the implementation of Condition of Approval 8.3.3 prior to the start of OMR Management, OMR Management initiates, if WOMT determines it is warranted, which limits south Delta exports to achieve a 14-day average OMR index no more negative than -5,000 cfs.

Condition of Approval 8.3.3 also limits south Delta exports for seven consecutive between the start of OMR Management to the end of February to achieve a 7-day average OMR index no more negative than -3,500 cfs within three days of when the following criterion is met:

- Cumulative water year salvage of LFS with fork length greater than, or equal to, 60 mm exceeds the salvage threshold.

If Condition of Approval 8.3.3 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR and CHNSR (Grimaldo et al. 2009).

Condition of Approval 8.4.1 – Larval and Juvenile Delta Smelt Entrainment Protection Action

Condition of Approval 8.4.1 limits south Delta exports after an Adult Delta Smelt Entrainment Protection Action to achieve a 7-day average OMR index of no more negative than -5,000 cfs within three days of when the following criterion is met:

- Average Secchi disk depth in the most recent survey is greater than 1 m.

Condition of Approval 8.4.1 also limits south Delta exports after an Adult Delta Smelt Entrainment Protection Action to achieve a 7-day average OMR index of no more negative than -3,500 cfs within three days of when the following criterion is met and until the average Secchi disk depth has increased to greater than 1 m:

- Average Secchi disk depth in the most recent survey is less than 1 m.

The CVP and SWP export facilities will operate to whichever of these OMR thresholds is appropriate given the latest Secchi disk depth data until the end of OMR Management. Condition of Approval 8.4.1 can off-ramp if a high-flow off-ramp occurs, whereby daily average Sacramento River flow at Rio Vista is greater than 55,000 cfs or daily average San Joaquin River flow at Vernalis is greater than 8,000 cfs. If daily average Sacramento River flow at Rio Vista drops below 40,000 cfs or the daily average San Joaquin River flow at Vernalis flow drops below 5,000 cfs, Condition of Approval 8.4.1 goes back into effect.

If Condition of Approval 8.4.1 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR and CHNSR (Grimaldo et al. 2009).

Conditions of Approval 8.4.2 – Larval and Juvenile Longfin Smelt Entrainment Protection Action

Condition of Approval 8.4.2 limits south Delta exports for seven consecutive days between January 1 and the end of OMR Management to achieve a 7-day average OMR index of no more negative than -3,500 cfs within three days of when the following criteria are met:

- The 7-day average QWEST is more positive than +1,500 cfs; and
- Larval and juvenile LFS catch in the most recent Smelt Larval Survey (SLS) or 20-mm survey at stations 809 and 812 exceeds the catch threshold set by the Age 1+ LFS Index defined in the 2024 SWP ITP.

Condition of Approval 8.4.2 can off-ramp or be adjusted if approved by WOMT. Condition of Approval 8.4.2 can also off-ramp if a high-flow off-ramp occurs, whereby daily average Sacramento River flow at Rio Vista is greater than 55,000 cfs or daily average San Joaquin River flow at Vernalis is greater than 8,000 cfs. If daily average Sacramento River flow at Rio Vista drops below 40,000 cfs or the daily average San Joaquin River flow at Vernalis flow drops below 5,000 cfs, Condition of Approval 8.4.2 goes back into effect.

Condition of Approval 8.4.2 also limits south Delta exports for 14 consecutive days to achieve a 14-day average OMR index of no more negative than -3,500 cfs or -2,500 cfs when annual loss of juvenile LFS salvage exceeds 50% or 75%, respectively, of the calculated annual loss threshold defined in the 2024 SWP ITP.

If Condition of Approval 8.4.2 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR and CHNSR (Grimaldo et al. 2009).

Condition of Approval 8.4.7 – White Sturgeon Entrainment Protection Action

Condition of Approval 8.4.7 requires DWR to convene the WS Monitoring Team (WSMT) the following business day if the following criteria at met:

- Young of year WS have been detected in at least one of the following north or central Delta survey stations in the last 90 days: 20mm Survey stations 705, 707, 711, or 716, or Bay Study Survey stations 751, 760, or 761; and
- The mean total exports over the last 90 days are greater than, or equal to, the exports defined by the following equation:

$$Exports_{90-day\ average} = 14{,}296.76 + -0.41 Vernalis\ Flow_{90-day\ average}$$

Upon convening, WSMT will review all available information to develop an assessment of the risk of further entrainment and salvage of WS. DWR and CDFW will develop a joint risk assessment and supporting documentation to accompany operations advice for WOMT to consider. WOMT will decide what operational changes are warranted with CDFW approval.

If Condition of Approval 8.4.7 initiates in any given water year, it may reduce the impacts to or take of CHNWR and CHNSR that are migrating through the Delta by reducing the magnitude of negative OMR flow, which is negatively correlated with entrainment of CHNWR and CHNSR (Grimaldo et al. 2009).

7. Mitigation for Take and Impacts of the Taking on Winter and Spring-run Chinook Salmon

7.1. Condition of Approval 9.2.1 Implementation of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Condition of Approval 9.2.1 requires DWR to complete the implementation of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (YBSHRFP Project) also known as "The Big Notch Project" by 2026 to enhance floodplain rearing habitat and fish passage in the Yolo Bypass, which will benefit CHNWR and CHNSR in addition to other species, including Central Valley steelhead, southern Distinct Population Segment (sDPS) of North American Green Sturgeon (*Acipenser medirostris*), and WS. The Big Notch Project will allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of the Fremont Weir. From November to March 15, Sacramento River water can passively flow through the notch during periods when Sacramento River elevations are greater than 14 ft NAVD88. After March 15, Big Notch Project flows will be limited to prevent additional inundation through Fremont Weir (DWR 2020b). The Big Notch Project will connect the new, gated notch to Tule Pond with a channel that parallels the existing east levee of the Yolo Bypass. It would allow flows up to approximately 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide flow for adult fish passage, juvenile emigration, and floodplain inundation for juvenile rearing habitat (DWR 2020b). The Big Notch Project also includes a supplemental fish passage facility on the west side of the Fremont Weir and improvements to allow fish to pass through Agricultural Road Crossing 1 and the channel north of Agricultural Road Crossing 1. Objectives of the Big Notch Project include increased access to and acreage of seasonal floodplain rearing habitat for juvenile fish, reduction in fish stranding, increased aquatic biotic production to provide food through an ecosystem approach, and a reduction in migratory delays and loss of fish at Fremont Weir and other structures in the Yolo Bypass (DWR 2020b).

Impacts of CVP and SWP operations on CHNWR and CHNSR were assessed under the 2009 NMFS BO and associated CDFW Consistency Determination (Number 2080-2009-011-00; CDFG 2009), with RPA Actions I.6.1 and I.7 required as mitigation for unavoidable loss and impacts to CHNWR and CHNSR and their critical habitat (NMFS 2009). RPA Actions I.6.1 and I.7 were required to avoid jeopardizing the continued existence of the species and provide for the recovery of CHNWR and CHNSR under baseline conditions identified in the 2008 Reclamation Biological Assessment (Reclamation 2008).

The 2009 NMFS BO and CDFW Consistency Determination for CHNWR and CHNSR (CDFG 2009) required DWR, in conjunction with Reclamation, to implement habitat enhancement projects to improve spawning and rearing habitat for Chinook Salmon in the Sacramento River Basin and Delta (NMFS 2009). Specifically, RPA Action I.6.1 required the restoration of floodplain rearing habitat for juvenile CHNWR and CHNSR in the lower Sacramento River Basin (later identified as the YBSHRFP Project). The action required reinitiation of consultation if less than half of the total acreage identified in the restoration plan (later identified as the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan; DWR and Reclamation 2012) was implemented by 2016. The Record of Decision/Notice of Determination for the YBSHRFP Project Environmental Impact Statement/Environmental Impact Report were signed on September 19, 2019. As of December 2023, DWR has completed all work to tie the new, gated notch into the Fremont Weir (DWR 2023b). Full operation of the gated intake is expected to begin November 2024. Future project construction to be completed by 2026 includes the supplemental fish passage facility on the west side of the Fremont Weir and improvements to Agricultural Road Crossing 1 and the channel north of Agricultural Road Crossing 1 located downstream of the Fremont Weir on Tule Canal (DWR 2020b).

Annually, DWR and Reclamation will provide a technical memorandum that includes operational plans and monitoring results from the Big Notch Project to CDFW, NMFS, and the Yolo Bypass Fisheries and Engineering Technical Team (FETT; DWR 2020b). Monitoring is a crucial component of the adaptive management process. The YBSHRFP Project Adaptive Management Plan (DWR 2020b) includes fish passage monitoring efforts planned for the Big Notch Project as well as additional monitoring elements for Wallace Weir and Fremont Weir fish passage improvements. Juvenile entrainment monitoring will include releases of marked (either PIT- or acoustically-tagged), hatchery-origin juvenile Chinook Salmon into the Sacramento River upstream of the Fremont Weir to monitor the fish movement near the Fremont Weir and gated notch. This monitoring action will occur each year for three years (if river stage is sufficient) following the construction of the Big Notch Project. Additionally, DWR will continue to monitor an existing RST located in the lower Yolo Bypass. All juvenile Chinook Salmon, including tagged fish, will be recorded. Food web monitoring will assess chlorophyll a, phytoplankton, and zooplankton concentrations within the Yolo Bypass at the RST and within the Sacramento River at Sherwood Harbor. CDFW will continue to operate the Wallace Weir Fish Collection Facility to capture and relocate adult salmonids. Monitoring efforts will record the number of salmonids caught at the fish collection facility during operations. Reclamation, DWR, and CDFW staff will visually inspect the Fremont Weir stilling basin, the deep pond, Tule Pond, and all channels incorporated into the Big Notch Project for stranded fish following operations. Additionally, CDFW periodically inspects the deep pond and Oxbow Pond for sturgeon presence following an overtopping event using Dual-frequency Identification Sonar (DIDSON) cameras and gill nets. Acoustic telemetry monitoring will occur during the first five years of operation of the Big Notch Project. Upstream-migrating adult CHNFR and WS will be captured in the lower Yolo Bypass and affixed with acoustic transmitters. Receivers will be located downstream of the fish passage structure and upstream of the structure in the Sacramento River to provide information on fish passage success. Adaptive Resolution Imagining Sonar (ARIS) cameras will be used to confirm successful and unsuccessful sturgeon passage attempts at the structure entrance (DWR 2020b). Monitoring juvenile fish entrainment and growth on the floodplain as well as adult passage will be imperative to accessing the goals of the Big Notch Project and ensuring benefits to species.

There are temporal losses associated with delays in Big Notch Project implementation for habitat enhancements in the Yolo Bypass and Sacramento River. These temporal losses compounded by continued operations of the SWP have impeded the recovery of CHNWR and CHNSR, as evidenced by continued declines in population abundance (see Sections 4.1.2 and 4.2.2 – Population Status and Trends and Sections 4.1.3 and 4.2.3 – Extinction Risk). Therefore, in addition to DWR's commitment to implement the Big Notch Project required by Condition of Approval 9.2.1, Condition of Approval 9.2.2 (see Section 7.2) and Condition of Approval 9.2.3 (see Section 7.3) together require DWR to make funding commitments as compensatory mitigation for impacts associated with continued Project operations through 2034.

7.2. Condition of Approval 9.2.2 Feather River Fish Passage and Hatchery Improvements

Condition of Approval 9.2.2 requires DWR to fund $19.9 million in CHNSR compensatory mitigation. This funding is carried forward from the compensatory mitigation obligation originally established the 2020 SWP ITP Condition of Approval 9.2.1, which required DWR to fund $20 million over the term of the 2020 SWP ITP towards enhancement and restoration projects to benefit CHNWR and CHNSR in the Sacramento River watershed upstream of the Delta. The 2020 SWP ITP Condition of Approval 9.2.1 was intended to fully mitigate Project impacts from 2020 through 2030 that are unavoidable even with minimization measures provided in the 2020 SWP ITP. Mitigation provided under the 2020 SWP ITP Condition of Approval 9.2.1 required DWR to fund habitat restoration that would benefit all life stages of CHNWR and CHNSR in upstream tributaries of the Delta where spawning, egg incubation, rearing, and emigration occurs (CDFW 2020d). To date, DWR has funded $100,000 towards the 2020 SWP ITP Condition of Approval 9.2.1 in the form of a draft feasibility study for a Willow Bend habitat restoration project intended to improve habitat conditions for juvenile and adult CHNWR and CHNSR in the reach of the Sacramento River near Moulton Weir in Colusa County. The Willow Bend feasibility study was not finalized or approved by CDFW and there are currently no next steps for the restoration project identified (CDFW 2021b). Under the 2024 SWP ITP, DWR has committed to funding the remainder of the $20 million identified for CDFW-approved compensatory mitigation for projects to benefit CHNWR and CHNSR.

Under Condition of Approval 9.2.2, DWR is committed to funding $1 million by July 2025 and an additional $14 million by 2026 towards the Sunset Weir and Pumps Project on the lower Feather River. The Sunset Weir and Pumps Project is identified as Alternative 3 in DWR's Alternatives Evaluation Study for the project. Alternative 3 includes the removal of the Sunset Pumps Diversion Dam, a boulder weir owned and operated by Sutter Extension Water District, located on the lower Feather River near Live Oak in Sutter County. The project also includes modification of existing Sunset Pumps to operate at a lower water surface elevation and installation of fish screens on twelve diversions upstream of the existing weir with the intention of not adversely affecting water delivery capabilities (ESA 2023). Currently the Sunset Pumps Diversion Dam functions as a boulder weir to maintain water surface elevation at the pump intakes; however, hydraulic modeling has confirmed that the boulder weir is a fish passage barrier under most flow conditions (ESA 2023, Appendix A). Additionally, acoustic tag data has shown predation near Sunset Pumps leading to a decrease in the survival of out-migrating juvenile Chinook Salmon and steelhead (ESA 2023).

The objective of the Sunset Weir and Pumps Project is to improve fish passage by removing the existing boulder weir, a known migratory barrier to CHNFR, CHNSR, Central Valley steelhead, the sDPS of North American Green Sturgeon, and WS, and installing CDFW approved fish-protective screens for the Sunset Pumps diversion and upstream neighboring private diversions using NMFS fish screen criteria. Removing the boulder weir will restore 8 miles of the Feather River to a more natural riverine condition making it more suitable for salmonid spawning and rearing (ESA 2023). Upgrades to the pump station will allow it to function without the increased river stage provided by the boulder weir by lowering pump intakes by 11 ft (ESA 2023). Additionally, installing fish-protective screens on each diversion will reduce out-migrating juvenile salmonid mortality caused by entrainment into the currently unscreened diversions.

The Sunset Weir and Pumps Project was recommended in the Sacramento Valley Salmon Resiliency Strategy (CNRA 2017), included in the HRL (previously Voluntary Agreements) non-flow commitments (VA Parties 2023), and is supported by the NMFS's 2014 Recovery Plan for Central Valley salmonids, specifically Recovery Action FER-2.13 (NMFS 2014). California Governor Gavin Newsom's Salmon Strategy for a Hotter, Drier Future also identified the Sunset Weir and Pumps Project as Action 1.13 of California's Priority 1 to remove barriers and modernize infrastructure for salmon migration (Office of California Governor Gavin Newsom 2024a). In addition to DWR's funding commitment towards the Sunset Weir and Pumps Project, CDFW has awarded a $9 million grant towards project implementation (Office of California Governor Gavin Newsom 2024b) and the Central Valley Project Improvement Act (CVPIA) has awarded about $3 million towards project implementation between fiscal year 2019 and fiscal year 2021 (Reclamation 2021). However, CDFW and CVPIA funding sources are not sufficient to cover the entire cost of the project. As a result, funding provided by Condition of Approval 9.2.2 is critical to ensure the likelihood of successful implementation of this project.

Under Condition of Approval 9.2.2, DWR is also committed to funding $4.9 million by 2026 for a disinfection system at the FRFH. The disinfection system is intended to reduce or remove pathogen contamination for hatchery reared CHNSR, CHNFR, and Central Valley steelhead, consistent with Action 4.8 of Governor Newsom's Salmon Strategy for a Hotter, Drier Future to install a water treatment system at the FRFH to facilitate adult CHNSR reintroduction above Oroville Dam (Office of California Governor Gavin Newsom 2024a). DWR is developing contract alternatives and designs of water treatment systems for FRFH in coordination with CDFW staff. A disinfection system is needed at FRFH due to the pathogenic threat of IHN. In 1998 and between 2000 and 2002, FRFH experienced high juvenile Chinook Salmon mortality due to IHN (Bendorf et al. 2007). Recurring outbreaks of IHN at FRFH were suspected to be a result of intensive stocking of hatchery-origin Chinook Salmon into Lake Oroville. Hatchery-origin Chinook Salmon stocking led to a higher concentration and prevalence of the virus in the water supply above FRFH (Bendorf et al. 2007, 2022). A water treatment system will limit the spread of IHN at FRFH allowing for reintroduction efforts to stock hatchery-origin adult CHNSR in the North Fork Feather River watershed above Lake Almanor. These efforts are consistent with Action 1.5 of Governor Newsom's Salmon Strategy for a Hotter, Drier Future that indicates DWR and CDFW will take the first steps towards CHNSR reintroduction on the North Fork Feather River by 2025 (Office of California Governor Gavin Newsom 2024a). Reintroducing Chinook Salmon above barriers into high-quality cold-water habitat may enhance Chinook Salmon resiliency to climate change and rising temperatures.

Improvements to juvenile upstream rearing habitat, required by Condition of Approval 9.2.2, will serve as mitigation for unavoidable impacts to juvenile CHNWR and CHNSR due to Project operations. In addition to the minimization measures identified under Conditions of Approval 6 through 8, there are remaining effects of Project operations on juveniles and their habitat. At the Skinner Fish Protective Facility and CCF, take associated with loss of juvenile CHNWR and CHNSR due to export operations is known to occur and is estimated daily. However, the full extent of take and impacts of the taking are more difficult to quantify and impacts resulting from SWP operations cannot be fully avoided or substantially reduced through minimization measures. For example, Project operations contribute to low in-river survival of emigrating CHNWR and CHNSR that must pass through the Sacramento River and Delta during periods of low flow conditions resulting in part from SWP export operations. Project operations cause delayed emigration and increased transit times related to Delta entrainment, which can increase the potential for mortality of juvenile CHNWR and CHNSR due to longer exposure periods coupled with poor in-Delta rearing and survival conditions. Through Condition of Approval 9.2.2, improving juvenile rearing habitat with the Sunset Weir and Pumps Project will mitigate for adverse effects of Project operations on CHNSR and their habitat. These habitat enhancements will increase habitat availability and improve the ecological function of the rearing and migratory corridor for juvenile CHNSR. CHNSR that utilize improved habitat on the lower Feather River may experience increases in growth and survival rates. Increased growth in juveniles improves the likelihood of their survival as they migrate downstream and are exposed to SWP export operations. Improvements in growth and survival can also lead to increased population resiliency during times of increased temperatures and water demands.

Improvements to adult passage, required by Condition of Approval 9.2.2, will serve as mitigation for unavoidable and unminimized impacts to adult CHNSR due to Project operations. Project operations cause reduced in-river flows and altered hydrology (e.g., reverse flows in Old and Middle rivers, false attraction towards export pumping) which can increase straying risk for adult CHNWR and CHNSR during migration (see Section 5.2.2 – Entrainment of Adult Chinook Salmon). Direct impacts to adult CHNWR and CHNSR are currently unquantified because data are not collected on the numbers of adults migrating through the Delta. Currently, adult entrainment data at the Skinner Fish Protective Facility is limited to species identification and fork length given that genetic samples are not taken on adult Chinook Salmon entrained into the facility to identify run. There are no minimization measures identified for the loss of adult CHNWR and CHNSR at the SWP export facilities (i.e., CCF and Skinner Fish Facility). There are also no risk assessments conducted by the SaMT that will propose minimization or OMR Management when adults are present or at high risk of straying into the SWP export facilities. Minimization measures for juvenile CHNWR and CHNSR identified under Conditions of Approval 8.2.1, 8.4.3, 8.4.4, and 8.4.5 may provide incidental benefits for adult CHNWR and CHNSR present in the entrainment zone of the CVP and SWP export facilities. Entrainment and loss of adult CHNWR and CHNSR at the CVP and SWP export facilities can result in pre-spawn mortality due to stranding or physical injuries sustained during the salvage process. Pre-spawn mortality can lead to a reduction in genetic diversity within these populations and a decline in juvenile production. Through Condition of Approval 9.2.2, providing improved upstream adult passage and spawning habitat with the Sunset Weir and Pumps Project will allow access to habitat that was formerly limited due to either structural or flow impediments. Increasing access to upstream habitat allows for spatial diversity in CHNSR spawning that may increase CHNSR juvenile production, life history diversity, and genetic diversity, and may also reduce the likelihood of redd superimposition. Improving fish passage throughout the Feather River will reduce migratory delays and loss of adult CHNSR at barriers and can enhance ecosystem function through improved habitat connectivity.

7.3. Condition of Approval 9.2.3 Winter-run and Spring-run Chinook Salmon Climate Change Support

Condition of Approval 9.2.3 requires DWR to fund $900,000 annually in CHNWR and CHNSR compensatory mitigation in addition to Condition of Approval 9.2.2, which is tied specifically to CHNSR measures that mitigate Project operations through 2030. Condition of Approval 9.2.3 is intended to fully mitigate Project impacts through 2034 that are unavoidable even with minimization measures provided in the 2024 SWP ITP. Mitigation provided under Condition of Approval 9.2.3 requires DWR to support projects that address stressors on CHNWR and CHNSR associated with climate change and includes actions such as: broodstock collection and holding of CHNWR and CHNSR to preserve genetic diversity of the population; further improvements to the Feather River Fish Hatchery in addition to Condition of Approval 9.2.2; habitat restoration or improvements to existing habitat; and improvements to fish passage within the Sacramento River watershed.

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Appendix A. Winter-run and Spring-run Chinook Salmon Temporal Occurrence in the Delta

A.1. Temporal Occurrence of Winter-run Chinook Salmon in the Delta

Table A- 1. Temporal occurrence of CHNWR in the Delta by life stage and month.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult[1]	M	H	H	H	M	M	L	L			M	M
Juvenile[2,3,6,7]	H	H	H	M				L	L	L	M	H

Table A- 2. Temporal occurrence of LAD CHNWR during juvenile migration by monitoring location and month.

Monitoring Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Knights Landing[2]	H	M	L	L				L	L	M	M	H
Sherwood Harbor[3]	H	H	H	M					L	L	M	H
Chipps Island[4]	M	M	H	H	L						L	L
CVP/SWP Salvage[5]	H	H	H	M	L	L						M

Table A- 3. Temporal occurrence of genetically-identified natural-origin CHNWR during juvenile migration by monitoring location and month.

Monitoring Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Knights Landing[6]	H	M	L	L					L	M	M	H
Sherwood Harbor[7]	M	H	H	M						L	M	M
Chipps Island[8]	M	M	H	H							L	L
CVP/SWP Salvage[9]	M	H	H	M					L	L	L	M

[1] Hallock and Fisher (1985); Moyle (2002); and Yoshiyama et al. (1998).

[2] Knights Landing RST LAD data, water years 2000-2022 (CalFish 2023).

[3] Sherwood Harbor Trawl LAD data, water years 1993-2022 (IEP 2024).

[4] Chipps Island Trawl LAD data, water years 1993-2022 (IEP 2024).

[5] CDFW Region 3 salvage database, water years 1993-2022 (CDFW 2022). Includes both hatchery-origin and natural-origin fish.

[6] Knights Landing RST genetic data, water years 2017-2019 (CDFW 2020).

[7] Sherwood Harbor Trawl genetic data, water years 2008-2011 and 2017-2021 (Buttermore et al. 2021b; Brian Pyper, personal communication, 5/2023).

[8] Chipps Island Trawl genetic data, water years 2008-2011 and 2017-2021 (Buttermore et al. 2021a; Brian Pyper, personal communication, 5/2023).

[9] Genetic CHNWR salvage data from CVP and SWP facilities, water years 1996-2021 (DWR et al. 2023).

[10] Genetic CHNSR salvage data from CVP and SWP facilities, water years 2017-2022 (DWR and CDFW 2023).

[11] Johnson et al. (2011); Killam (2012); YCWA (2014); and Killam et al. (2015).

A.2. Temporal Occurrence of Spring-run Chinook Salmon in the Delta

Table A- 4. Temporal occurrence of CHNSR in the Delta by life stage and month.

Life Stage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adult[11]	M	H	H	H	M	M	M	L	L			
Juvenile[2,3,6,7]	L	L	M	H	M	L					L	L

Table A- 5. Temporal occurrence of LAD CHNSR during juvenile migration by monitoring location and month. Monitoring data encompasses primarily YOY and not yearling CHNSR.

Monitoring Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Knights Landing[2]	M	M	H	H	M					L	L	L
Sherwood Harbor[3]	L	L	M	H	M	L					L	L
Chipps Island[4]	L	L	M	H	H	M	L					L
Salvaged[5]	L	L	M	H	H	M			L	L		

Table A- 6. Temporal occurrence of genetically-identified natural-origin CHNSR during juvenile migration by monitoring location and month. Monitoring data encompasses primarily YOY and very few yearling CHNSR.

Monitoring Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Knights Landing[6]	M	H	H	M	L							L
Sherwood Harbor[7]	L	L	M	H	M	L						L
Chipps Island[8]	L	L	M	H	H	L						L
Salvaged[10]	L	L	M	H	H	M	L					

[1] Hallock and Fisher (1985); Moyle (2002); and Yoshiyama et al. (1998).

[2] Knights Landing RST LAD data, water years 2000-2022 (CalFish 2023).

[3] Sherwood Harbor Trawl LAD data, water years 1993-2022 (IEP 2024).

[4] Chipps Island Trawl LAD data, water years 1993-2022 (IEP 2024).

[5] CDFW Region 3 salvage database, water years 1993-2022 (CDFW 2022). Includes both hatchery-origin and natural-origin fish.

[6] Knights Landing RST genetic data, water years 2017-2019 (CDFW 2020).

[7] Sherwood Harbor Trawl genetic data, water years 2008-2011 and 2017-2021 (Buttermore et al. 2021b; Brian Pyper, personal communication, 5/2023).

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[9] Genetic CHNWR salvage data from CVP and SWP facilities, water years 1996-2021 (DWR et al. 2023).

[10] Genetic CHNSR salvage data from CVP and SWP facilities, water years 2017-2022 (DWR and CDFW 2023).

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Appendix B. Velocity Density Distribution for Sacramento River at Freeport and Walnut Grove

Sacramento River flow entering the Delta is correlated with through-Delta survival of juvenile Chinook Salmon (Hance et al. 2021), reflecting the influence of flow on juvenile Chinook Salmon junction routing, travel time, and potential exposure to predatory fish. Velocity and flow direction are the two key factors that can impact juvenile salmonids in the Delta via water exports and river inflows (SST 2017). DWR conducted an assessment of potential hydrodynamic changes between Baseline Conditions and Proposed Project scenarios using DSM2-HYDRO velocity outputs to evaluate potential impacts of Project operations on juvenile Chinook Salmon routing and through-Delta survival. Figure B- 1 through Figure B- 40 show the density distribution of velocity by month and water year type for Baseline Conditions and two Proposed Project scenarios (9A_V2A and ITP_Spring). See Section 5.1 – Effects of South Delta Export Operations on Rearing, Routing, and Survival of Chinook Salmon for additional information on each modeling scenario. DSM2-HYDRO modeling results presented below are based on information CDFW obtained from DWR's ITP Application (DWR 2023) and subsequent coordination with DWR. See Section 5.1.2.1.1 – Velocity for a discussion of the velocity density distribution plots below.

B.1. Velocity Density Distribution Plots for Sacramento River at Freeport – Baseline Conditions vs. 9A_V2A

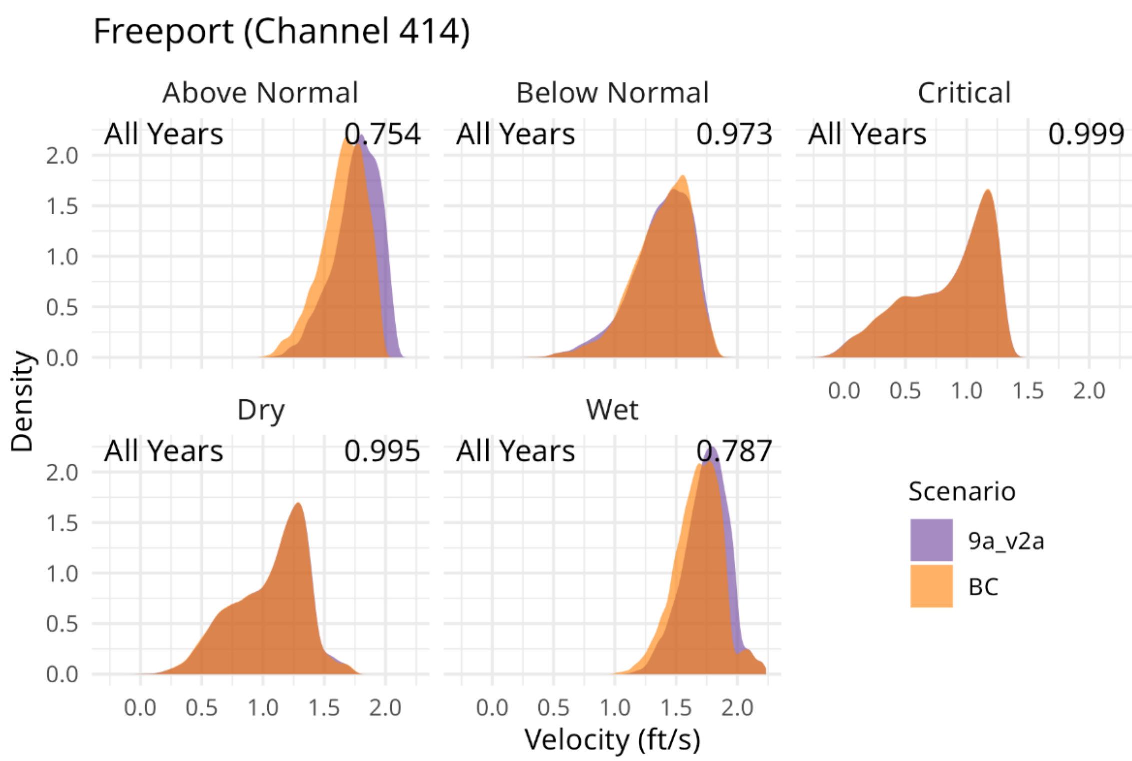

Figure B- 1. September Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

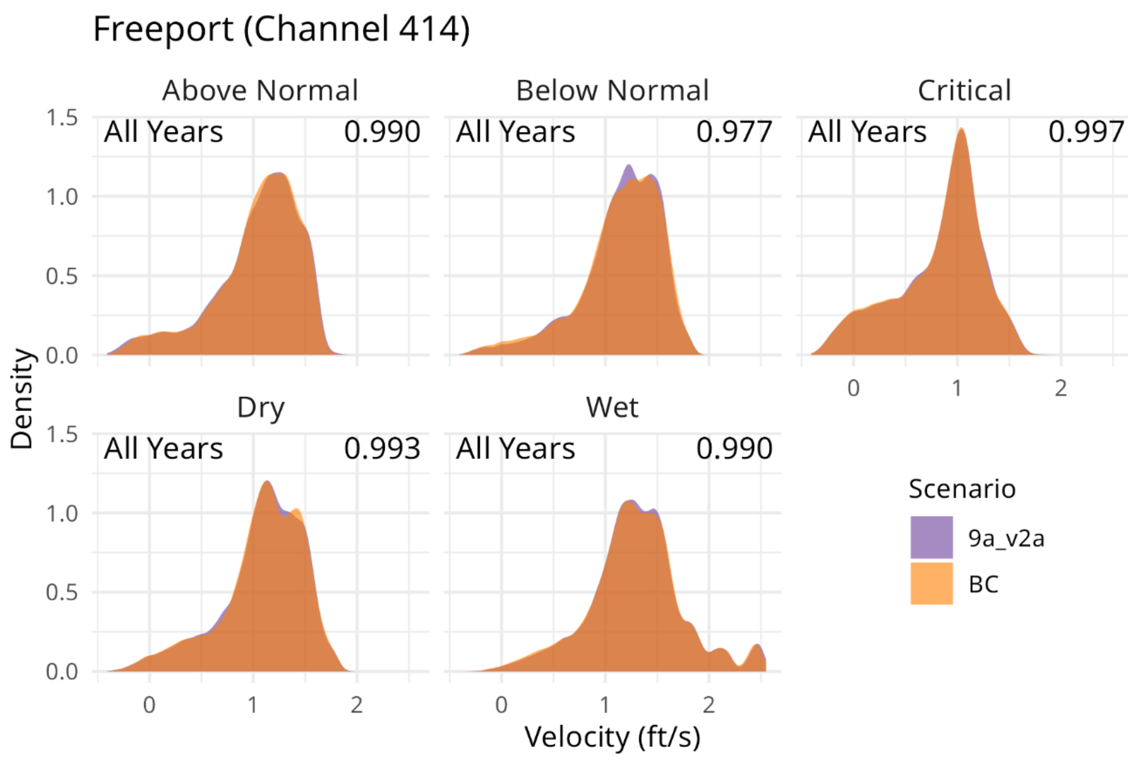

Figure B- 2. October Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

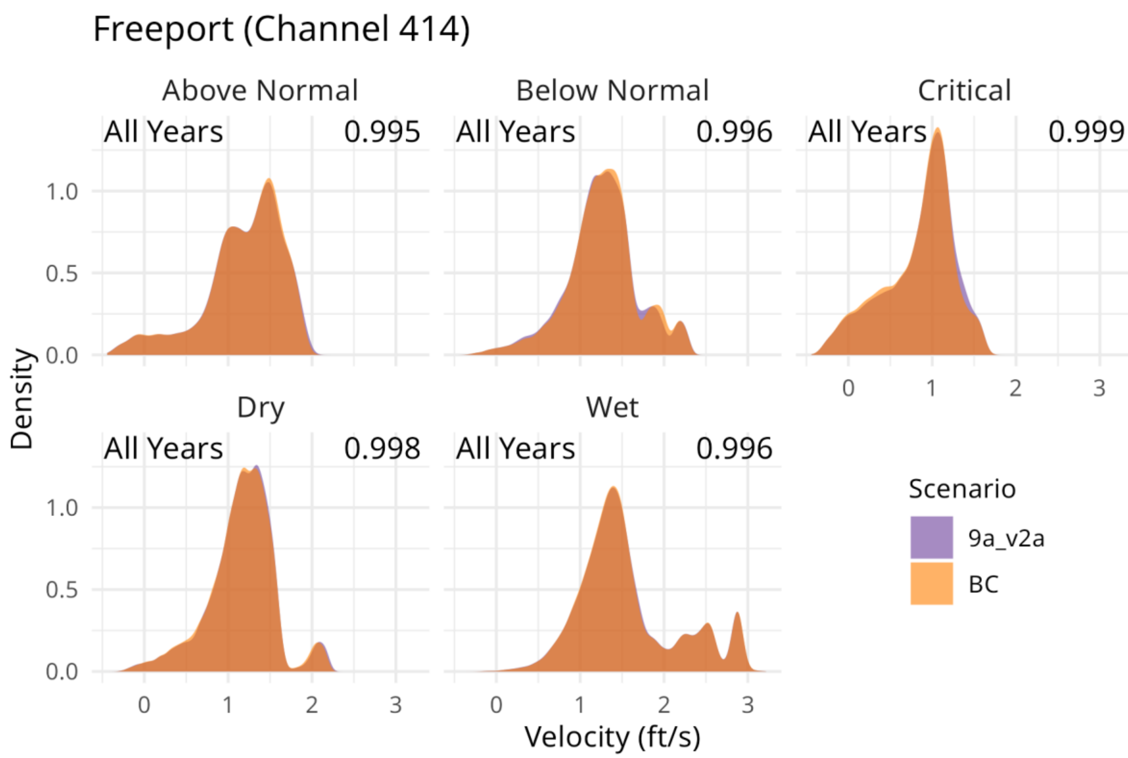

Figure B- 3. November Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

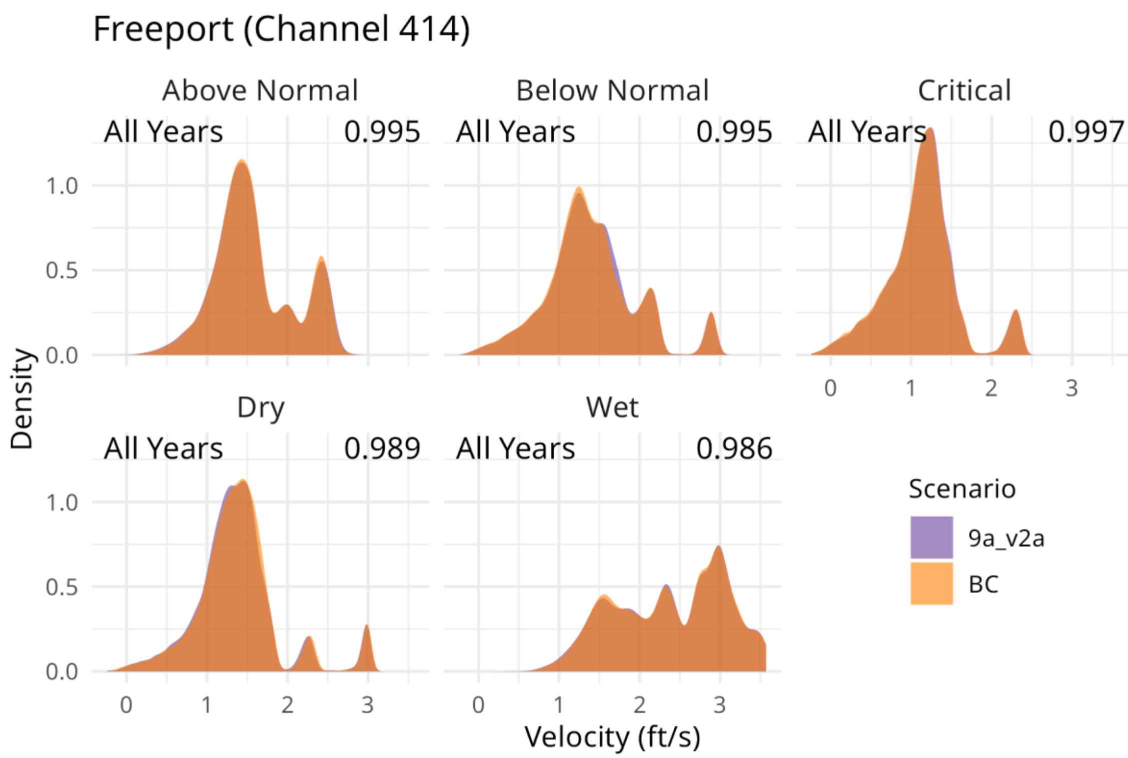

Figure B- 4. December Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

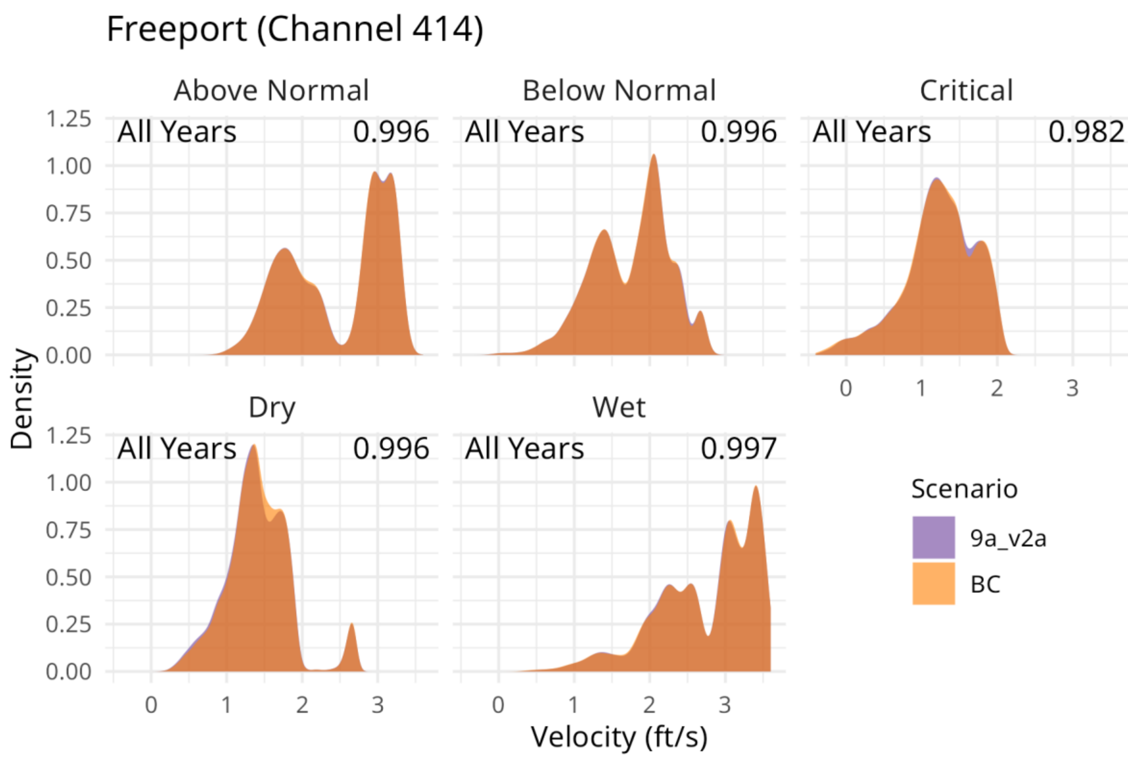

Figure B- 5. January Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

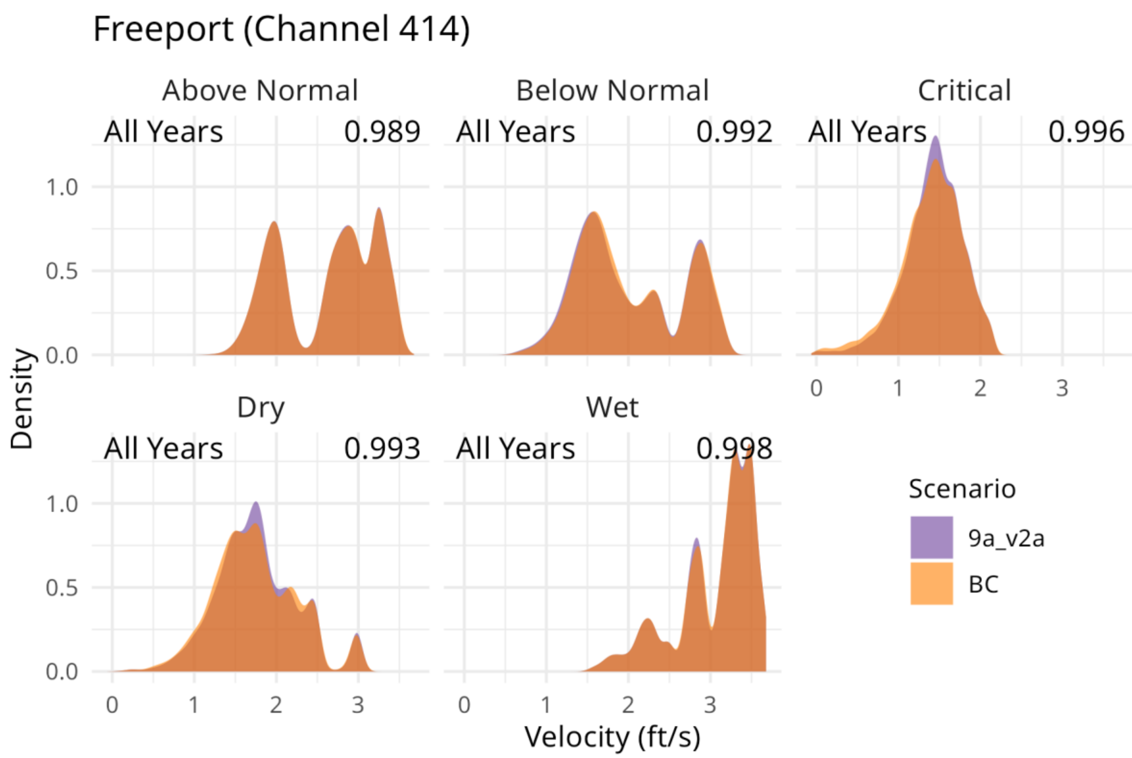

Figure B- 6. February Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

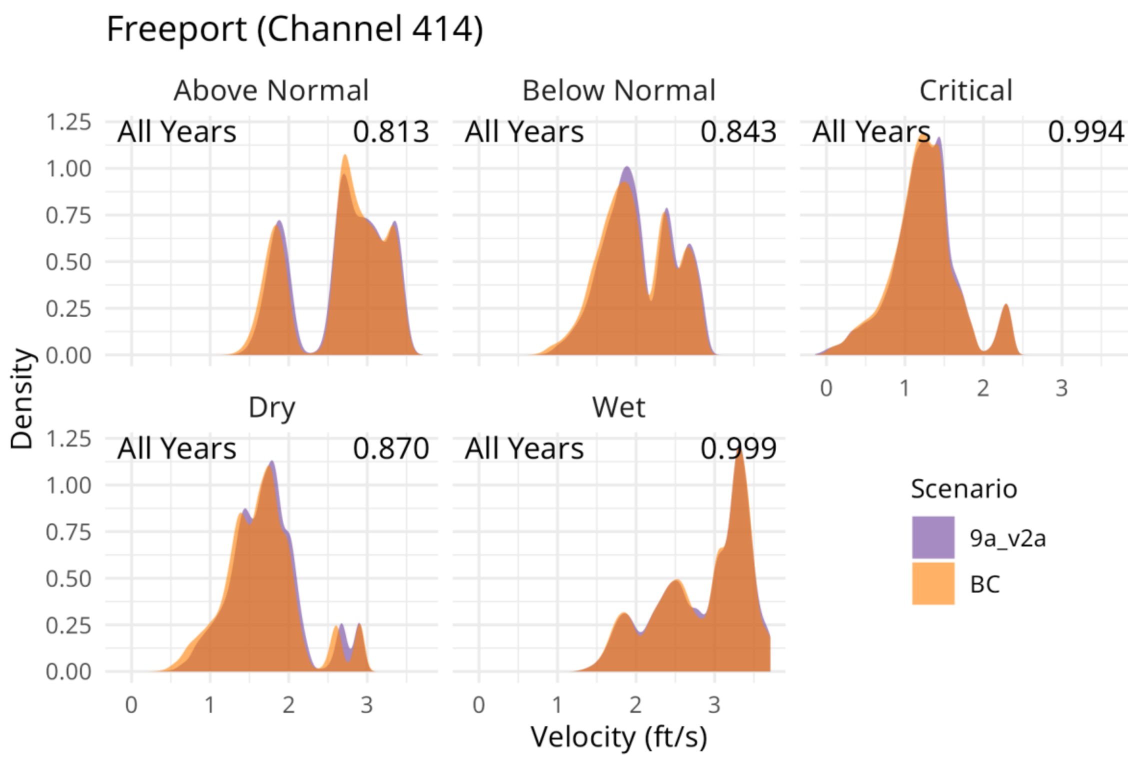

Figure B- 7. March Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

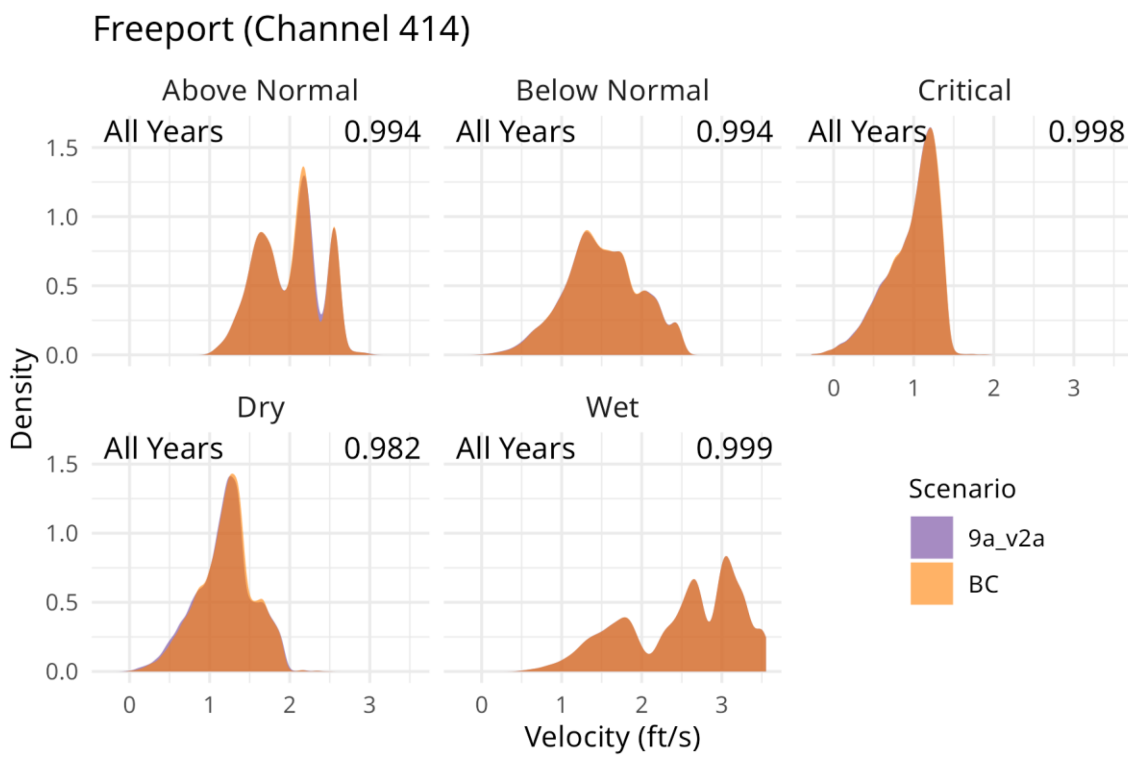

Figure B- 8. April Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

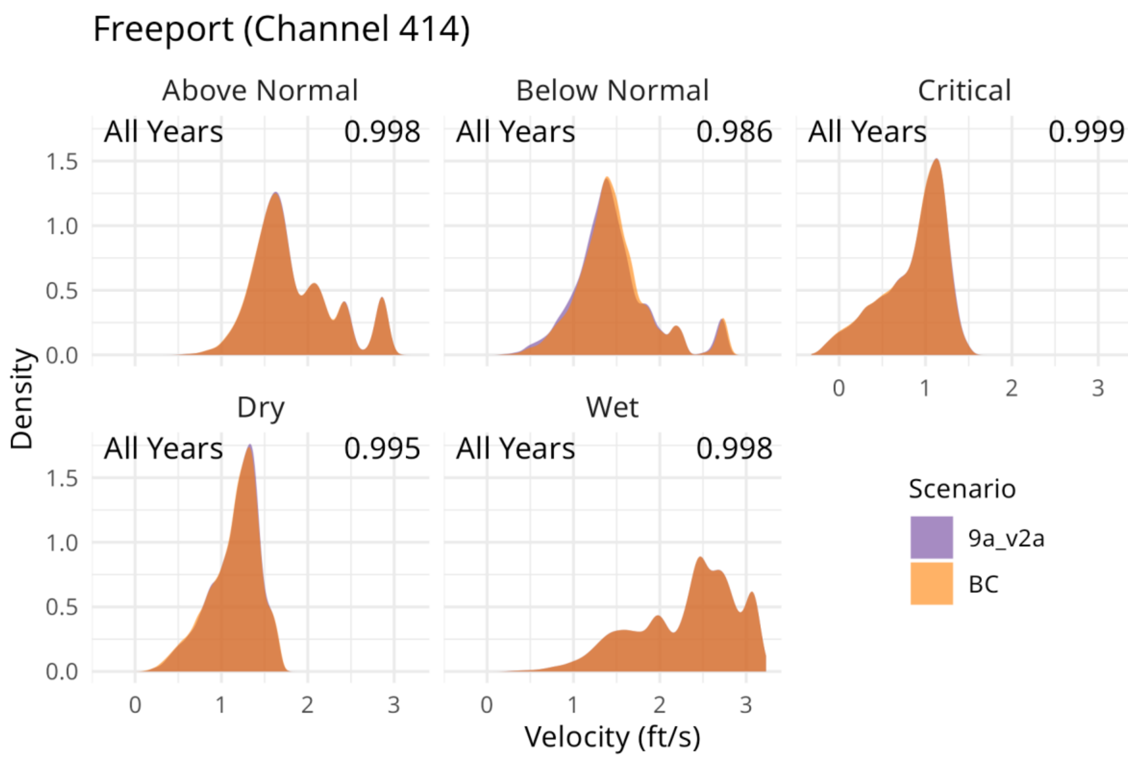

Figure B- 9. May Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

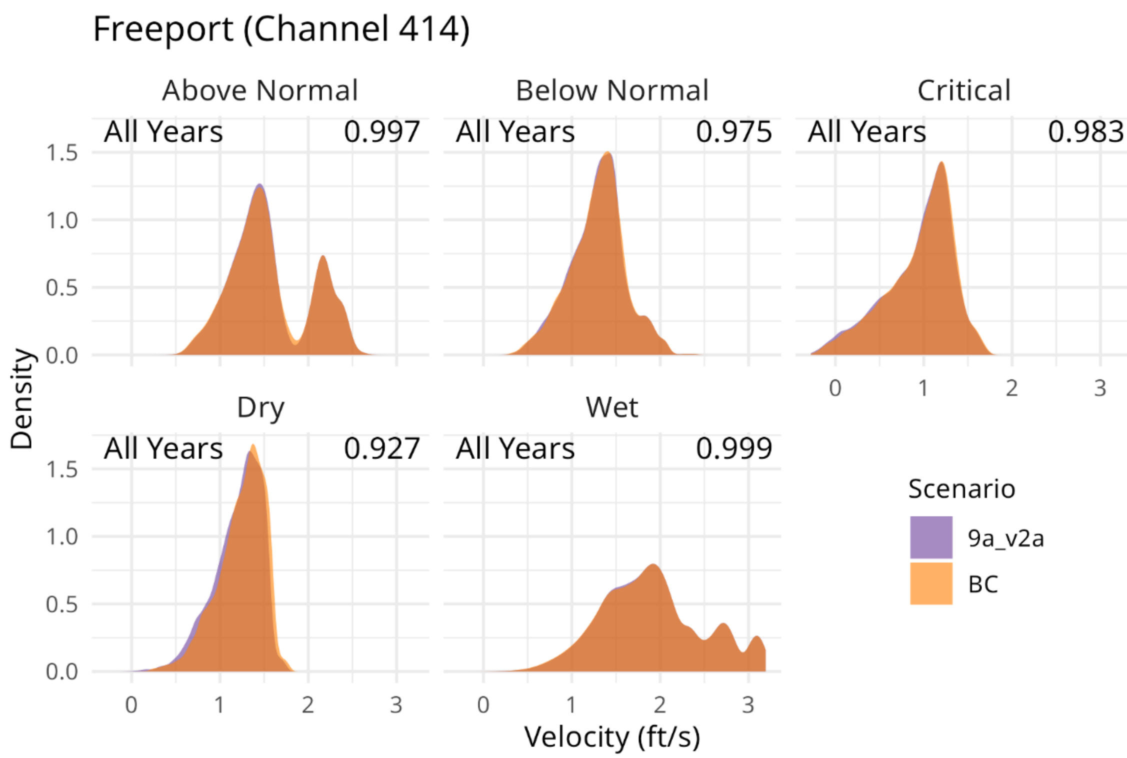

Figure B- 10. June Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

B.2. Velocity Density Distribution Plots for Sacramento River at Freeport – Baseline Conditions vs. ITP_Spring

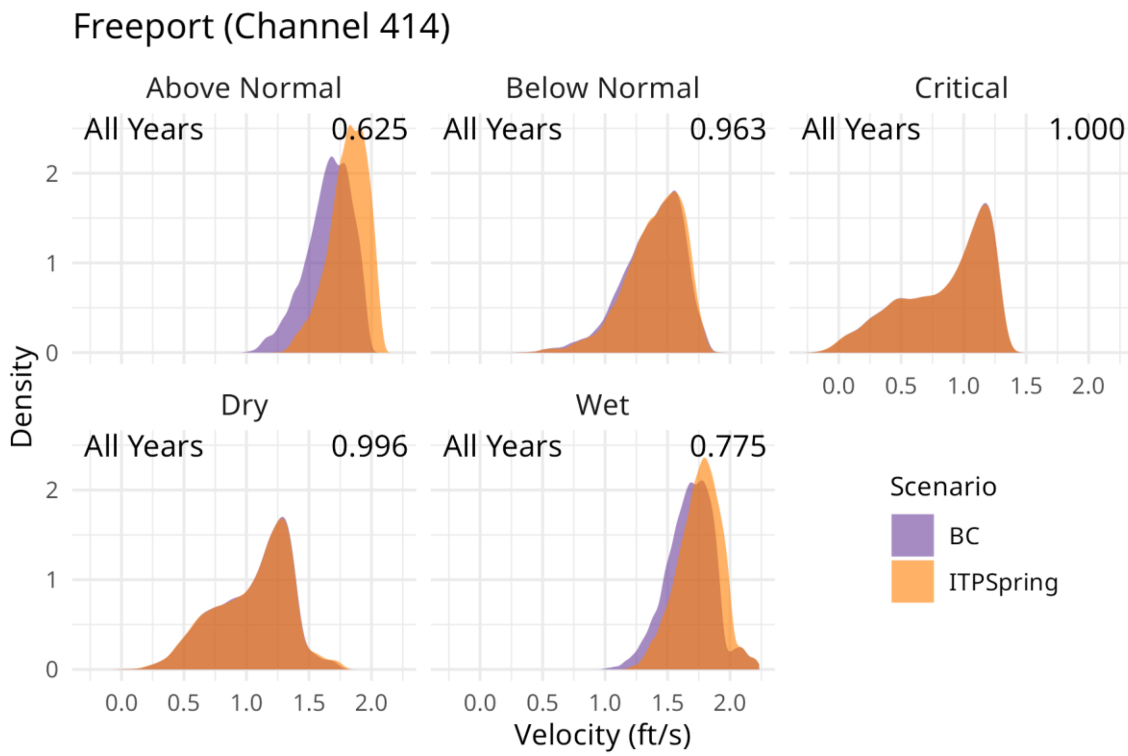

Figure B- 11. September Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

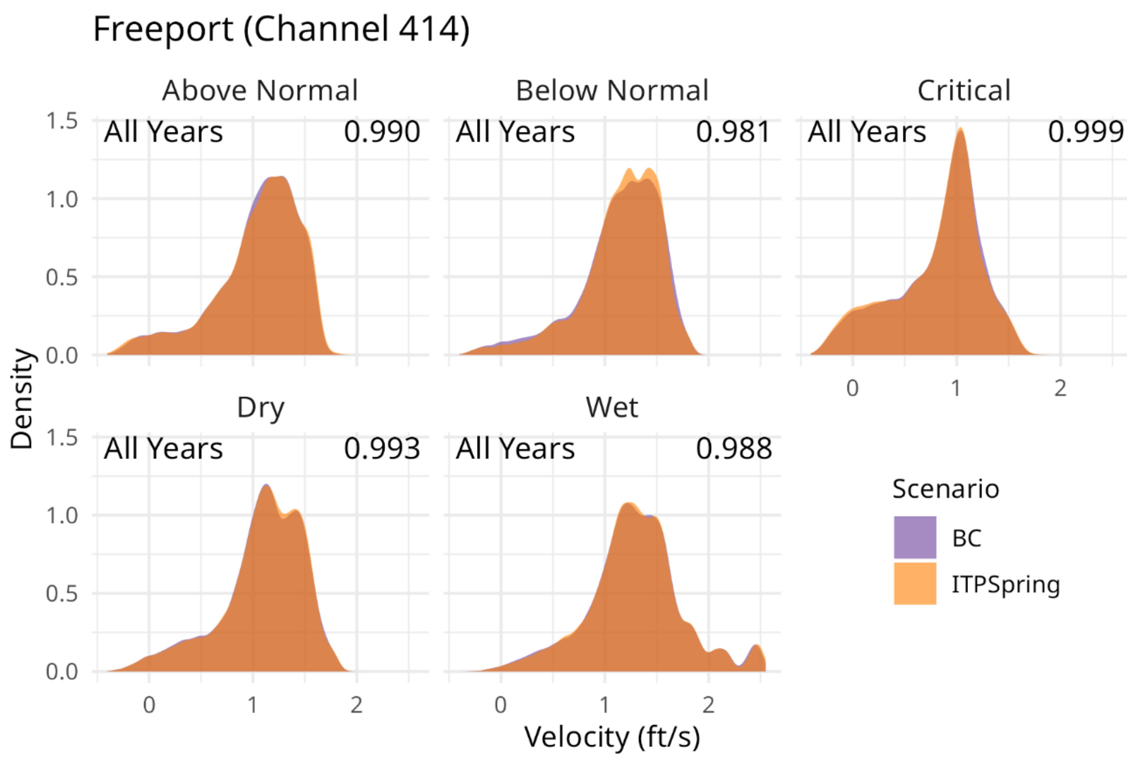

Figure B- 12. October Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

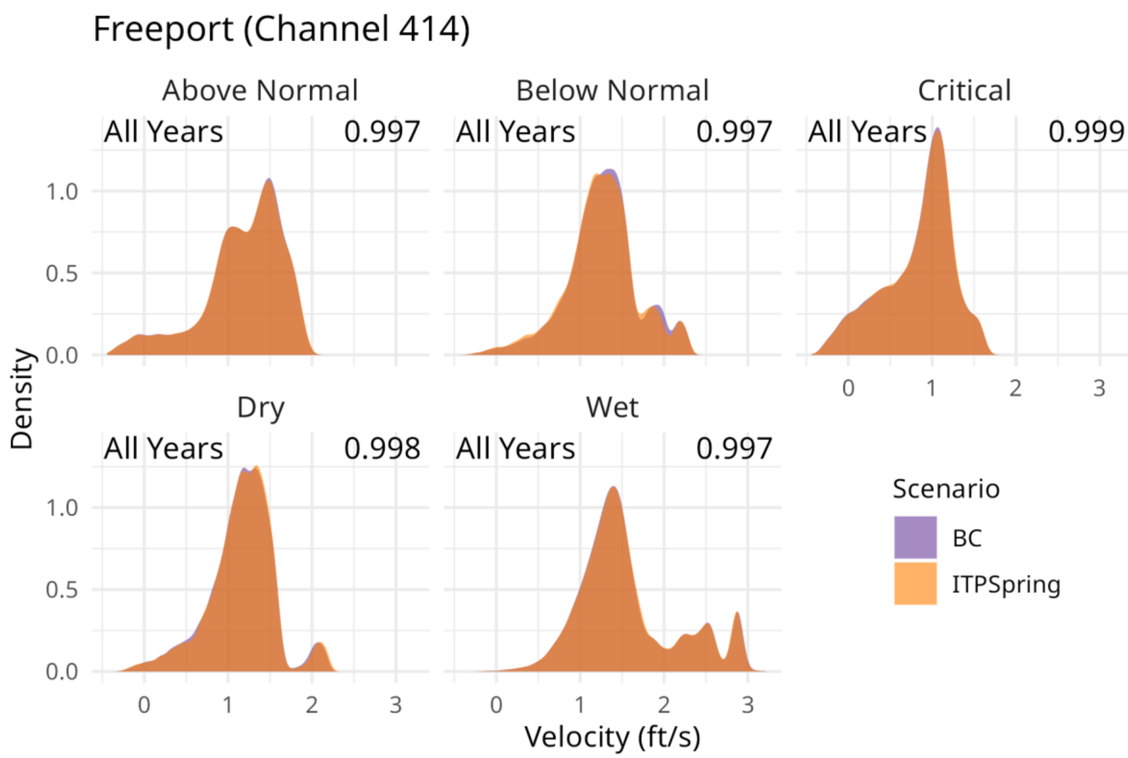

Figure B- 13. November Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

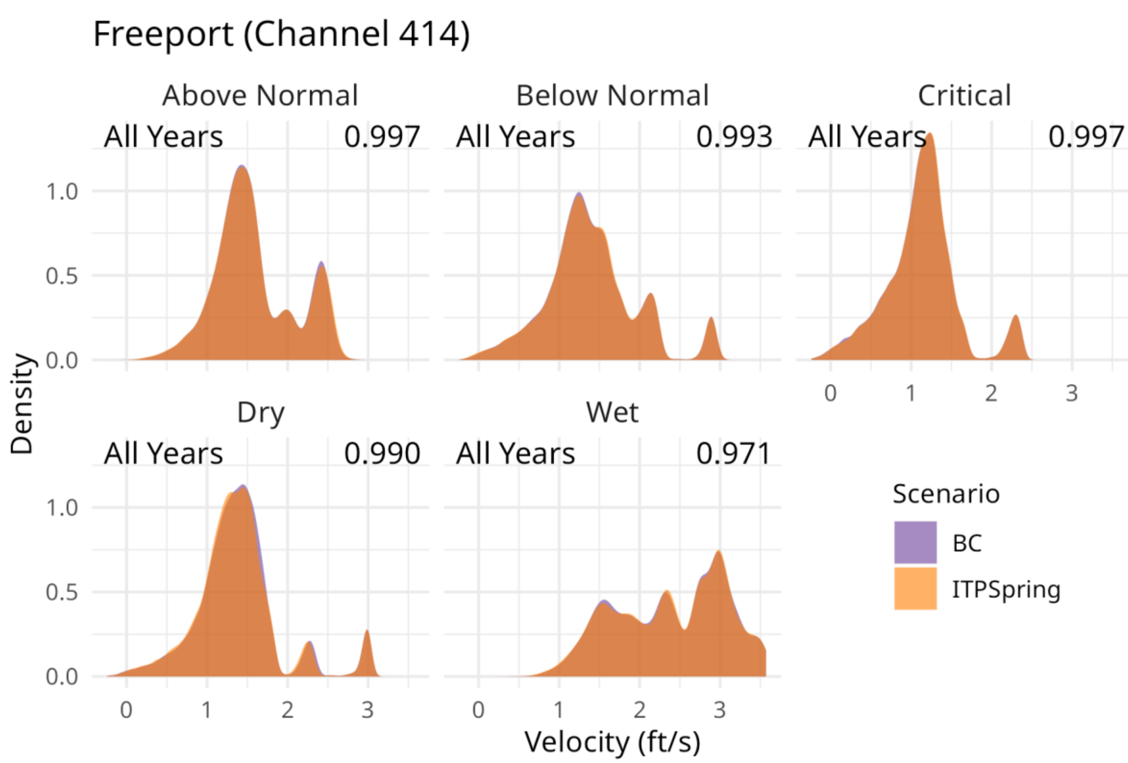

Figure B- 14. December Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

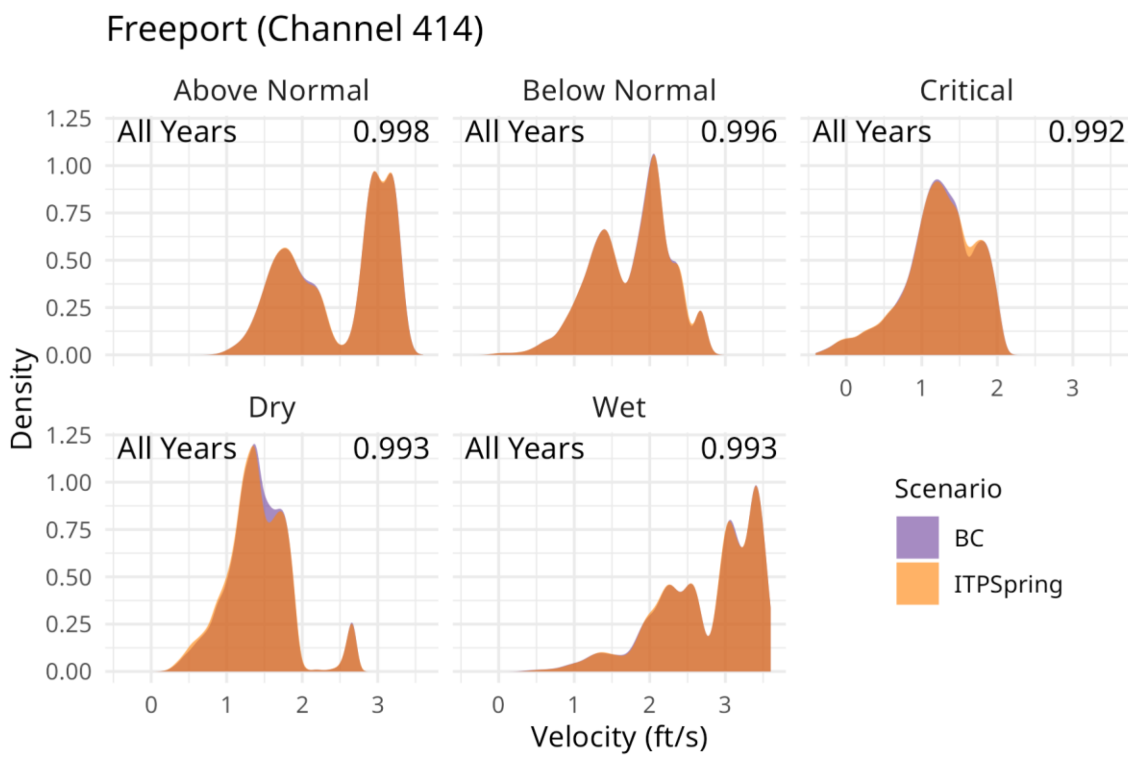

Figure B- 15. January Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

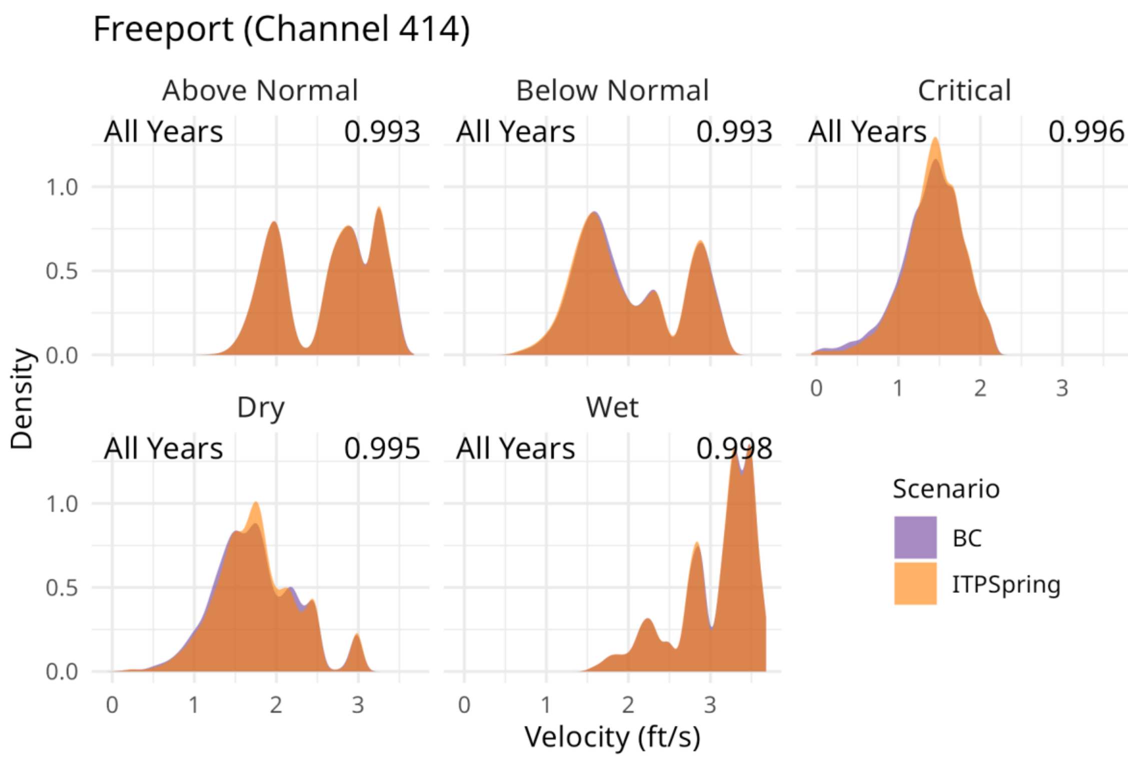

Figure B- 16. February Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

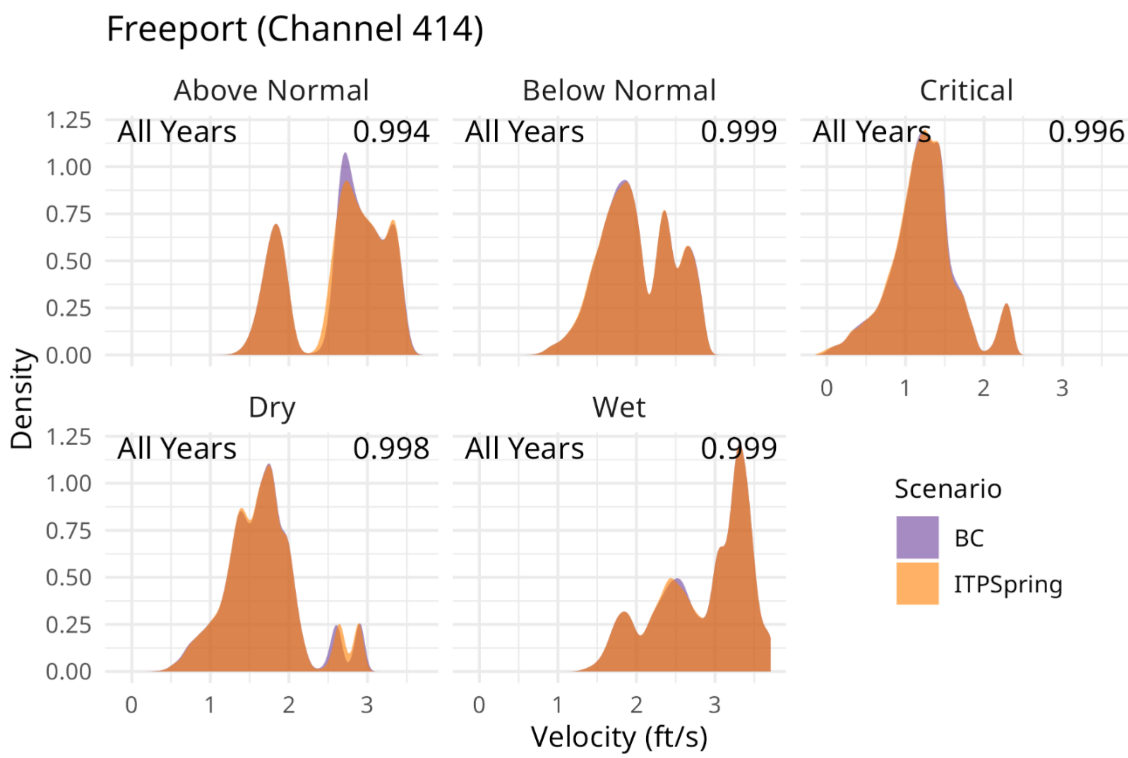

Figure B- 17. March Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

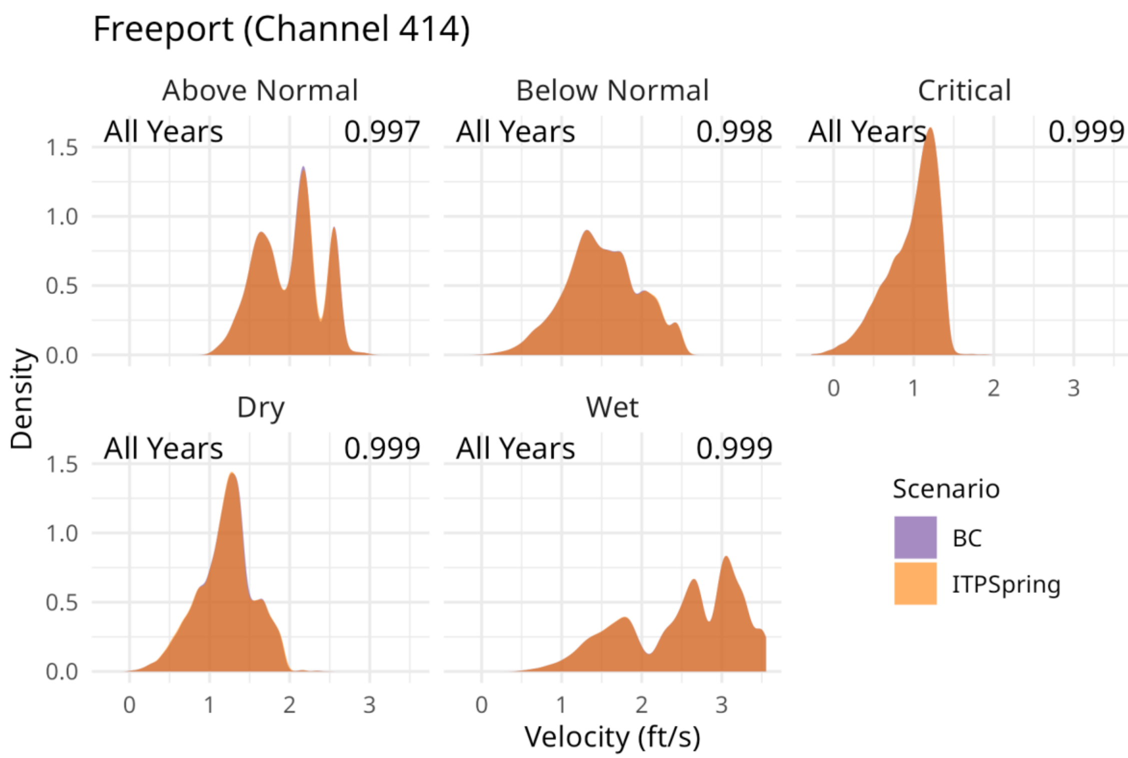

Figure B- 18. April Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

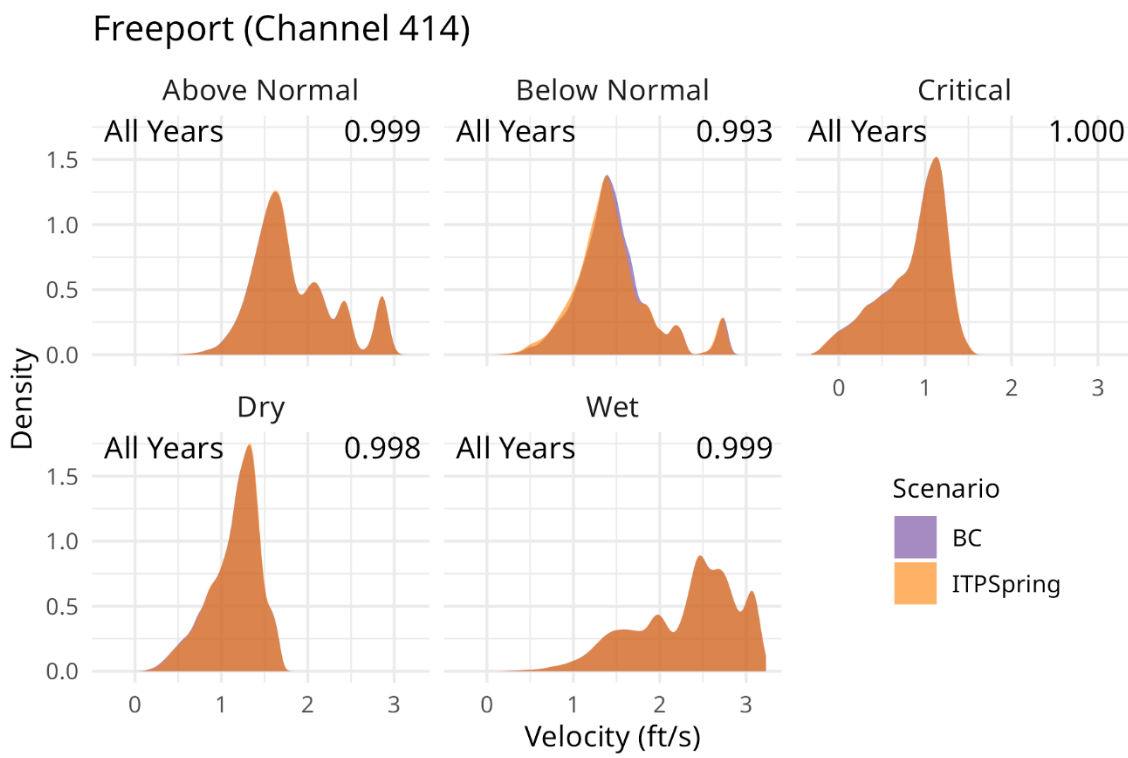

Figure B- 19. May Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

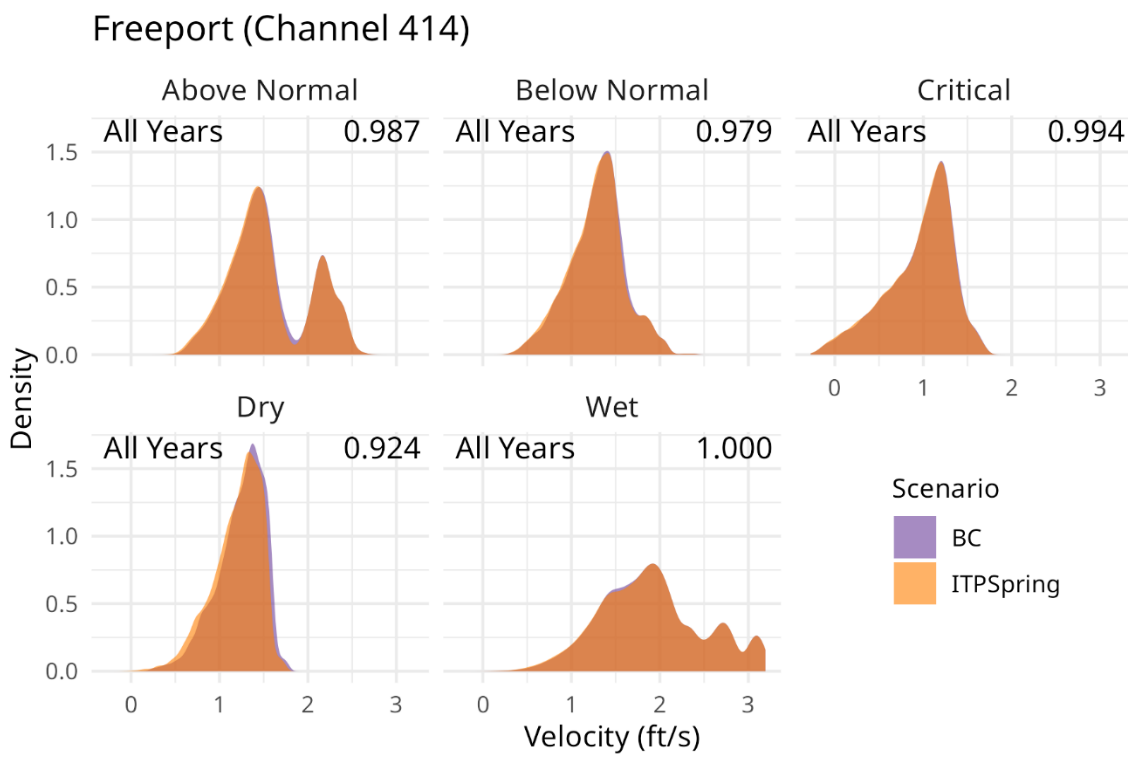

Figure B- 20. June Velocity Density Distribution for Sacramento River at Freeport for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

B.3. Velocity Density Distribution Plots for Sacramento River at Walnut Grove – Baseline Conditions vs. 9A_V2A

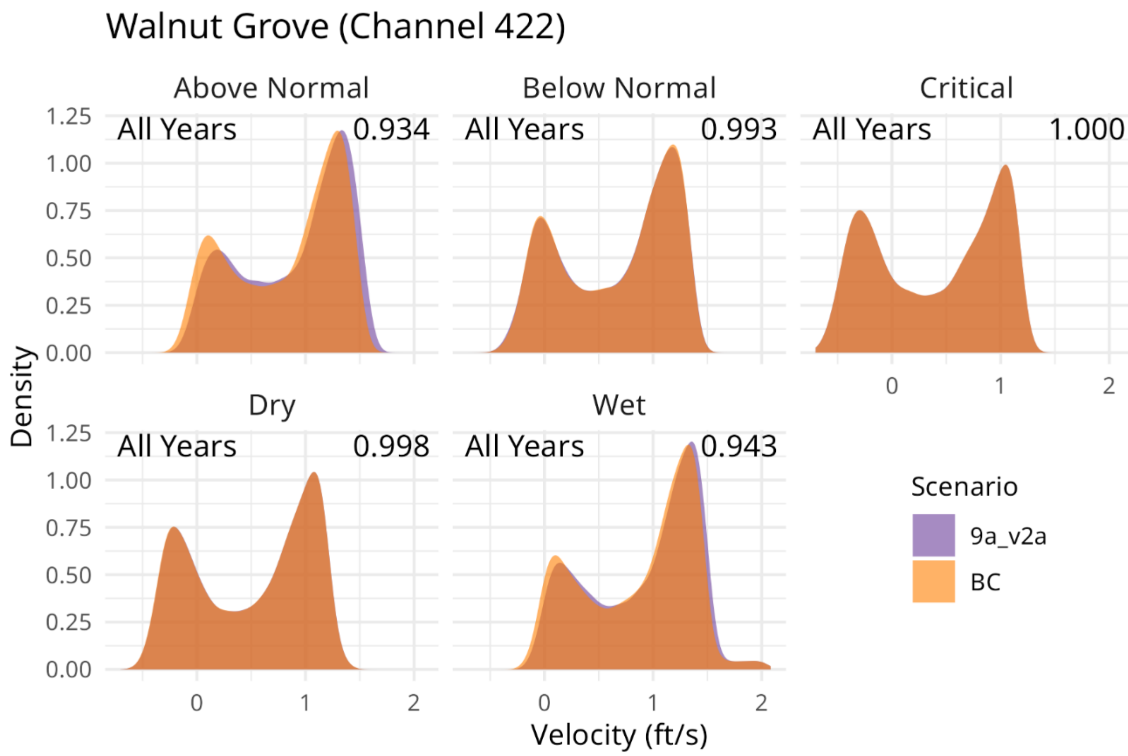

Figure B- 21. September Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

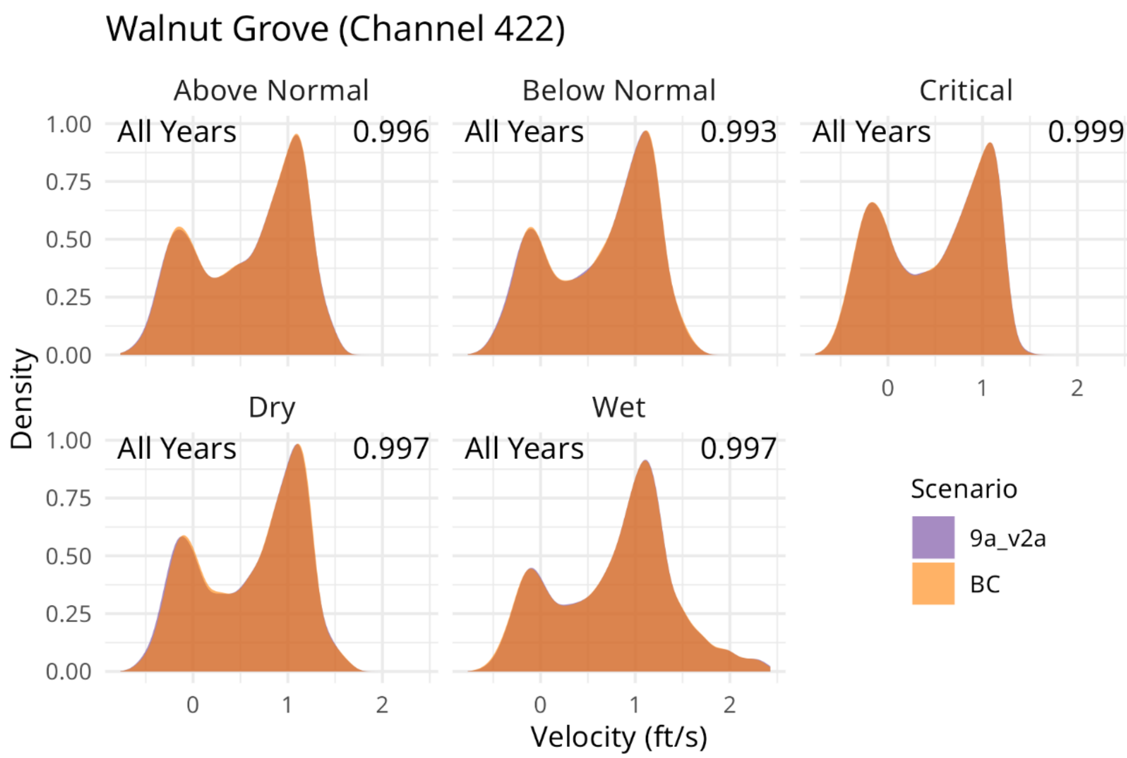

Figure B- 22. October Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

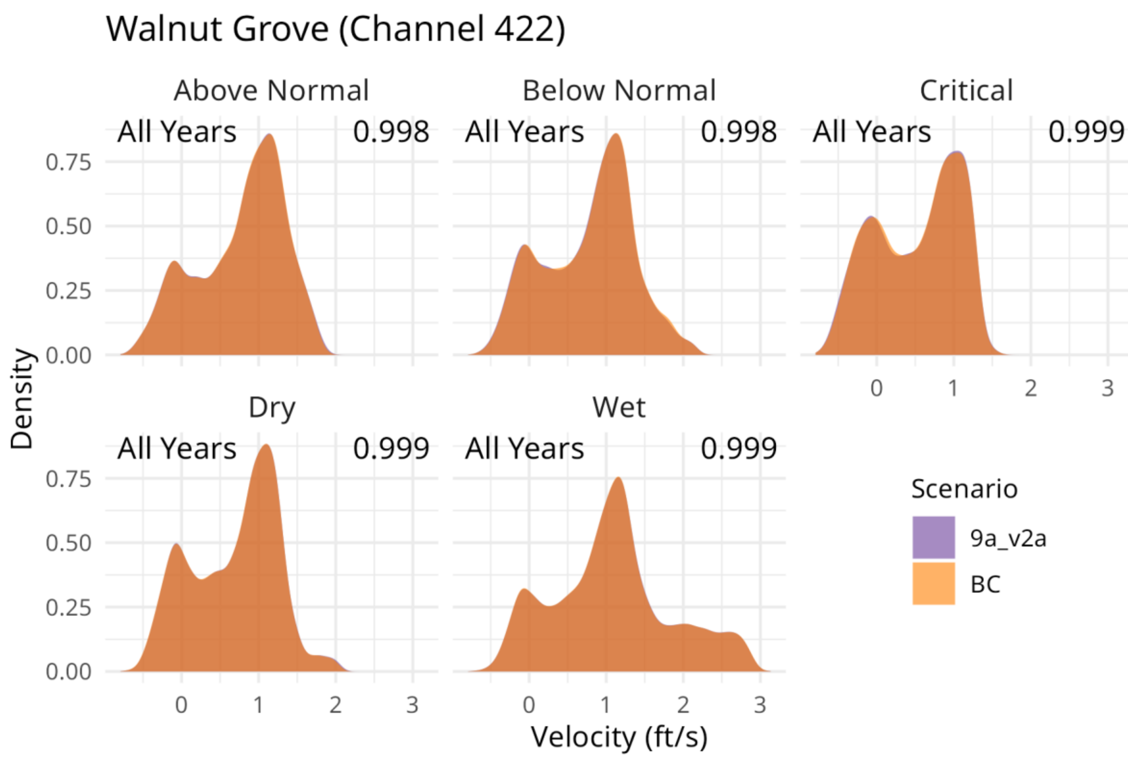

Figure B- 23. November Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

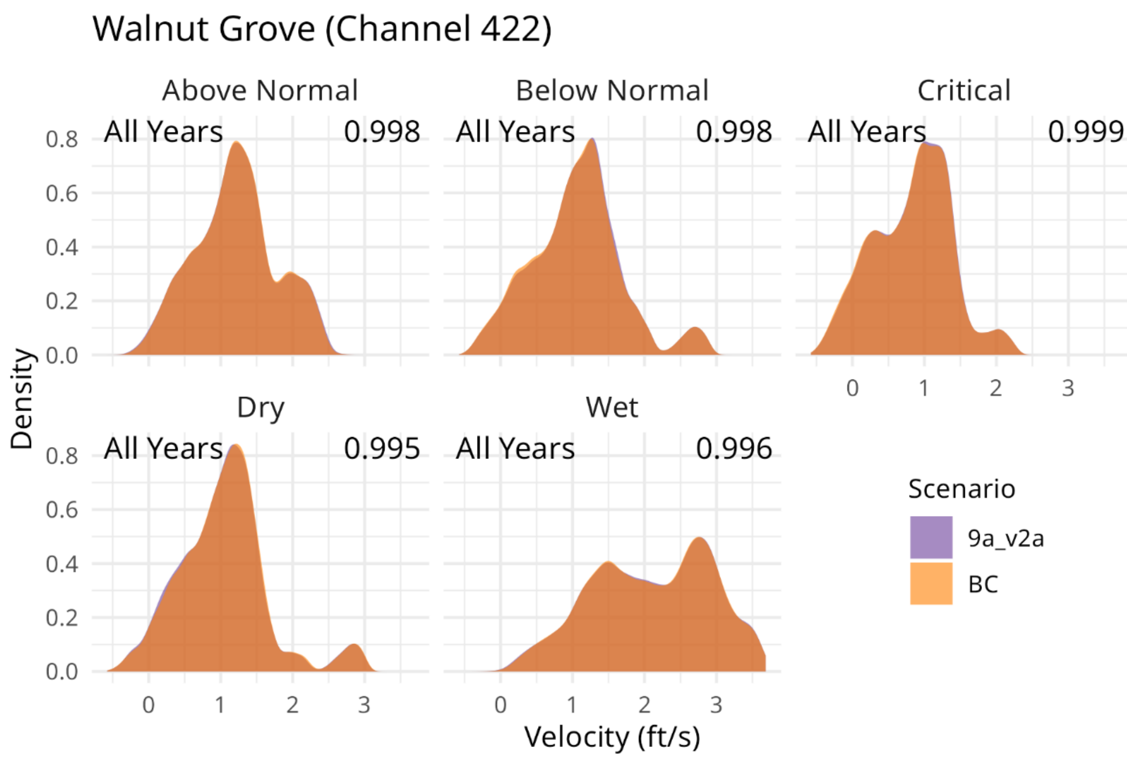

Figure B- 24. December Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type**.**

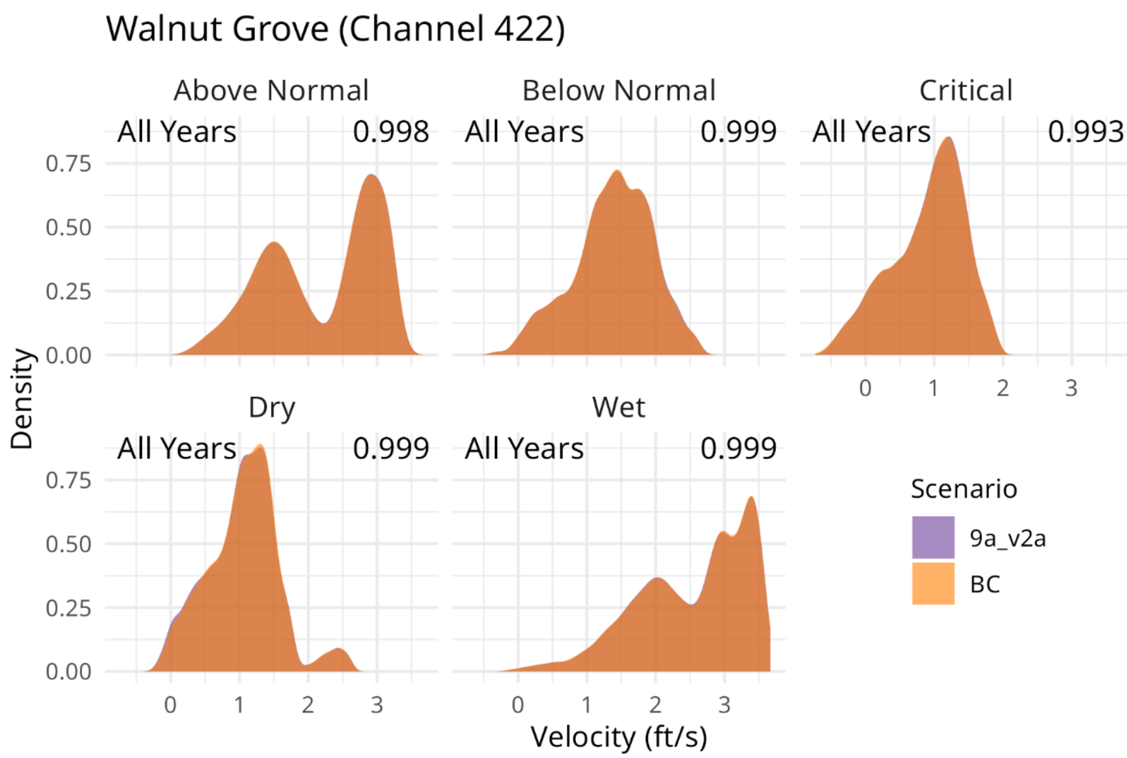

Figure B- 25. January Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

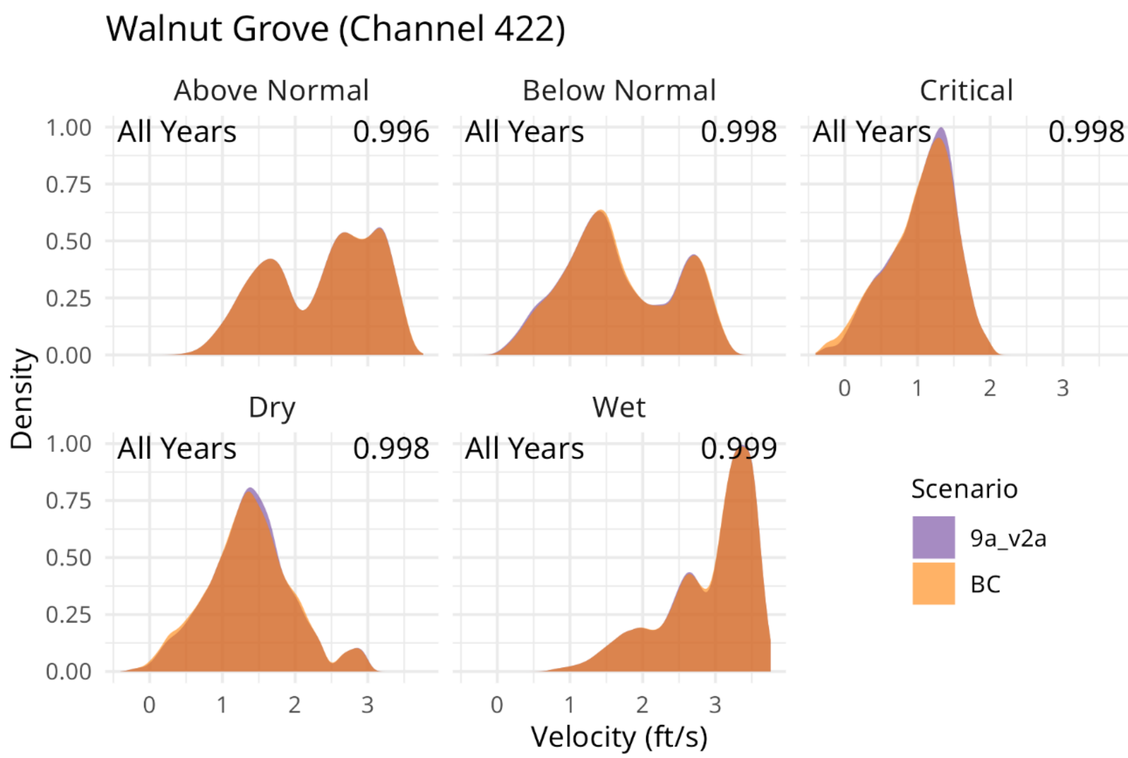

Figure B- 26. February Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

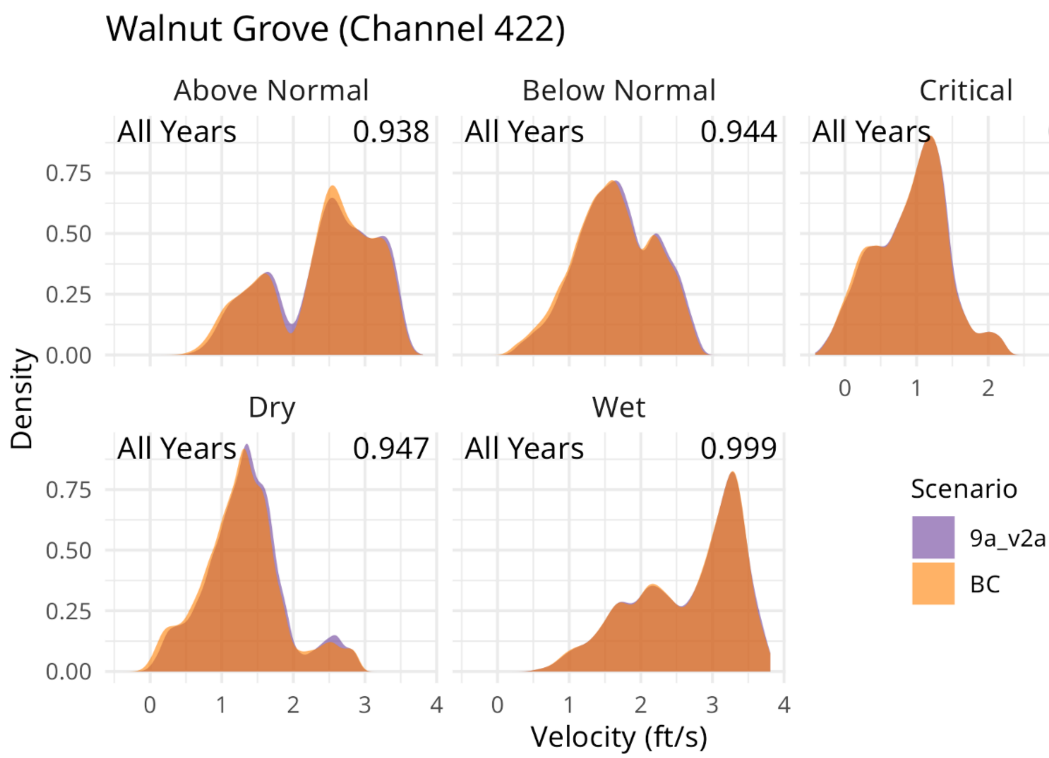

Figure B- 27. March Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

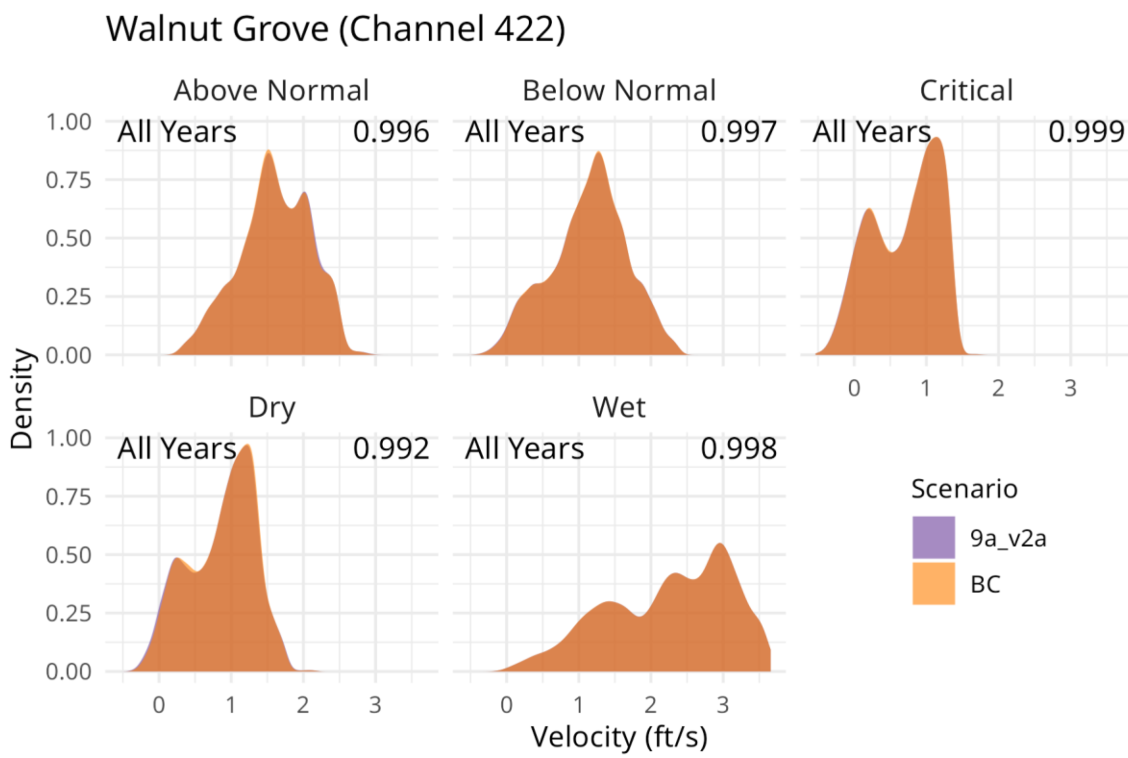

Figure B- 28. April Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

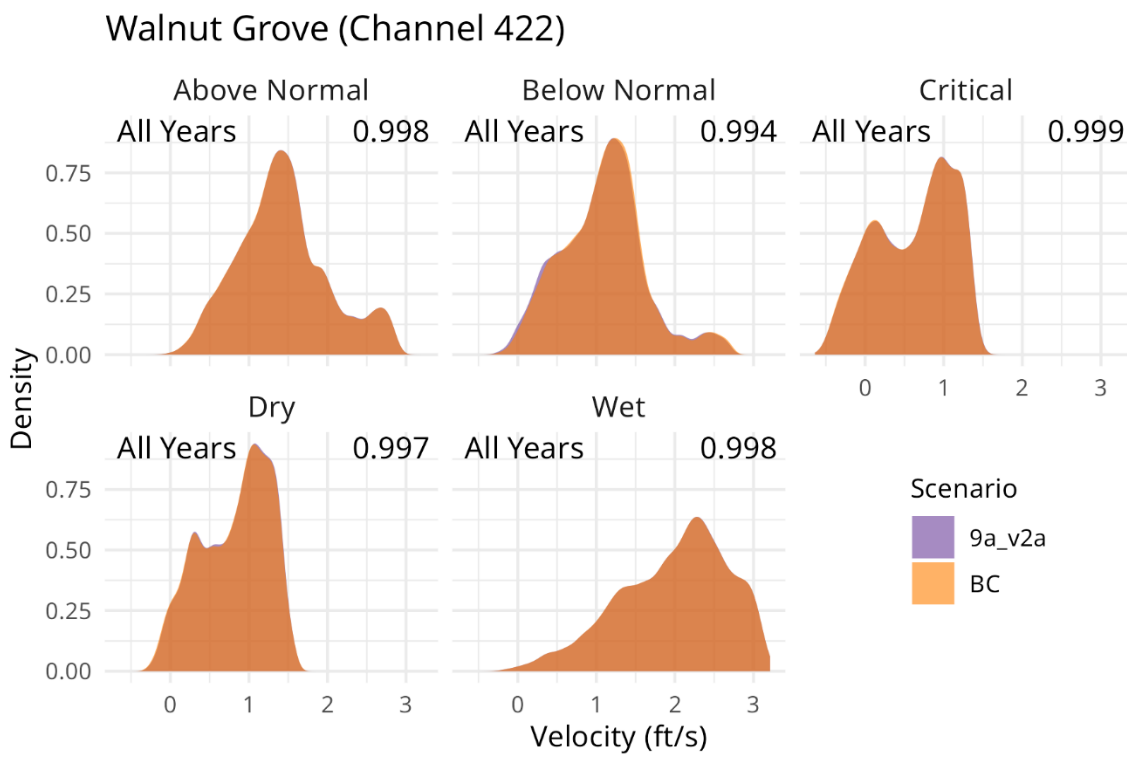

Figure B- 29. May Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

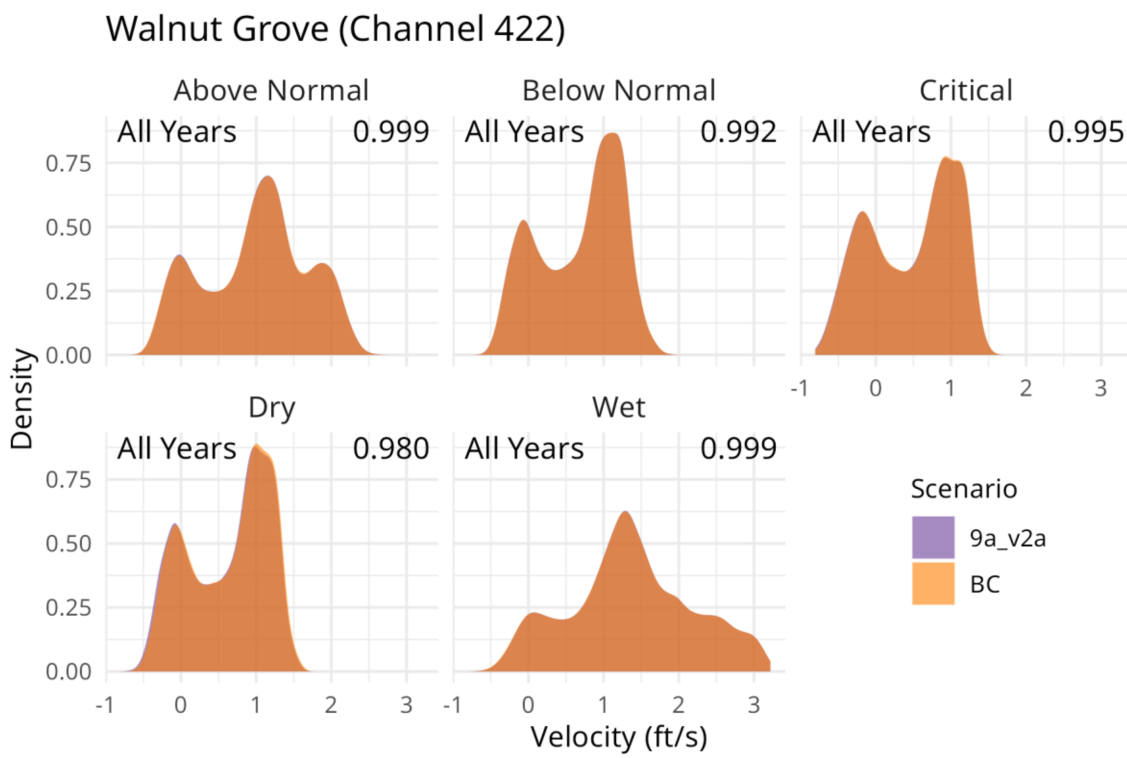

Figure B- 30. June Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario 9A_V2A. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and 9A_V2A for a given water year type.

B.4. Velocity Density Distribution Plots for Sacramento River at Walnut Grove – Baseline Conditions vs. ITP_Spring

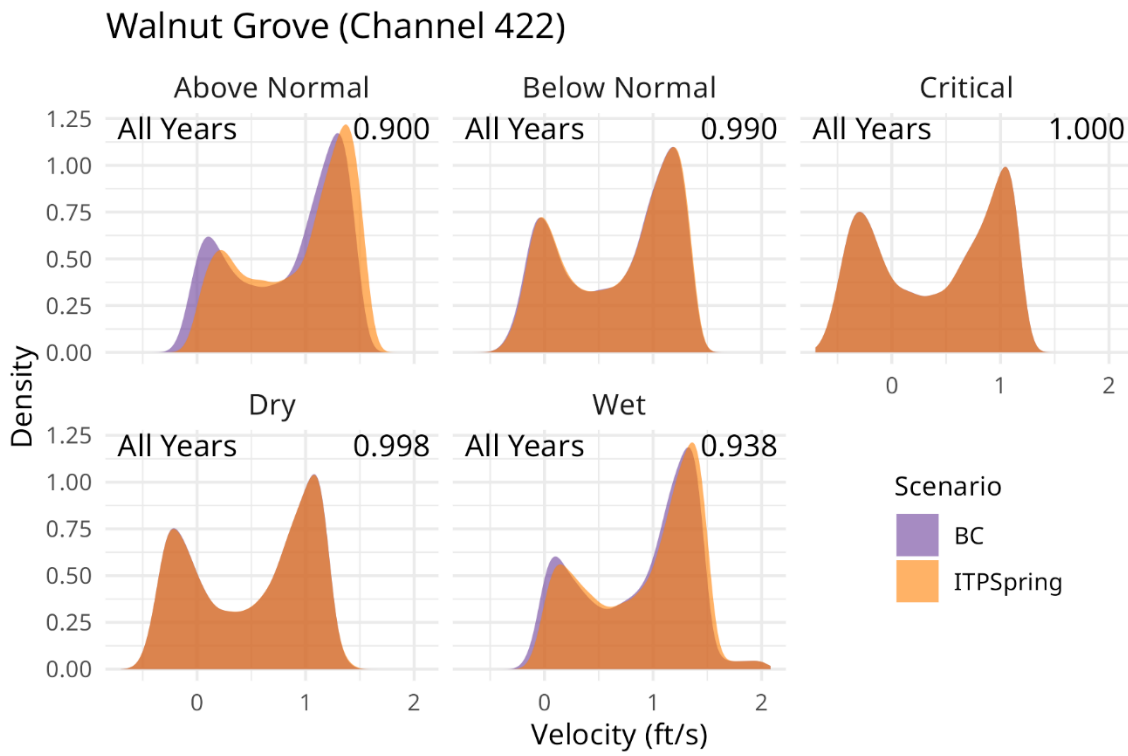

Figure B- 31. September Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

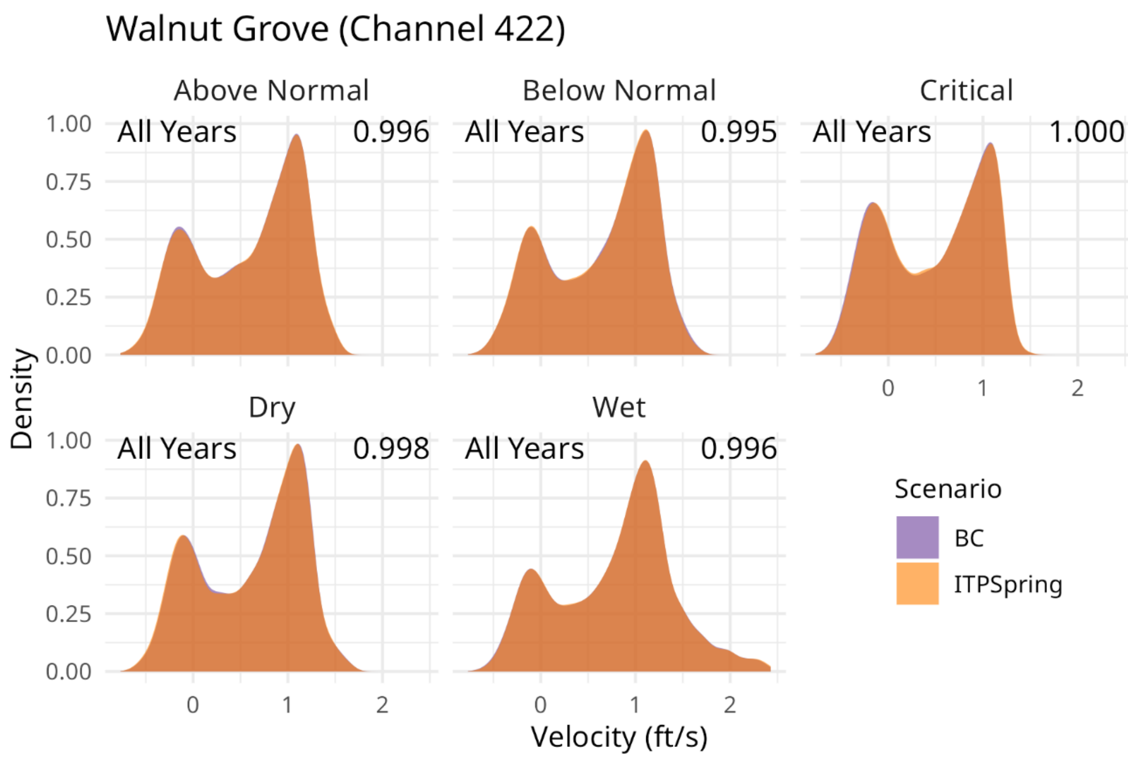

Figure B- 32. October Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

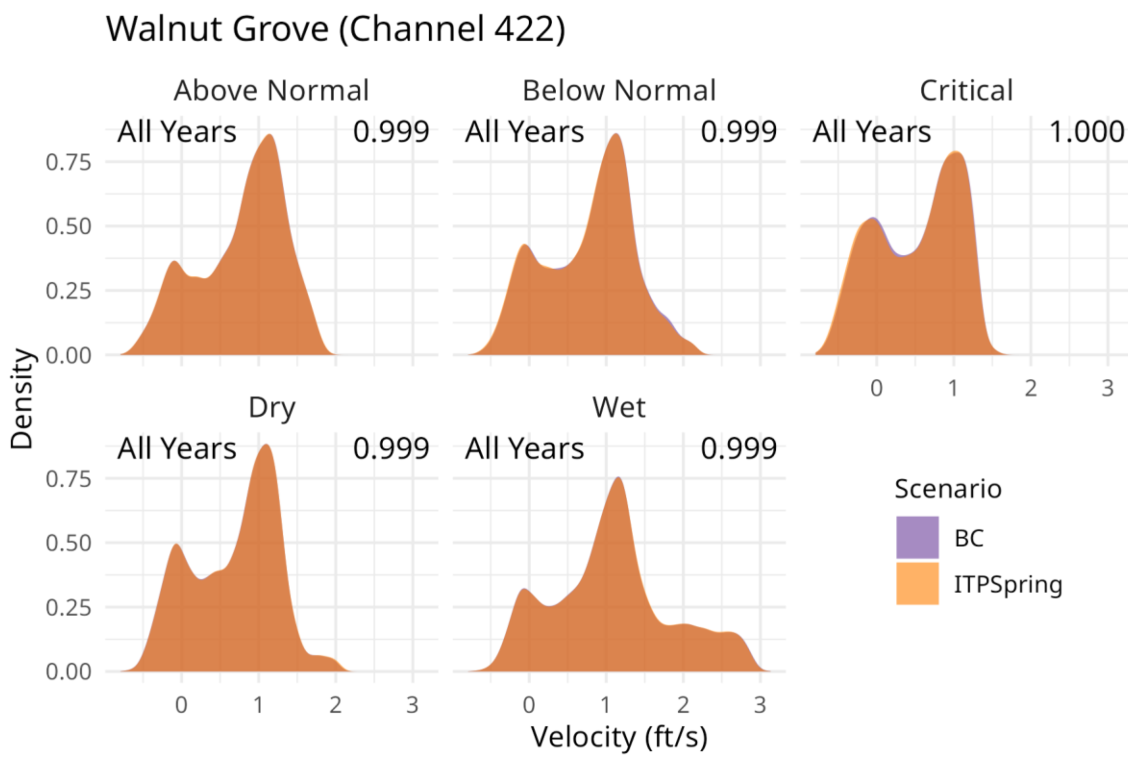

Figure B- 33. November Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

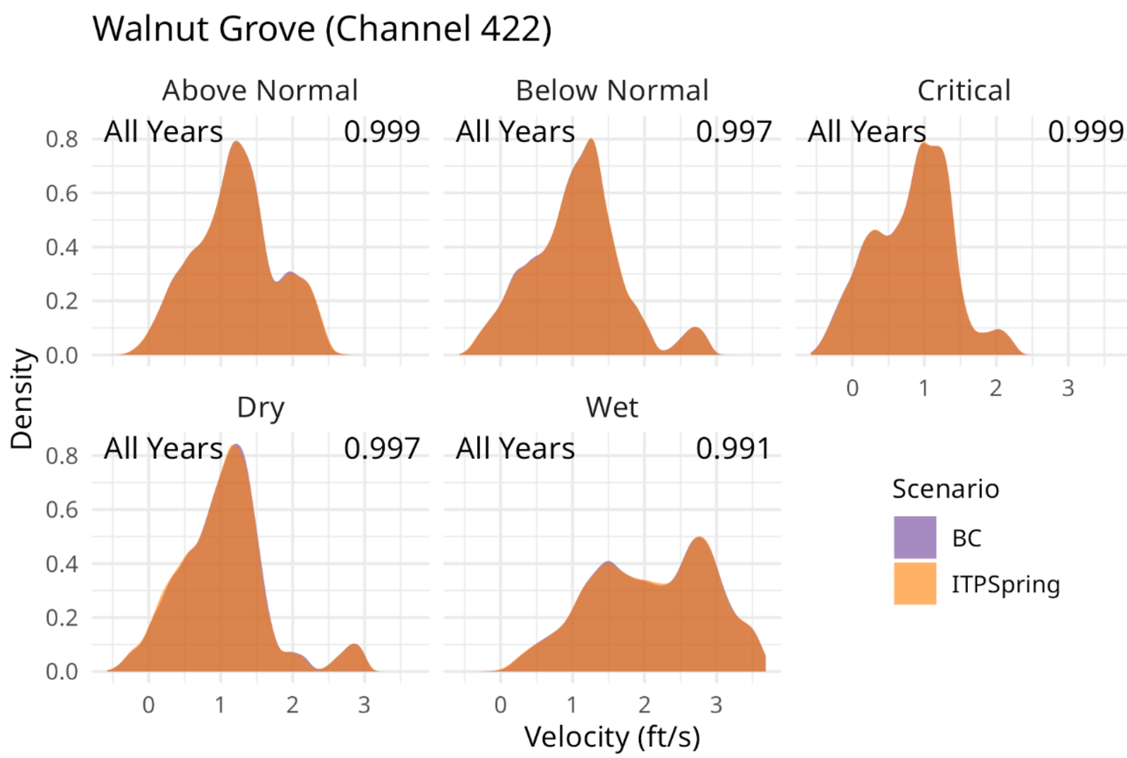

Figure B- 34. December Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

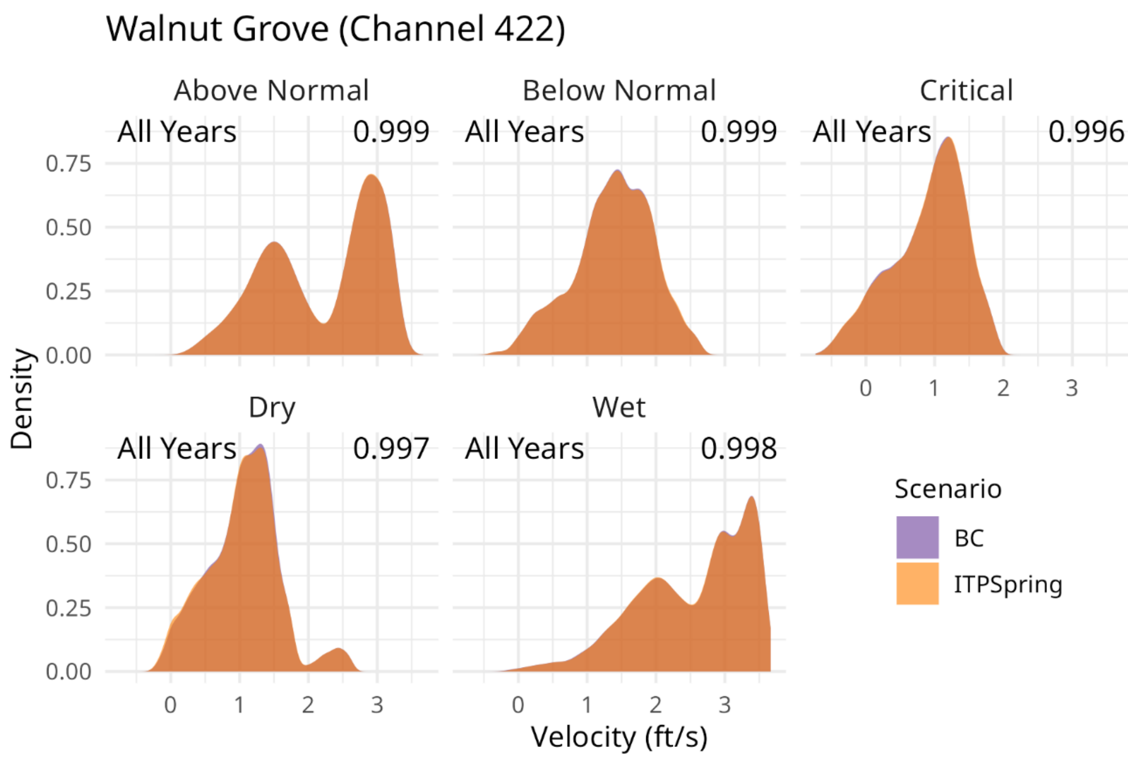

Figure B- 35. January Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

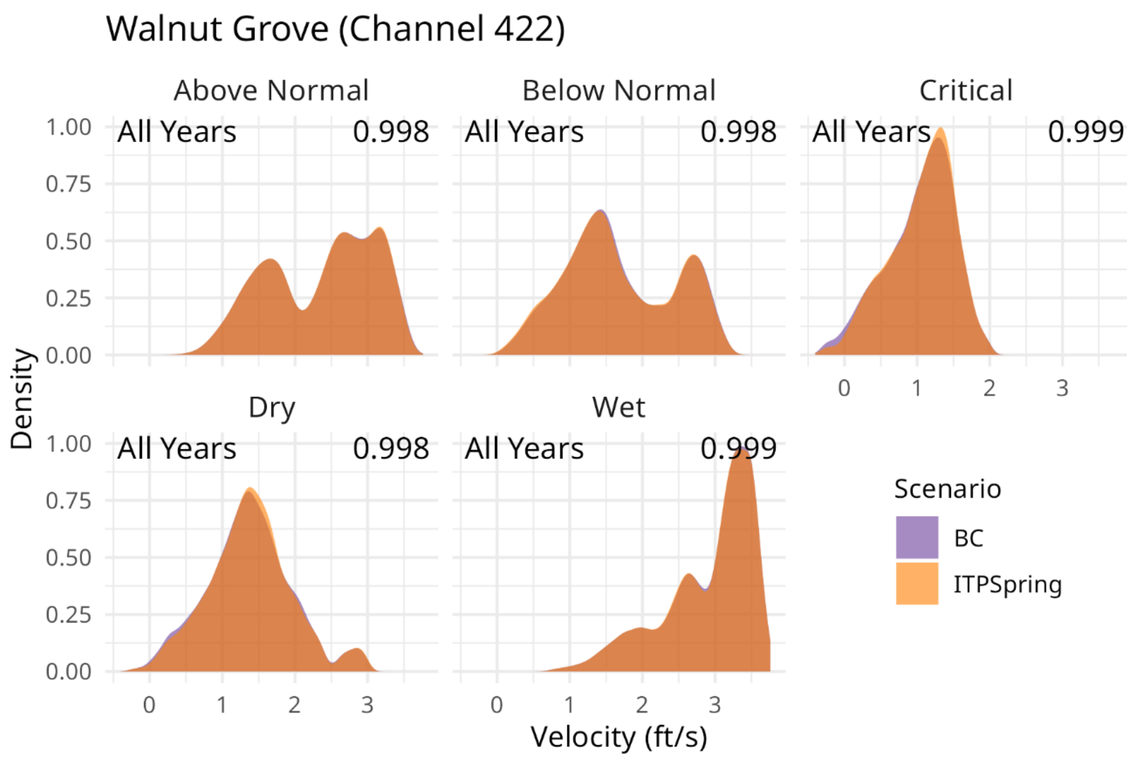

Figure B- 36. February Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

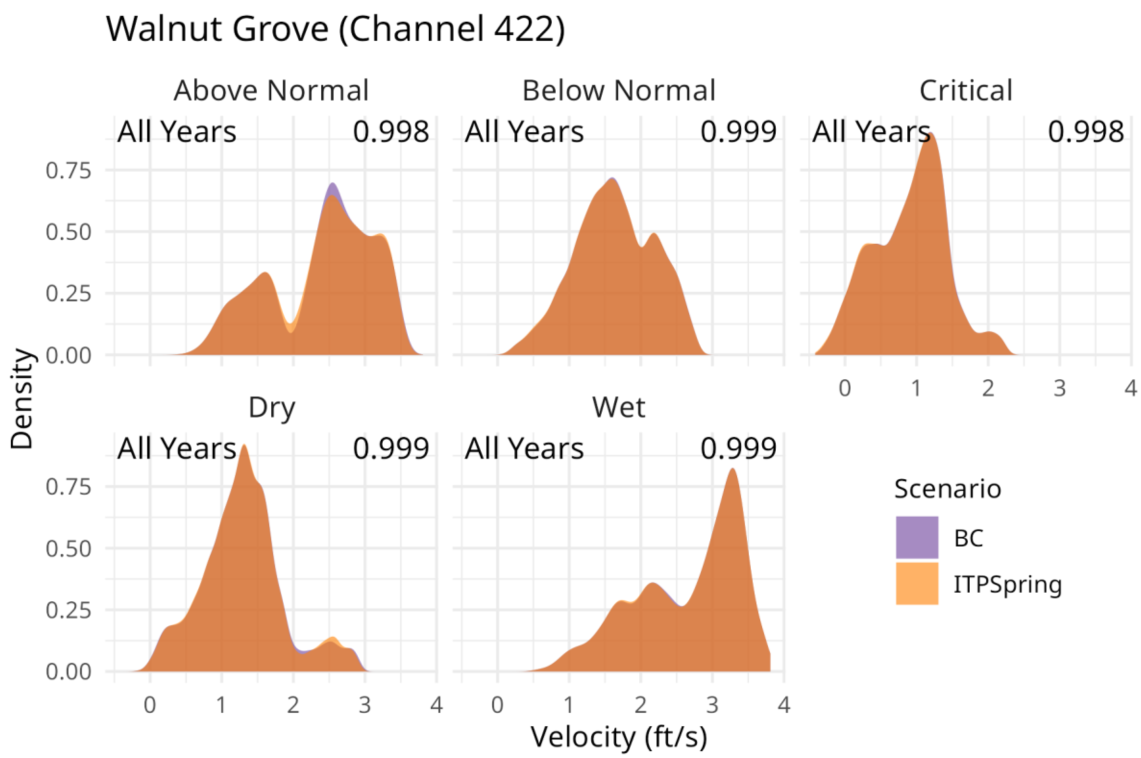

Figure B- 37. March Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

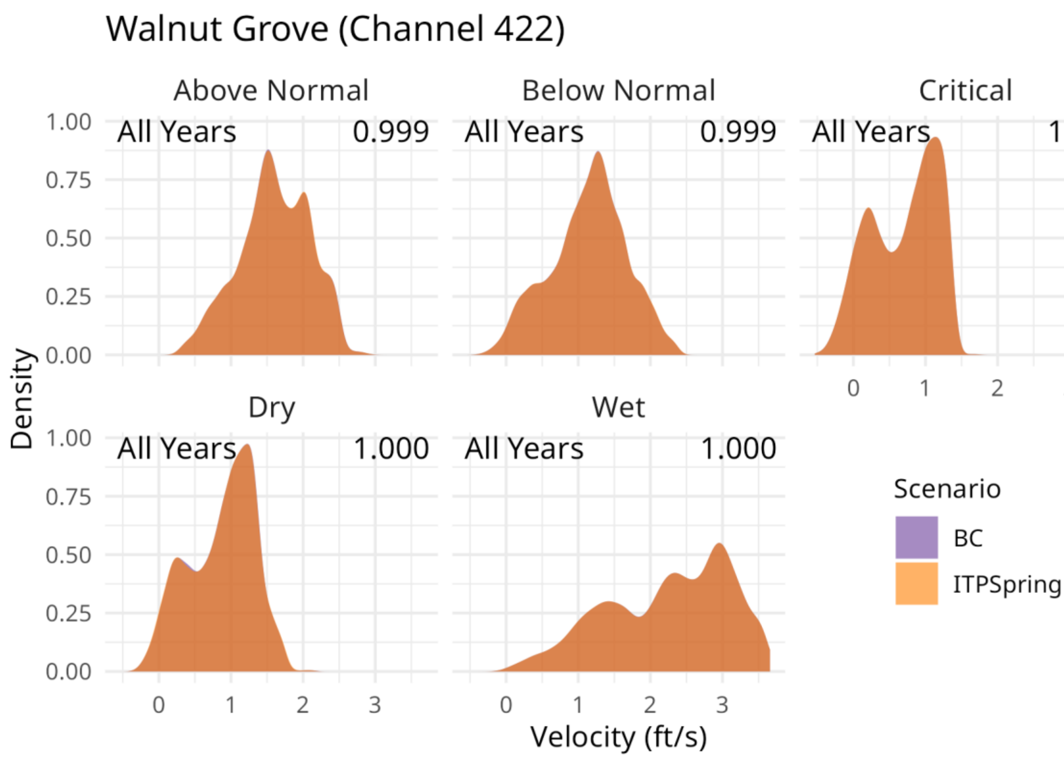

Figure B- 38. April Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

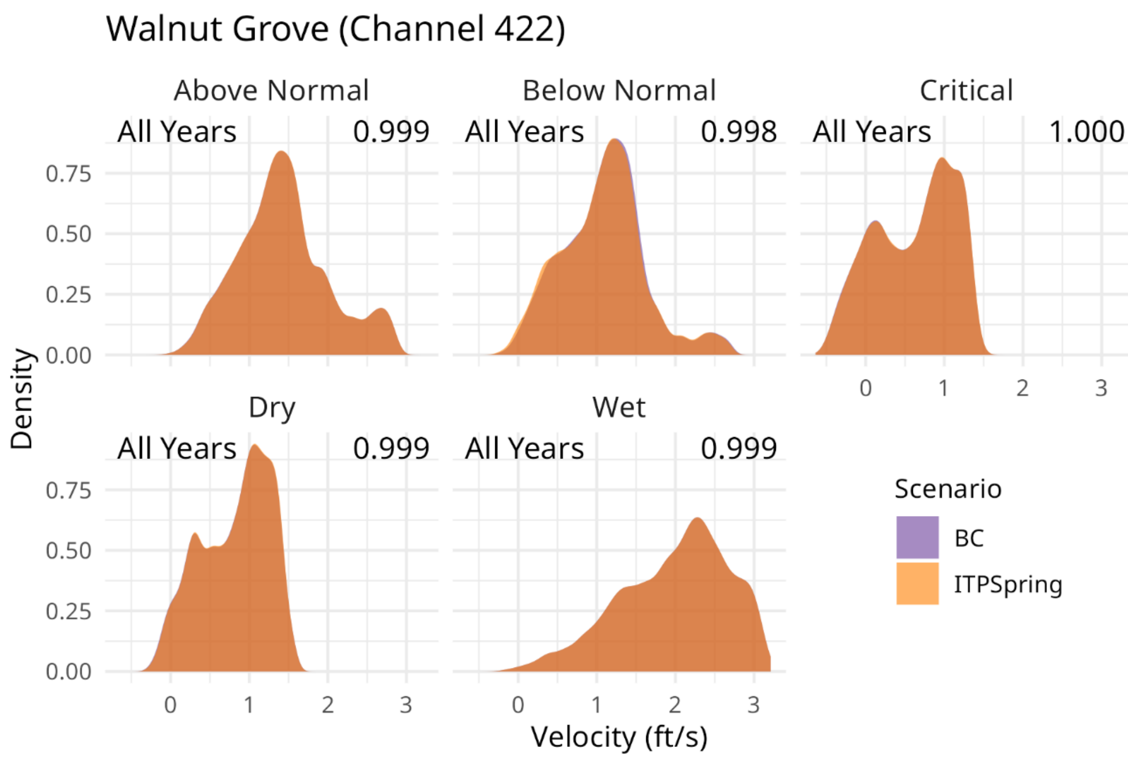

Figure B- 39. May Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

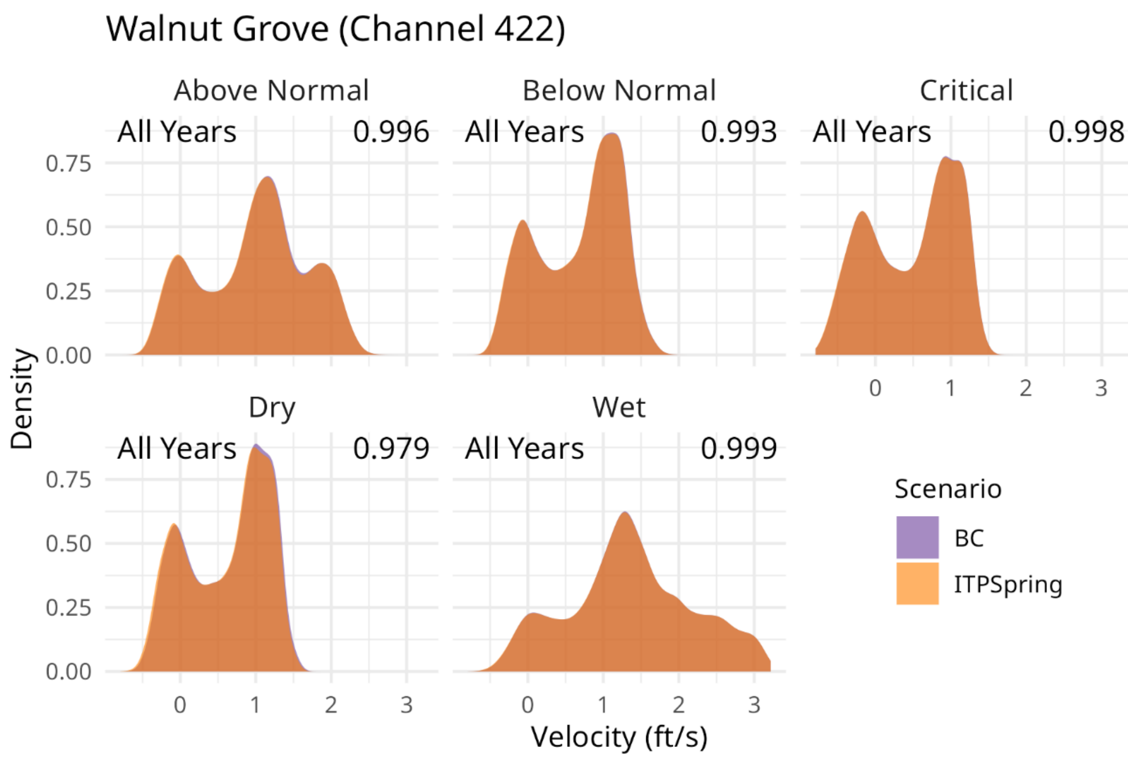

Figure B- 40. June Velocity Density Distribution for Sacramento River at Walnut Grove for Baseline Conditions and Proposed Project scenario ITP_Spring. The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and ITP_Spring for a given water year type.

References

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Appendix C. CalSim Modeling Results

Appendix C includes CalSim 3 modeling results of Baseline Conditions and two Proposed Project scenarios (9A_V2A and ITP_Spring). Table C- 1 through Table C- 12 present CalSim 3 modeling results for mean Sacramento River flow at Freeport grouped by water year type. Table C- 13 through Table C- 24 and Figure C- 1 through Figure C- 4 present CalSim 3 modeling results for mean monthly SWP south Delta exports grouped by water year type. Table C- 25 through Table C- 36 and Figure C- 5 through Figure C- 8 present mean monthly OMR flows grouped by water year type. CalSim 3 modeling results presented below are based on information CDFW obtained from coordination with DWR.

C.1. Modeling Assumptions

CalSim 3 modeling conducted for DWR's ITP Application produced monthly water supply values for water years 1922 through 2021 (DWR 2023). Modeled Baseline Conditions assume existing CVP operations (under the implementation of the 2019 NMFS BO, the 2019 USFWS BO, and the water year 2022 and 2023 Interim Operations Plans – Export Curtailments for Spring Outflow) and existing SWP operations (under the implementation of the 2019 NMFS BO, the 2019 USFWS BO, and the 2020 SWP ITP). The water year 2022 and 2023 Interim Operations Plans – Export Curtailments for Spring Outflow applied to existing CVP operations assumed CVP contribution in April and May of critical, dry, and below normal water year types to the 2020 SWP ITP Condition of Approval 8.17 – Export Curtailments for Spring Outflow (see below for more details; Pacific Coast Federation of Fishermen's Associations, et al. v. Raimondo, et al. 2022, 2023). CVP contribution in critical, dry, and below normal water years assumed CVP export as the maximum of 900 cfs or up to 60% of the total permittable export under Condition of Approval 8.17. The two modeled Proposed Project scenarios (9A_V2A and ITP_Spring) assumed existing CVP operations and proposed SWP operations (under the implementation of the 2024 SWP ITP).

The ITP_Spring CalSim 3 modeling scenario includes proposed SWP operations as well as SWP implementation of the 2020 SWP ITP Condition of Approval 8.17 – Export Curtailments for Spring Outflow (Condition of Approval 8.12.1). The 2020 SWP ITP Condition of Approval 8.17 includes export curtailments for all water year types, determined by the 75% exceedance forecast for the San Joaquin Valley Index, by requiring DWR to manage exports to achieve a specific inflow to export (I:E) ratio for each water year type using San Joaquin River flow at Vernalis and combined CVP and SWP exports from April 1 through May 31. The 9A_V2A CalSim 3 modeling scenario includes proposed SWP operations as well as DWR's contribution to the HRL, which includes a Delta inflow block of water and SWP export curtailments (Condition of Approval 8.12.2). The increase in Delta inflow equates to a 50 thousand acre-feet (TAF) inflow block of water in March of dry, below normal, and above normal water year types. These flows may also be released in April or May, if approved by CDFW. The SWP export curtailment equates to a 92.5 TAF Delta outflow block of water in April through May of dry and below normal water year types and a 117.5 TAF Delta outflow block of water April through May of above normal water year types. No Delta inflow block or export curtailments are proposed for critical or wet water year types.

Baseline Conditions, ITP_Spring, and 9A_V2A scenarios all include CVP operations adhering to the 2020 SWP ITP Condition of Approval 8.17 per the water year 2022 and 2023 Interim Operations Plans (Pacific Coast Federation of Fishermen's Associations, et al. v. Raimondo, et al. 2022, 2023). Including the CVP contribution towards Condition of Approval 8.17 in Baseline Conditions is appropriate considering the timing of the ITP Application (DWR 2023), whereby CVP operations were controlled by the water year 2023 Interim Operations Plan.

The ITP Application indicates that historical 50% exceedance forecast of the Sacramento Valley "40-30-30" water year hydrologic classification index was used to determine water year type in CalSim 3 (DWR 2023, Appendix E), which can change monthly between January and June until the final water year type determination is made. DWR modeled OMR Management minimization measures in CalSim 3 by estimating the historical percentage of each month during OMR Management, January through June, that would have historically been subject to OMR action responses beyond operating to -5,000 cfs (referred to as "historical percentage of month"). The historical percentage of month method used the percentage of each month that an OMR minimization measure would historically be triggered under Baseline Conditions and Proposed Project scenarios based on historical data from water years 2010 to 2022. Historical percentages of each month under OMR action responses were averaged by water year type and input into CalSim 3 as the average OMR percentage by water year type and month applied to water years 1922 through 2021 for OMR managed at -3,500 cfs (DWR 2023, Appendix E). Between water years 2010 and 2022, there were zero above normal water year types for March through June; therefore, DWR applied the average of below normal and wet water year types for March through June to above normal water year types for water years 1922 through 2021.

DWR did not model in CalSim 3 all OMR minimization measures or all components of OMR minimization measures as presented in the 2024 SWP ITP for implementation. For example, under Baseline Conditions, CHNWR daily loss thresholds (2020 SWP ITP Conditions of Approval 8.6.2 and 8.6.3) were not modeled in CalSim 3. Therefore, any OMR action responses resulting from a daily threshold exceedance would not be accounted for in the Baseline Conditions. For both Proposed Project scenarios, although the Winter-run Chinook Salmon Weekly Distributed Loss Thresholds were modeled in CalSim 3, rolling 7-day sums of loss each day were not used to determine threshold exceedances (see Section 6.2.7; Condition of Approval 8.4.4). Instead, threshold exceedances contributed to OMR restrictions when the total loss for each 7-day week, beginning with week 1 as January 1 through January 7, exceeded the weekly threshold. This approach to modeling did not allow for threshold exceedances to occur more than once per week, which may underestimate the percentage of each month under an OMR action response for CalSim 3 modeling. Other real-time management actions from the ITP Application, including the Winter-run Chinook Salmon Early Season Weekly Loss Thresholds (see Section 6.2.5; Condition of Approval 8.2.1) and Spring-run Chinook Salmon Protection Action and Surrogate Annual Loss Thresholds (see Section 6.2.8; Condition of Approval 8.4.5), were not modeled because historical exceedances either never occurred between water years 2010 through 2022 or only occurred in low numbers that did not generate patterns for modeling assumptions (DWR 2023). OMR measures for steelhead were incorporated in CalSim 3 modeling of Baseline Conditions and Proposed Project scenarios; however, steelhead OMR measures are not conditioned in the 2024 SWP ITP because they are not currently listed under CESA. Instead, these measures were referenced in the Project Description of the 2024 SWP ITP Application (DWR 2023). DWR conducted a comparison of the water volumes in Table 5 of the ITP (and used in operational scenario 9A_V2A) to the outflows that would be expected, on average, in above normal, below normal, and dry water year types if Condition of Approval 8.12.1 was implemented and concluded that they are equivalent (DWR 2024e).

It should be noted that, although the intent of the ITP Application was to isolate impacts of the Proposed Project on Covered Species from those of CVP, due to limitations of CalSim 3 and the simulation of joint SWP and CVP operations for managing OMR flows, all OMR Management measures were modeled jointly for the Proposed Project and Reclamation's Proposed Action rather than CVP OMR Management measures authorized under the 2019 NMFS and USFWS BOs (DWR 2023). All elements of CVP operations other than OMR Management measures were modeled as authorized under the 2019 NMFS and USFWS BOs. To aid in identifying SWP contribution to changes in OMR flow modeled in CalSim 3, DWR included Table E-7-1 in their ITP Application that shows the estimated SWP proportion of an effect that may be a result of joint operations of the SWP and CVP (DWR 2023). The SWP proportion of an effect is the proportion of the change in OMR flow between Baseline Conditions and the Proposed Project that is attributable to SWP. Table E-7-1 can be used in conjunction with biological modeling results to better understand how SWP operations may contribute to changes in Covered Species impacts in the Delta resulting from CVP and the Project; however, this Effects Analysis does not consider Table E-7-1 in summarizing modeling results.

C.2. Mean Sacramento River Flow at Freeport by Month and Water Year Type

Table C- 1. Mean October Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	14,238	14,301 (0%)	14,279 (0%)
Above Normal	10,754	10,735 (0%)	10,792 (0%)
Below Normal	12,008	12,074 (1%)	12,124 (1%)
Dry	11,242	11,228 (0%)	11,298 (1%)
Critical	8,193	8,241 (1%)	8,092 (-1%)

Table C- 2. Mean November Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	19,275	19,300 (0%)	19,315 (0%)
Above Normal	12,798	12,816 (0%)	12,793 (0%)
Below Normal	13,863	13,716 (-1%)	13,658 (-1%)
Dry	12,156	12,238 (1%)	12,242 (1%)
Critical	8,304	8,501 (2%)	8,347 (1%)

Table C- 3. Mean December Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	38,326	38,311 (0%)	38,312 (0%)
Above Normal	19,238	19,226 (0%)	19,256 (0%)
Below Normal	16,409	16,594 (1%)	16,446 (0%)
Dry	16,120	15,913 (-1%)	15,940 (-1%)
Critical	12,175	12,291 (1%)	12,224 (0%)

Table C- 4. Mean January Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	49,611	49,609 (0%)	49,619 (0%)
Above Normal	40,840	40,853 (0%)	40,824 (0%)
Below Normal	22,233	22,292 (0%)	22,275 (0%)
Dry	16,110	15,967 (-1%)	15,954 (-1%)
Critical	13,504	13,564 (0%)	13,534 (0%)

Table C- 5. Mean February Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	58,955	58,948 (0%)	58,887 (0%)
Above Normal	44,381	44,362 (0%)	44,333 (0%)
Below Normal	28,831	28,645 (-1%)	28,662 (-1%)
Dry	21,943	22,122 (1%)	22,123 (1%)
Critical	15,633	15,972 (2%)	15,953 (2%)

Table C- 6. Mean March Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	51,700	51,864 (0%)	51,664 (0%)
Above Normal	44,719	45,232 (1%)	44,505 (0%)
Below Normal	26,880	27,591 (3%)	26,838 (0%)
Dry	20,280	21,094 (4%)	20,301 (0%)
Critical	13,458	13,633 (1%)	13,372 (-1%)

Table C- 7. Mean April Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	41,478	41,477 (0%)	41,470 (0%)
Above Normal	25,970	26,035 (0%)	25,973 (0%)
Below Normal	17,525	17,489 (0%)	17,542 (0%)
Dry	12,680	12,530 (-1%)	12,666 (0%)
Critical	9,842	9,787 (-1%)	9,836 (0%)

Table C- 8. Mean May Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	34,789	34,788 (0%)	34,787 (0%)
Above Normal	23,271	23,303 (0%)	23,297 (0%)
Below Normal	17,000	16,721 (-2%)	16,724 (-2%)
Dry	11,993	12,072 (1%)	12,044 (0%)
Critical	8,603	8,652 (1%)	8,642 (0%)

Table C- 9. Mean June Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	25,726	25,757 (0%)	25,675 (0%)
Above Normal	18,576	18,544 (0%)	18,370 (-1%)
Below Normal	13,942	13,889 (0%)	13,787 (-1%)
Dry	13,111	12,611 (-4%)	12,552 (-4%)
Critical	9,802	9,623 (-2%)	9,712 (-1%)

Table C- 10. Mean July Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	19,747	19,701 (0%)	19,728 (0%)
Above Normal	21,240	21,074 (-1%)	21,060 (-1%)
Below Normal	21,195	21,001 (-1%)	20,952 (-1%)
Dry	18,418	18,421 (0%)	18,410 (0%)
Critical	10,616	10,534 (-1%)	10,585 (0%)

Table C- 11. Mean August Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	17,661	17,621 (0%)	17,669 (0%)
Above Normal	18,936	18,405 (-3%)	18,362 (-3%)
Below Normal	17,505	17,312 (-1%)	17,377 (-1%)
Dry	13,073	12,837 (-2%)	12,769 (-2%)
Critical	8,518	8,326 (-2%)	8,348 (-2%)

Table C- 12. Mean September Sacramento River Flow at Freeport (cfs) under Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	19,574	20,568 (5%)	20,757 (6%)
Above Normal	18,945	20,695 (9%)	21,500 (13%)
Below Normal	14,947	14,925 (0%)	15,189 (2%)
Dry	10,808	10,851 (0%)	10,828 (0%)
Critical	8,516	8,518 (0%)	8,519 (0%)

C.3. Mean SWP South Delta Exports by Month and Water Year Type

Table C- 13. Mean October SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	4,167	4,079 (-2%)	4,072 (-2%)
Above Normal	2,485	2,382 (-4%)	2,429 (-2%)
Below Normal	3,250	3,177 (-2%)	3,179 (-2%)
Dry	2,719	2,738 (1%)	2,744 (1%)
Critical	1,667	1,670 (0%)	1,522 (-9%)

Table C- 14. Mean November SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	5,565	5,582 (0%)	5,602 (1%)
Above Normal	4,389	4,302 (-2%)	4,321 (-2%)
Below Normal	4,374	4,387 (0%)	4,393 (0%)
Dry	3,846	3,852 (0%)	3,853 (0%)
Critical	1,565	1,571 (0%)	1,567 (0%)

Table C- 15. Mean December SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	4,519	4,452 (-1%)	4,475 (-1%)
Above Normal	4,212	4,222 (0%)	4,230 (0%)
Below Normal	3,926	4,038 (3%)	3,906 (-1%)
Dry	3,716	3,529 (-5%)	3,542 (-5%)
Critical	2,472	2,467 (0%)	2,480 (0%)

Table C- 16. Mean January SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	4,262	4,175 (-2%)	4,172 (-2%)
Above Normal	2,965	2,900 (-2%)	2,900 (-2%)
Below Normal	2,861	2,756 (-4%)	2,767 (-3%)
Dry	2,572	2,547 (-1%)	2,525 (-2%)
Critical	2,685	2,346 (-13%)	2,333 (-13%)

Table C- 17. Mean February SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	5,917	5,975 (1%)	5,963 (1%)
Above Normal	3,873	3,591 (-7%)	3,833 (-1%)
Below Normal	3,219	3,052 (-5%)	3,054 (-5%)
Dry	2,464	2,211 (-10%)	2,176 (-12%)
Critical	2,585	2,454 (-5%)	2,466 (-5%)

Table C- 18. Mean March SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	5,124	5,233 (2%)	5,312 (4%)
Above Normal	3,251	3,335 (3%)	3,334 (3%)
Below Normal	2,988	2,910 (-3%)	2,913 (-2%)
Dry	2,160	2,123 (-2%)	2,123 (-2%)
Critical	1,626	1,624 (0%)	1,624 (0%)

Table C- 19. Mean April SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	3,567	3,633 (2%)	3,622 (2%)
Above Normal	788	1,072 (36%)	786 (0%)
Below Normal	801	992 (24%)	809 (1%)
Dry	797	838 (5%)	796 (0%)
Critical	720	872 (21%)	718 (0%)

Table C- 20. Mean May SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	2,588	3,823 (48%)	2,821 (9%)
Above Normal	1,209	1,981 (64%)	1,272 (5%)
Below Normal	906	1,694 (87%)	977 (8%)
Dry	683	884 (29%)	682 (0%)
Critical	609	861 (41%)	629 (3%)

Table C- 21. Mean June SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	4,067	3,960 (-3%)	3,962 (-3%)
Above Normal	2,583	2,367 (-8%)	2,337 (-10%)
Below Normal	2,074	1,930 (-7%)	1,891 (-9%)
Dry	1,780	1,605 (-10%)	1,591 (-11%)
Critical	784	714 (-9%)	749 (-4%)

Table C- 22. Mean July SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	7,038	7,051 (0%)	7,068 (0%)
Above Normal	6,999	7,150 (2%)	7,150 (2%)
Below Normal	7,013	6,953 (-1%)	6,969 (-1%)
Dry	5,323	5,499 (3%)	5,475 (3%)
Critical	531	490 (-8%)	500 (-6%)

Table C- 23. Mean August SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	6,803	7,129 (5%)	7,177 (5%)
Above Normal	6,949	7,153 (3%)	7,180 (3%)
Below Normal	6,376	6,347 (0%)	6,459 (1%)
Dry	1,706	1,664 (-2%)	1,651 (-3%)
Critical	329	351 (7%)	332 (1%)

Table C- 24. Mean September SWP south Delta exports (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	5,438	6,553 (21%)	6,775 (25%)
Above Normal	4,144	5,204 (26%)	5,980 (44%)
Below Normal	4,446	4,316 (-3%)	4,559 (3%)
Dry	1,659	1,592 (-4%)	1,591 (-4%)
Critical	525	520 (-1%)	518 (-1%)

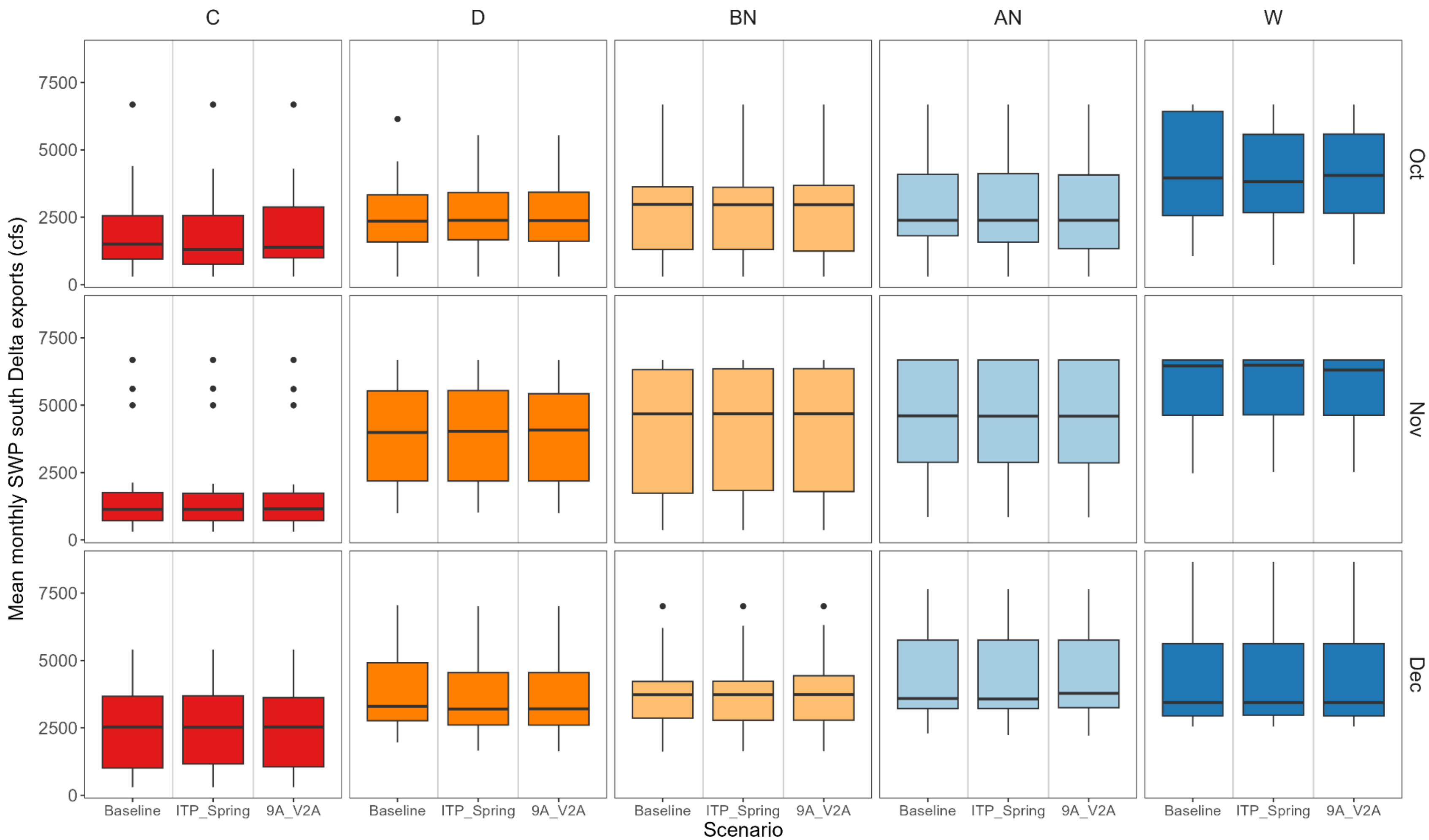

Figure C- 1. Mean SWP south Delta exports (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; October through December. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points.

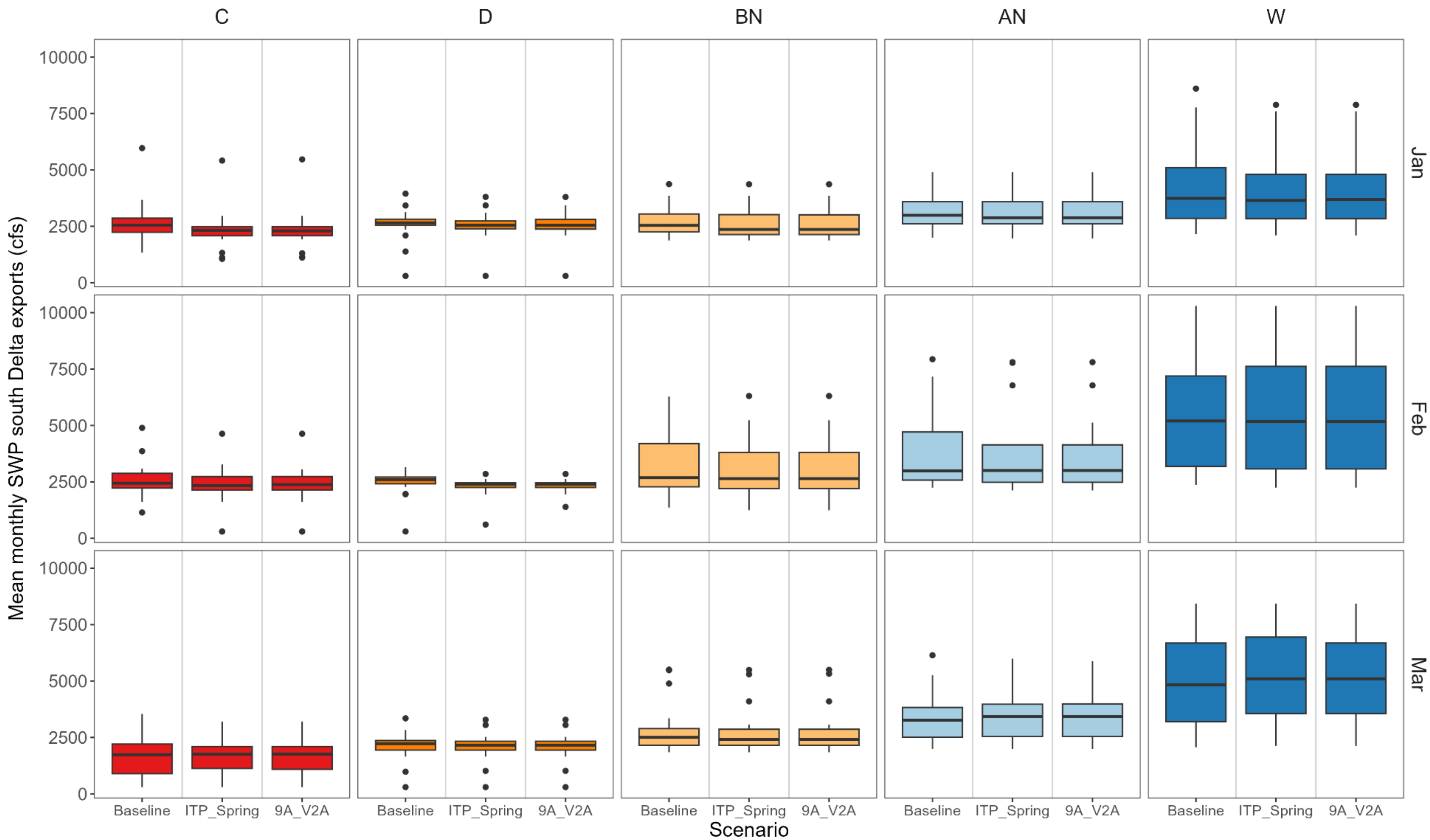

Figure C- 2. Mean SWP south Delta exports (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; January through March. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points.

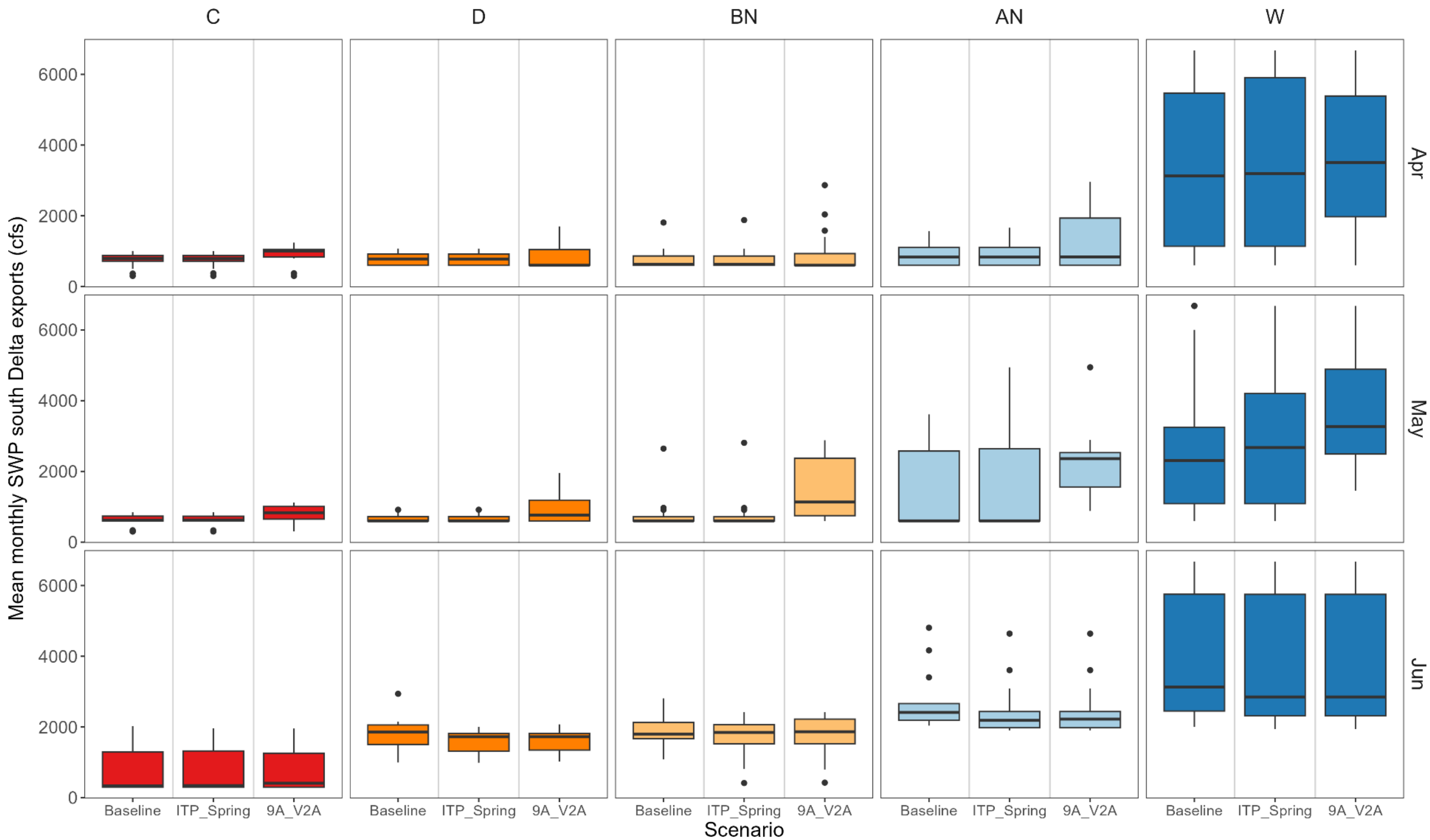

Figure C- 3. Mean SWP south Delta exports (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; April through June. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points.

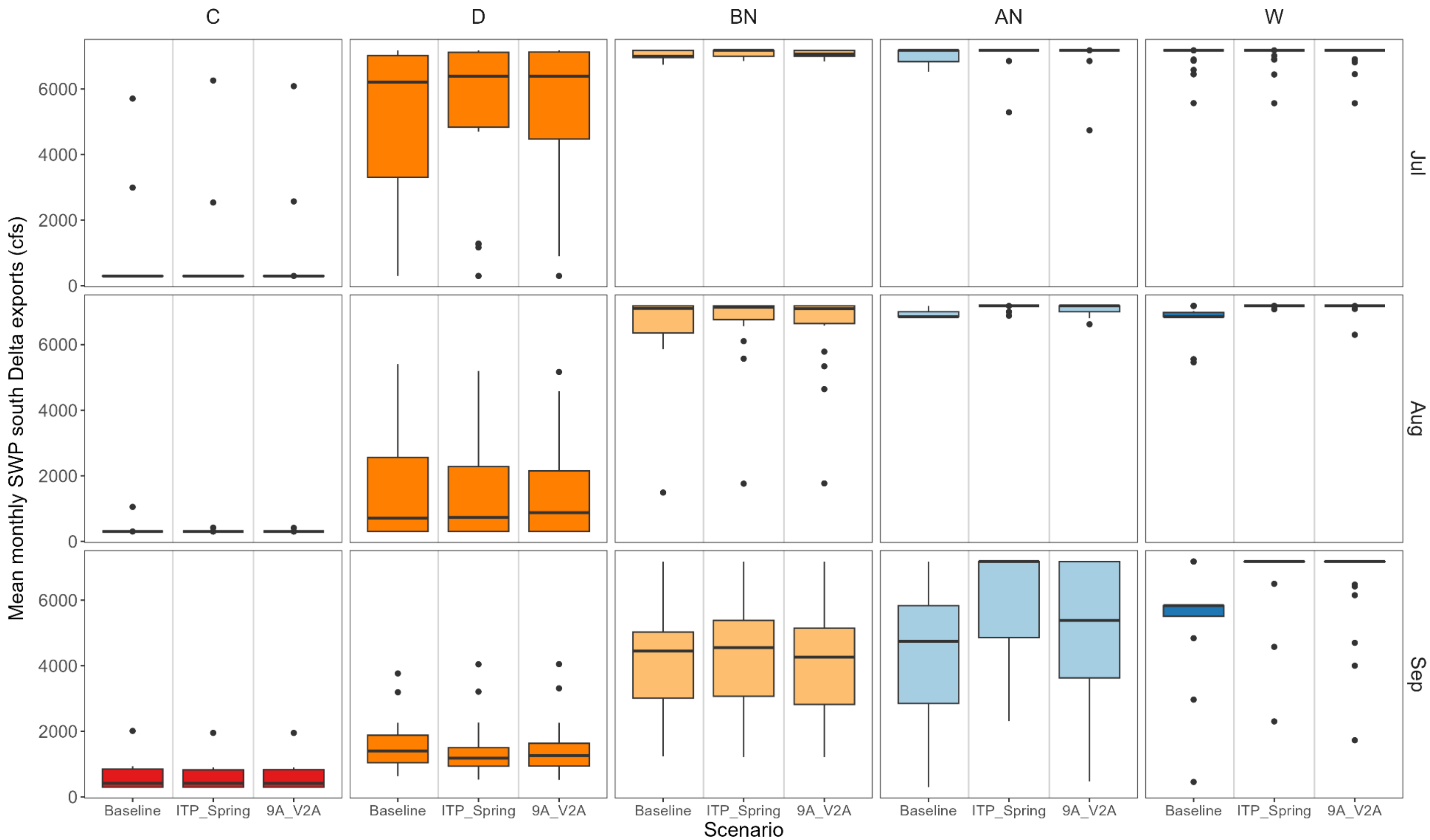

Figure C- 4. Mean SWP south Delta exports (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; July through September. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points.

C.4. Mean OMR Flows by Month and Water Year Type

Table C- 25. Mean October OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-6,381	-6,318 (1%)	-6,306 (1%)
Above Normal	-5,343	-5,435 (-2%)	-5,496 (-3%)
Below Normal	-5,137	-5,140 (0%)	-5,231 (-2%)
Dry	-5,053	-5,014 (1%)	-5,057 (0%)
Critical	-3,878	-3,909 (-1%)	-3,816 (2%)

Table C- 26. Mean November OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-8,210	-8,278 (-1%)	-8,275 (-1%)
Above Normal	-7,119	-7,091 (0%)	-7,097 (0%)
Below Normal	-7,157	-7,136 (0%)	-7,124 (0%)
Dry	-6,813	-6,839 (0%)	-6,831 (0%)
Critical	-4,116	-4,244 (-3%)	-4,079 (1%)

Table C- 27. Mean December OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-5,812	-5,776 (1%)	-5,777 (1%)
Above Normal	-6,298	-6,328 (0%)	-6,322 (0%)
Below Normal	-6,094	-6,087 (0%)	-5,991 (2%)
Dry	-6,352	-6,206 (2%)	-6,217 (2%)
Critical	-4,228	-4,294 (-2%)	-4,243 (0%)

Table C- 28. Mean January OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-3,569	-3,424 (4%)	-3,432 (4%)
Above Normal	-4,544	-4,366 (4%)	-4,365 (4%)
Below Normal	-4,237	-4,030 (5%)	-4,037 (5%)
Dry	-4,458	-4,307 (3%)	-4,295 (4%)
Critical	-4,088	-3,647 (11%)	-3,756 (8%)

Table C- 29. Mean February OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-2,986	-3,017 (-1%)	-3,013 (-1%)
Above Normal	-3,999	-3,708 (7%)	-3,900 (2%)
Below Normal	-4,331	-4,067 (6%)	-4,067 (6%)
Dry	-4,317	-3,953 (8%)	-3,953 (8%)
Critical	-4,201	-3,942 (6%)	-3,910 (7%)

Table C- 30. Mean March OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-1,658	-1,747 (-5%)	-1,818 (-10%)
Above Normal	-3,208	-3,320 (-3%)	-3,323 (-4%)
Below Normal	-3,656	-3,590 (2%)	-3,590 (2%)
Dry	-3,595	-3,500 (3%)	-3,500 (3%)
Critical	-2,868	-2,851 (1%)	-2,848 (1%)

Table C- 31. Mean April OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-412	-456 (-11%)	-479 (-16%)
Above Normal	-313	-693 (-121%)	-338 (-8%)
Below Normal	513	374 (-27%)	510 (0%)
Dry	-445	-487 (-9%)	-443 (0%)
Critical	-844	-951 (-13%)	-842 (0%)

Table C- 32. Mean May OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-1,498	-2,709 (-81%)	-1,841 (-23%)
Above Normal	-1,950	-2,947 (-51%)	-2,308 (-18%)
Below Normal	-48	-738 (-1435%)	-70 (-46%)
Dry	-556	-782 (-41%)	-555 (0%)
Critical	-888	-1,057 (-19%)	-905 (-2%)

Table C- 33. Mean June OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-3,709	-3,483 (6%)	-3,465 (7%)
Above Normal	-4,554	-4,135 (9%)	-4,117 (10%)
Below Normal	-4,661	-4,251 (9%)	-4,236 (9%)
Dry	-4,436	-4,005 (10%)	-4,006 (10%)
Critical	-2,340	-2,134 (9%)	-2,199 (6%)

Table C- 34. Mean July OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-8,895	-8,925 (0%)	-8,935 (0%)
Above Normal	-9,449	-9,613 (-2%)	-9,680 (-2%)
Below Normal	-10,637	-10,658 (0%)	-10,658 (0%)
Dry	-9,292	-9,467 (-2%)	-9,444 (-2%)
Critical	-3,517	-3,418 (3%)	-3,463 (2%)

Table C- 35. Mean August OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-9,300	-9,633 (-4%)	-9,648 (-4%)
Above Normal	-10,186	-10,335 (-1%)	-10,342 (-2%)
Below Normal	-10,287	-10,310 (0%)	-10,340 (-1%)
Dry	-5,955	-6,188 (-4%)	-6,084 (-2%)
Critical	-2,445	-2,257 (8%)	-2,295 (6%)

Table C- 36. Mean September OMR flows (cfs) under the Proposed Project and Baseline Conditions CalSim 3 modeling scenarios grouped by water year type. Percent differences between the Proposed Project scenarios (9A_V2A and ITP_Spring) and Baseline Conditions are in parentheses.

Water Year Type	Baseline Conditions	9A_V2A	ITP_Spring
Wet	-8,358	-9,430 (-13%)	-9,555 (-14%)
Above Normal	-7,310	-7,991 (-9%)	-8,669 (-19%)
Below Normal	-9,056	-8,899 (2%)	-9,164 (-1%)
Dry	-5,367	-5,269 (2%)	-5,232 (3%)
Critical	-3,373	-3,366 (0%)	-3,367 (0%)

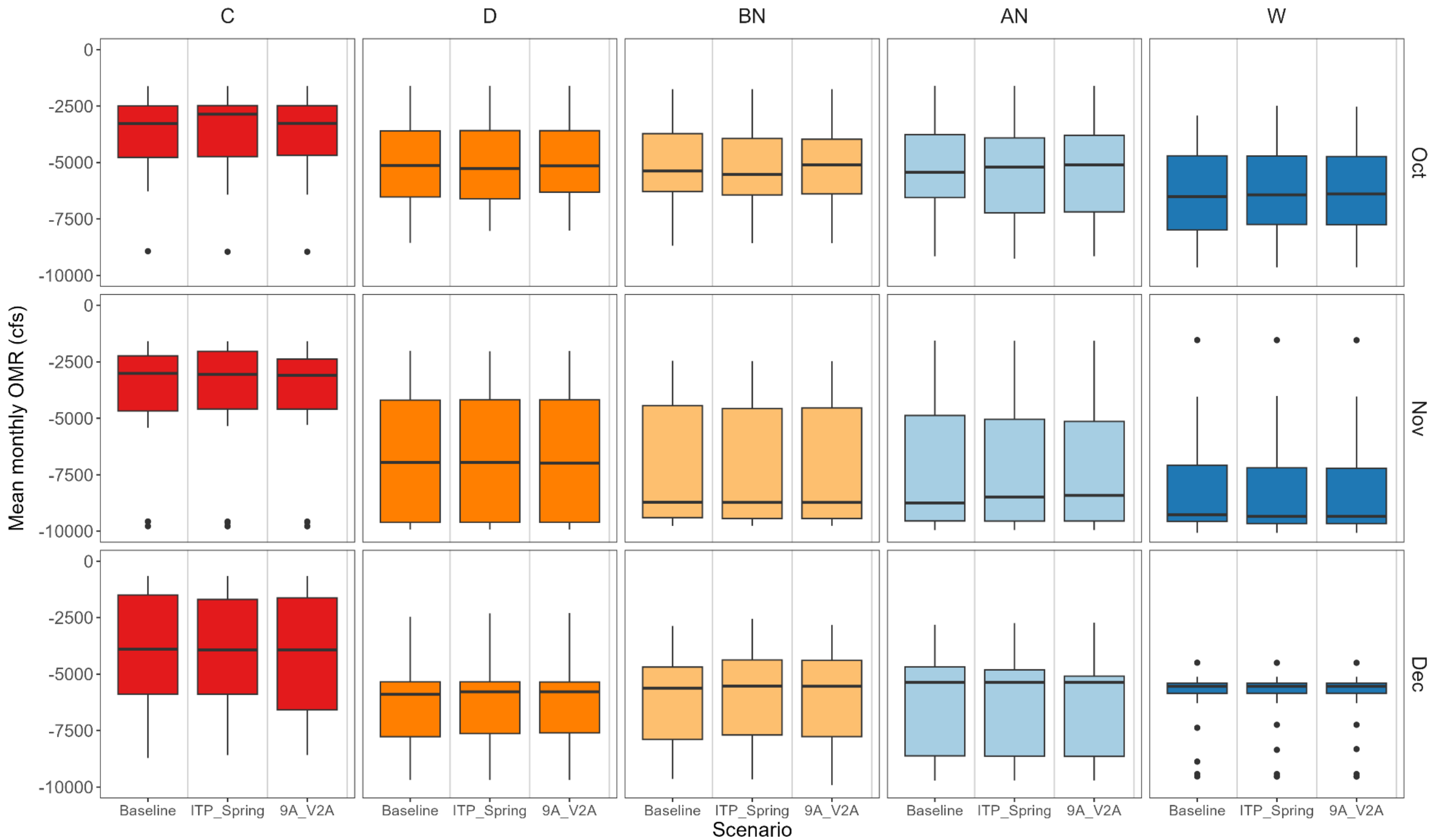

Figure C- 5. Mean OMR flows (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; October through December. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points. Graphics were magnified to focus on the interquartile range and median, so some outliers may not be shown.

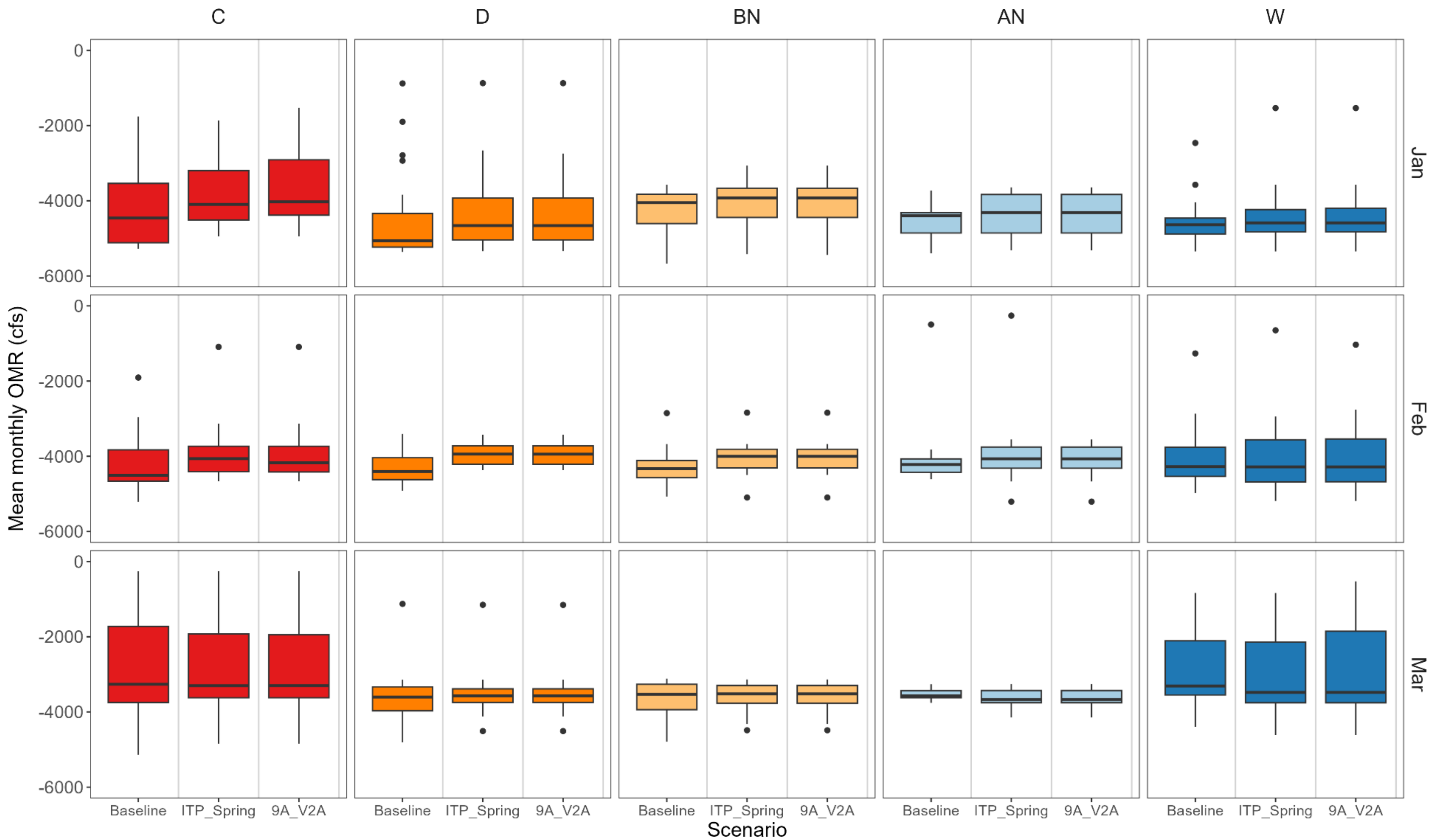

Figure C- 6. Mean OMR flows (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; January through March. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points. Graphics were magnified to focus on the interquartile range and median, so some outliers may not be shown.

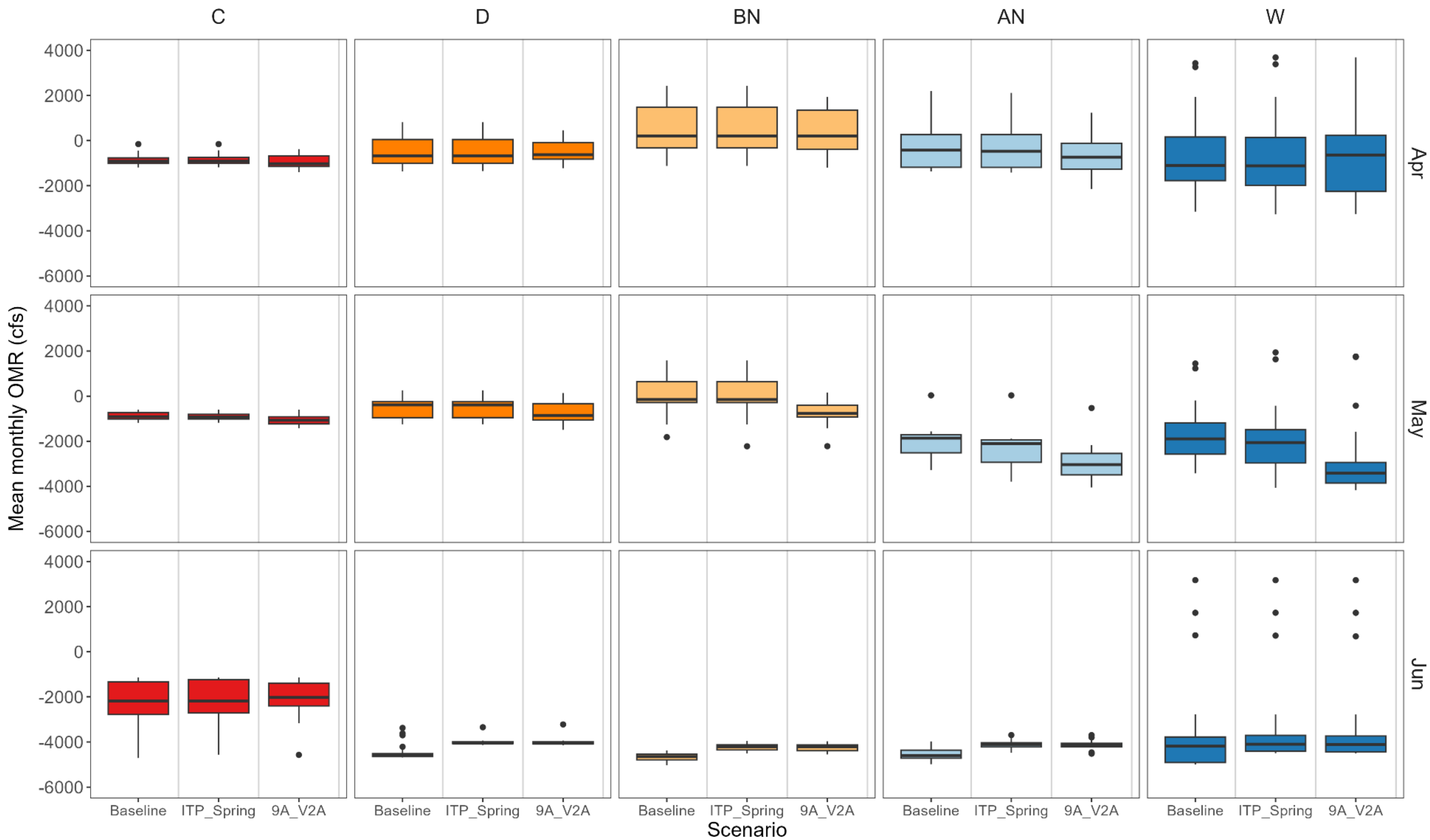

Figure C- 7. Mean OMR flows (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; April through June. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points. Graphics were magnified to focus on the interquartile range and median, so some outliers may not be shown.

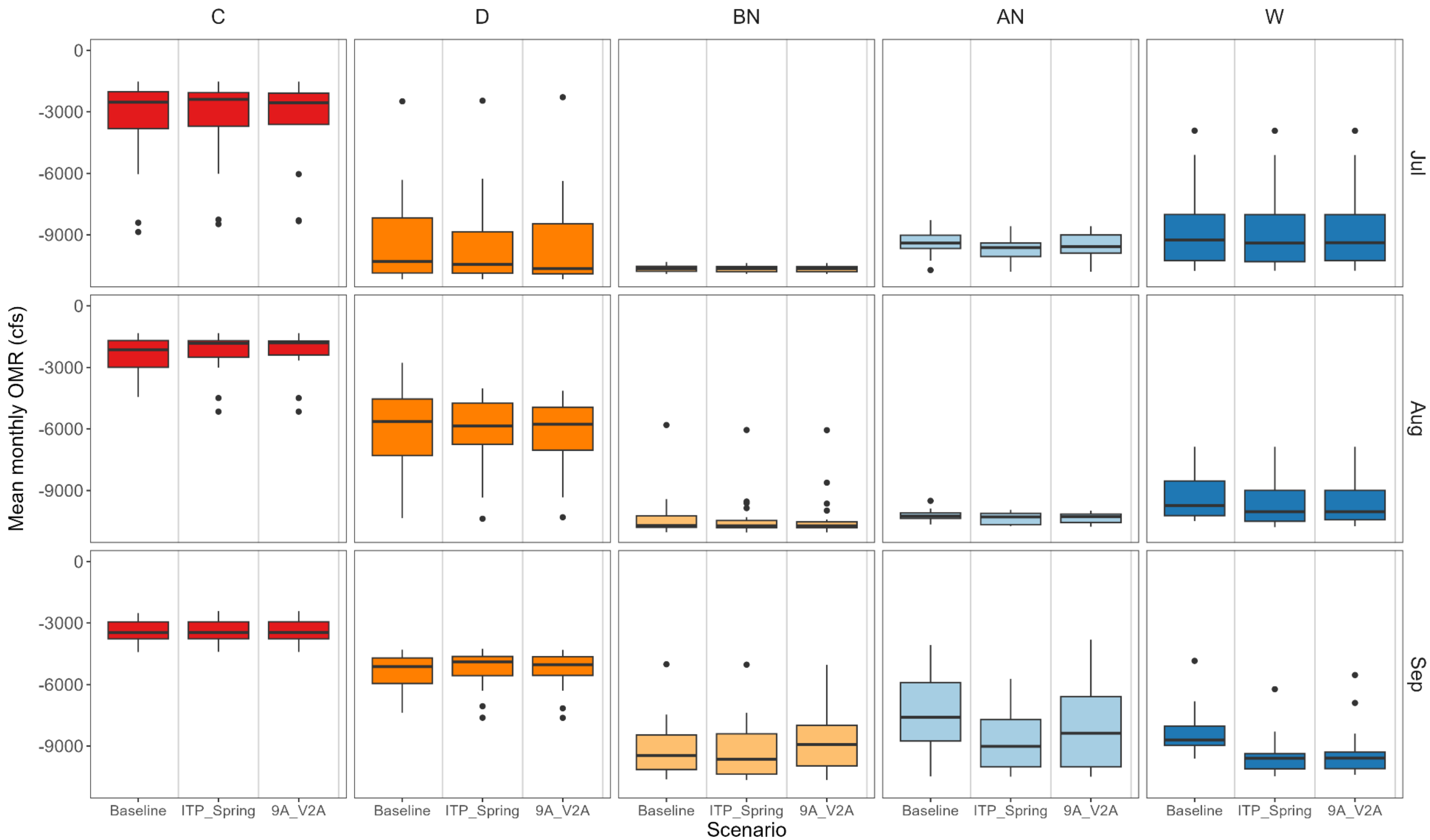

Figure C- 8. Mean OMR flows (cfs) under the Proposed Project (9A_V2A and ITP_Spring) and Baseline Conditions CalSim 3 modeling scenarios by month and water year type; July through September. The black line through each box represents the median and the box encompasses the range of the first and third quartiles. The ends of the whiskers represent the minimum and maximum values. Outliers [1.5 x (Quartile 3 - Quartile 1)] are represented as points. Graphics were magnified to focus on the interquartile range and median, so some outliers may not be shown.

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Appendix D. Juvenile Size Distribution in Delta Monitoring and Salvage

CDFW conducted the following analysis to evaluate any trends that may be detectable in size distribution of genetically-identified natural-origin CHNWR and CHNSR observed in Delta monitoring and in salvage at the CVP and SWP export facilities. Catch data for genetically-identified natural-origin CHNWR and CHNSR from the Sherwood Harbor trawl (Buttermore et al. 2021b) and Chipps Island trawl (Buttermore et al. 2021a) were available for water years 2017 to 2021. Loss data for genetically-identified natural-origin CHNWR for water years 2010 to 2022 (DWR et al. 2023) were subjected to QA/QC by DWR, Reclamation, and CDFW. Loss data for genetically-identified natural-origin CHNSR (DWR and CDFW 2023) were available for water years 2017 to 2022. For additional information on data sources and limitations see CDFW (2024).

The USFWS Delta Juvenile Fish Monitoring Program at Sherwood Harbor and Chipps Island collects data on six life stages of Chinook Salmon. Each Chinook Salmon captured in Sherwood Harbor trawl and Chipps Island trawl is assigned a life stage number based on physical characteristics: stage 1 – yolk sac fry; stage 2 – fry; stage 3 – parr; stage 4 – silvery parr; stage 5 – smolt; and stage 6 – adult/jack (Jonathan Speegle, personal communication, 6/2024; Eric Louwerens, personal communication, 6/2024). Fry-sized Chinook Salmon, stages 1 and 2, have been captured by Sherwood Harbor trawl between water years 2010 and 2022 with fork lengths ranging from 23 to 59 mm. Zero stage 1 fish have been captured at Chipps Island trawl in water years 2010 to 2022. However, stage 2 fry-sized fish have been captured with fork lengths ranging from 35 to 54 mm (Jonathan Speegle, personal communication, 6/2024). Between water years 2017 and 2021, 18.5% of all Chinook Salmon observed in monitoring at Sherwood Harbor were categorized as fry. In contrast, only 0.04% of Chinook Salmon observed in monitoring at Chipps Island trawl were categorized as fry. Smolts, stage 5, made up 74.8% of Chinook Salmon observed at Chipps Island trawl and 19.5% of Chinook Salmon observed at Sherwood Harbor trawl (Jonathan Speegle, personal communication, 6/2024).

Of the genetically-identified natural-origin CHNWR observed at Sherwood Harbor trawl, 21% were categorized as fry, 18.5% as parr, 40.7% as silvery parr, and 19.8% as smolt (Table D- 1; Figure D- 1). Fork lengths of sampled CHNWR ranged from 31 mm to 134 mm. Of the genetically-identified natural-origin CHNSR observed at Sherwood Harbor, 7.1% were categorized as fry, 11.1% as parr, 40.5% as silvery parr, and 41.3% as smolt (Table D- 1; Figure D- 2). Fork lengths of sampled CHNSR ranged from 35 mm to 136 mm.

Table D- 1. Juvenile genetically-identified natural-origin CHNWR and CHNSR Sherwood Harbor trawl catch by fork length for water years 2017-2021. Table cells represented with "-" indicate zero catch within a fork length range.

Fork Length (mm)	CHNWR Catch	CHNSR Catch
30-39	19	8
40-49	6	8
50-59	2	3
60-69	1	7
70-79	9	19
80-89	5	17
90-99	6	18
100-109	16	38
110-119	11	9
120-129	4	-
130-139	2	1

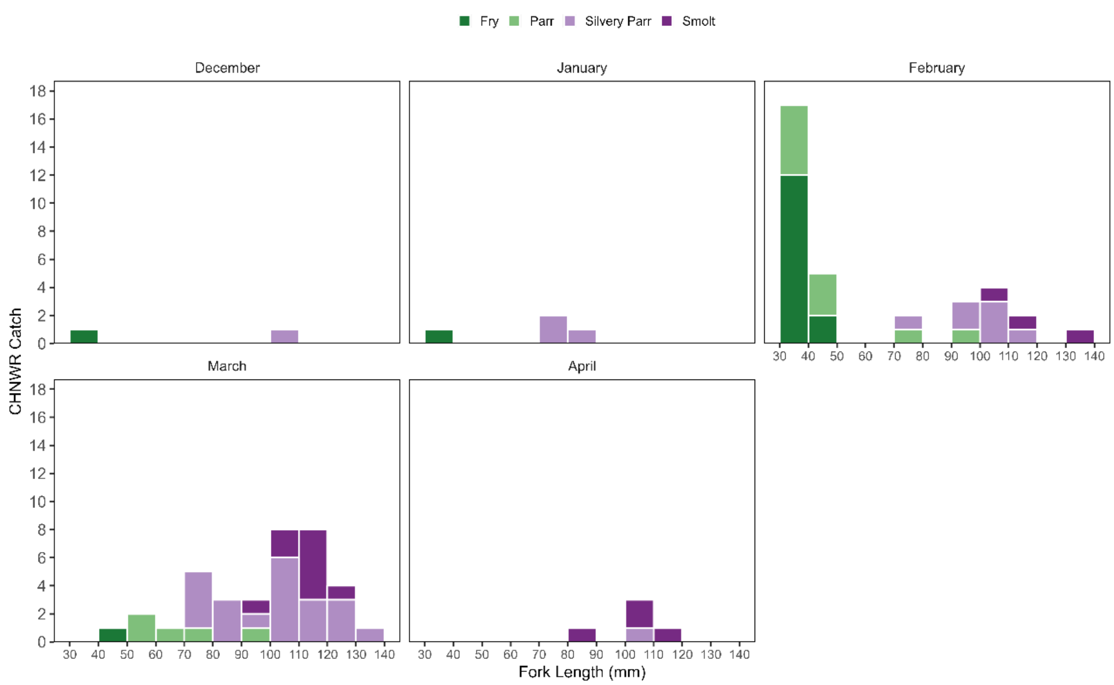

Figure D- 1. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNWR catch at Sherwood Harbor trawl grouped by life stage for water years 2017-2021.

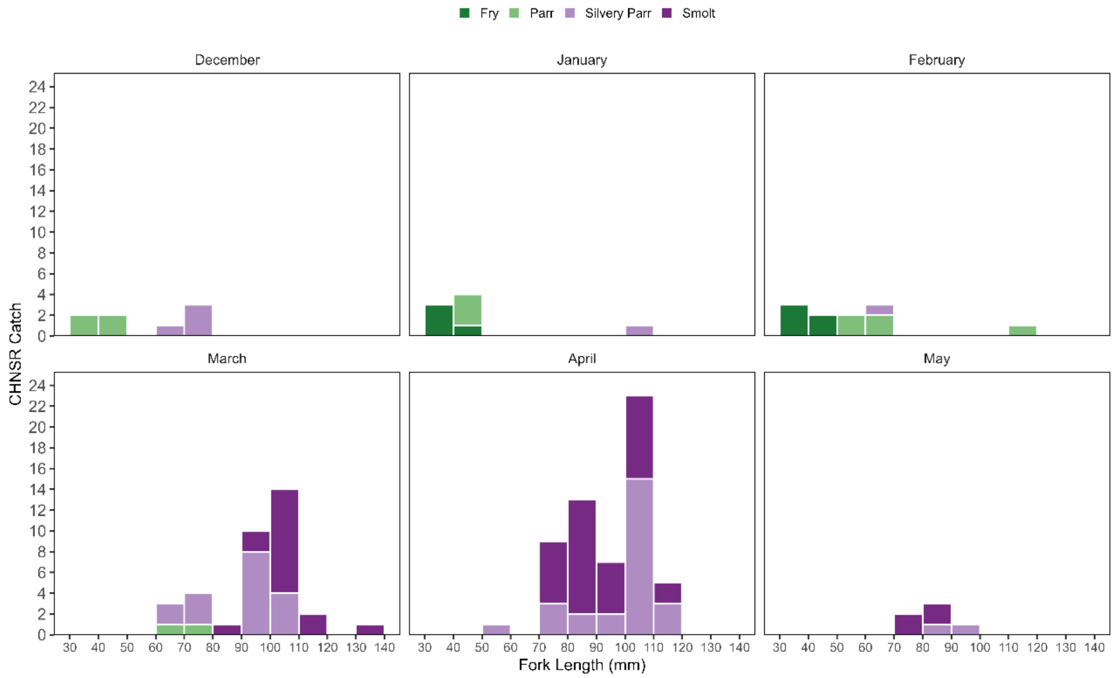

Figure D- 2. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNSR catch at Sherwood Harbor trawl grouped by life stage for water years 2017-2021.

Of the genetically-identified natural-origin CHNWR observed at Chipps Island trawl, 0% were categorized as fry, 1.1 % as parr, 19.4% as silvery parr, and 79.4% as smolt (Table D- 2; Figure D- 3). Fork lengths of sampled CHNWR ranged from 90 mm to 158 mm. Of the genetically-identified natural-origin CHNSR captured at Chipps Island trawl, 0.5% were categorized as fry, 1.6% as parr, 30.5% as silvery parr and 67.4% as smolt (Table D- 2; Figure D- 4). Fork lengths of sampled CHNSR ranged from 72 mm to 185 mm.

Table D- 2. Juvenile genetically-identified natural-origin CHNWR and CHNSR Chipps Island trawl catch by fork length for water years 2017-2021. Table cells represented with "-" indicate zero catch within a fork length range.

Fork Length (mm)	CHNWR Catch	CHNSR Catch
70-79	-	7
80-89	-	27
90-99	8	40
100-109	58	75
110-119	67	32
120-129	32	4
130-139	13	1
140-149	2	2
150-159	2	-
160-169	-	1
170-179	-	-
180-189	-	1

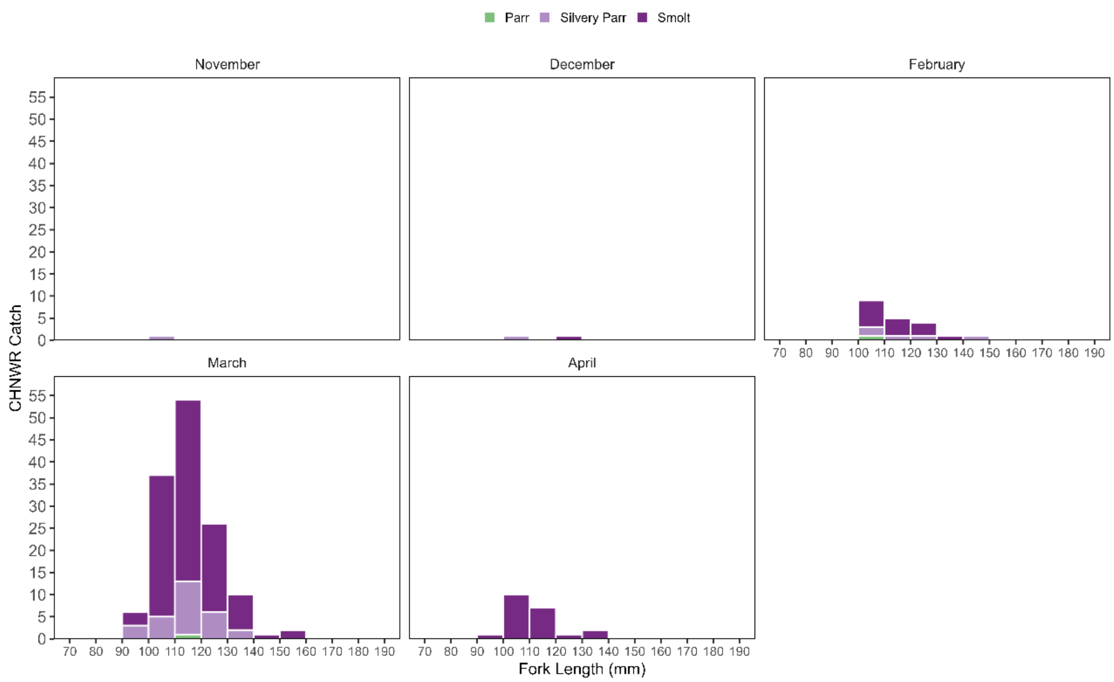

Figure D- 3. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNWR catch in Chipps Island trawl grouped by life stage for water years 2017-2021.

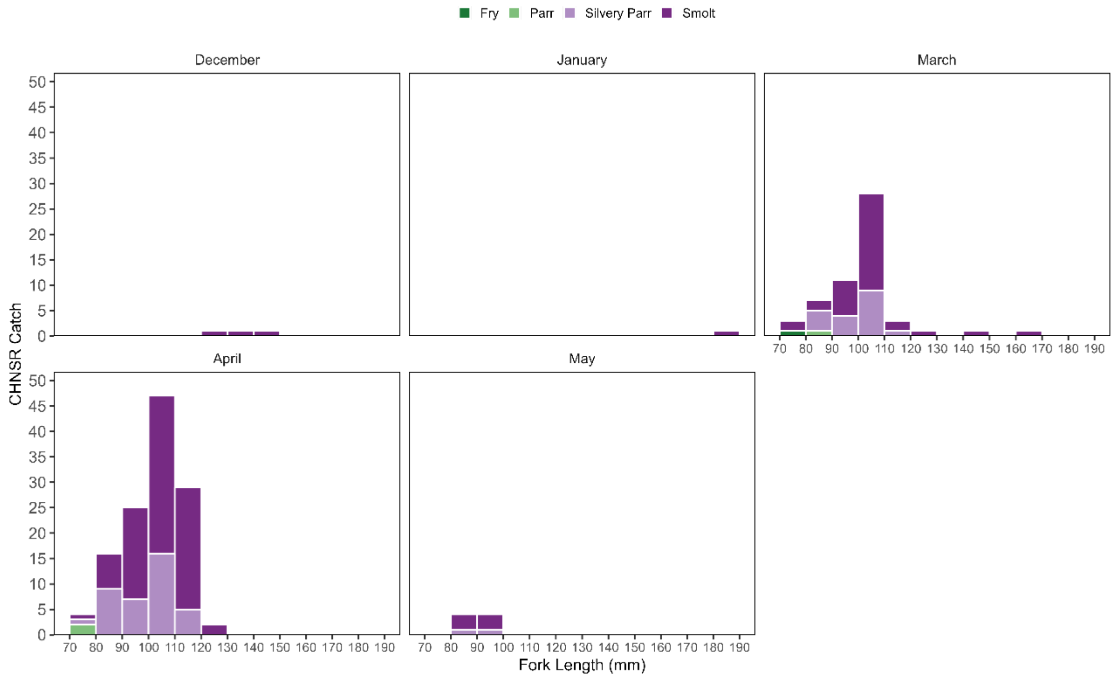

Figure D- 4. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNSR catch in Chipps Island trawl grouped by life stage for water years 2017-2021.

These differences in the proportions of each life stage observed at Sherwood Harbor and Chipps Island trawls are indicative of morphological and physiological transitions that occur as juvenile Chinook Salmon migrate through and rear in the Delta, with a much larger proportion of fish exiting the Delta as smolts compared to entering the Delta. Juvenile Chinook Salmon are observed at Sherwood Harbor as they enter the Delta, and many will continue to rear, grow, and undergo smoltification as they transit the Delta prior to entering the ocean. Chipps Island trawl is considered the monitoring exit point of the Delta. Most Chinook Salmon observed at Chipps Island are smolts that are physiologically ready to reside in the marine environment. The low proportion of fry exiting the Delta is expected as fry are not physically able to survive saline ocean conditions. Additionally, larger sizes of juvenile Chinook Salmon entering the ocean are associated with higher survival during the first few months of ocean residency (Woodson et al. 2013).

Entrainment into the CVP and SWP export facilities is a risk for juvenile CHNWR and CHNSR migrating downstream through the Delta (see Section 5.2.1.1 – Effects of South Delta Export Operations on Juvenile Chinook Salmon; NMFS 2019). Juvenile Chinook Salmon have high mortality rates once they enter the SWP facilities through CCF due to predation by fish and birds (Clark et al. 2009). Pre-screen loss in CCF is assumed to be 75% at the SWP facility, while pre-screen loss at the CVP facility occurs between the trash racks and primary channel and is assumed to be 15% (see Attachment 8 to the 2024 SWP ITP; CDFW 2018). Juvenile Chinook Salmon also experience mortality at the louvers, termed “screening (louver) efficiency,” where fish are screened from entering Banks Pumping Plant at SWP or Jones Pumping Plant at CVP. Fish that are salvaged at the Skinner Fish Protective Facility and the Tracy Fish Collection Facility may also experience loss during the handling, transport, and release process (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon). Fork lengths of salvaged genetically-identified natural-origin CHNWR range from 60 mm to 223 mm (Table D- 3; Figure D- 5). Fork lengths of salvaged genetically-identified natural-origin CHNSR range from 32 mm to 130 mm. Of the genetically-identified natural-origin CHNWR salvaged, approximately 82% fall between fork lengths of 110 mm to 149 mm. Of the genetically-identified natural-origin CHNSR salvaged, approximately 85% fall between fork lengths of 80 mm and 119 mm (Table D- 3; Figure D- 6).

Table D- 3. Juvenile genetically-identified natural-origin CHNWR loss by fork length for water years 2010-2022 and juvenile genetically-identified natural-origin CHNSR loss by fork length for water years 2017-2022. Table cells represented with “-” indicate zero loss within a fork length range.

Fork Length (mm)	CHNWR Loss	CHNSR Loss
30-39	-	18.5
40-49	-	8.58
50-59	-	-
60-69	21.31	-
70-79	10.04	6.28
80-89	5.34	140.88
90-99	35.93	116.69
100-109	214.19	114.46
110-119	841.85	113.13
120-129	1023.2	52.5
130-139	876.35	2.6
140-149	536.18	-
150-159	275.75	-
160-169	78.19	-
170-179	39.59	-
180-189	17.36	-
210-219	2.88	-
220-229	3.52	-

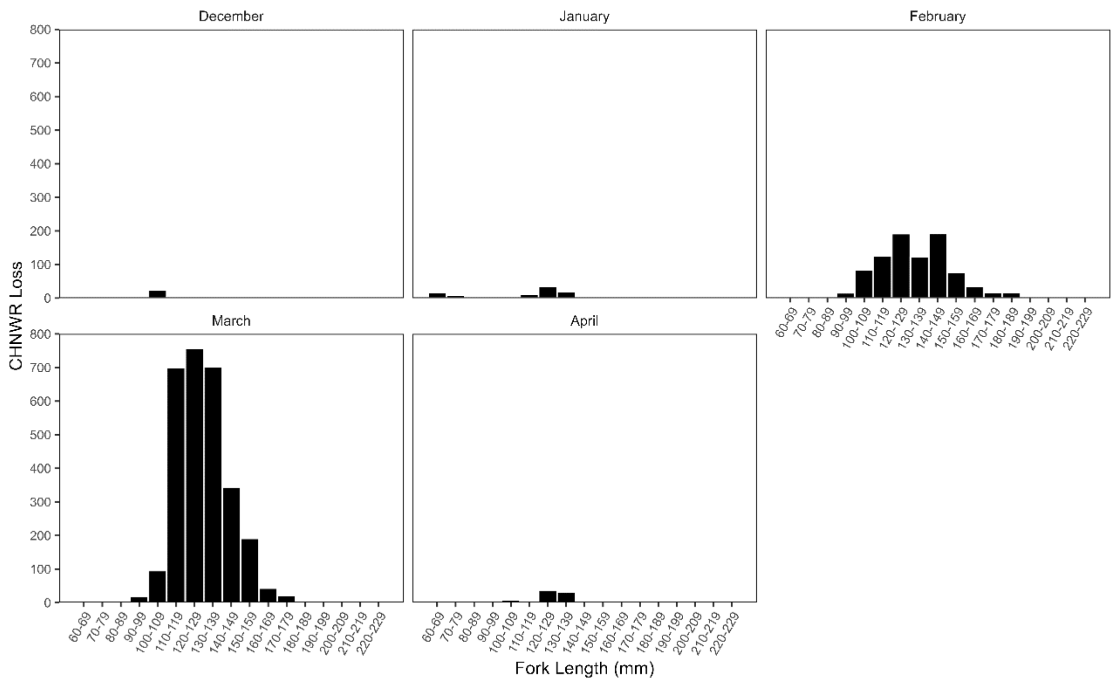

Figure D- 5. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNWR loss for water years 2010-2022.

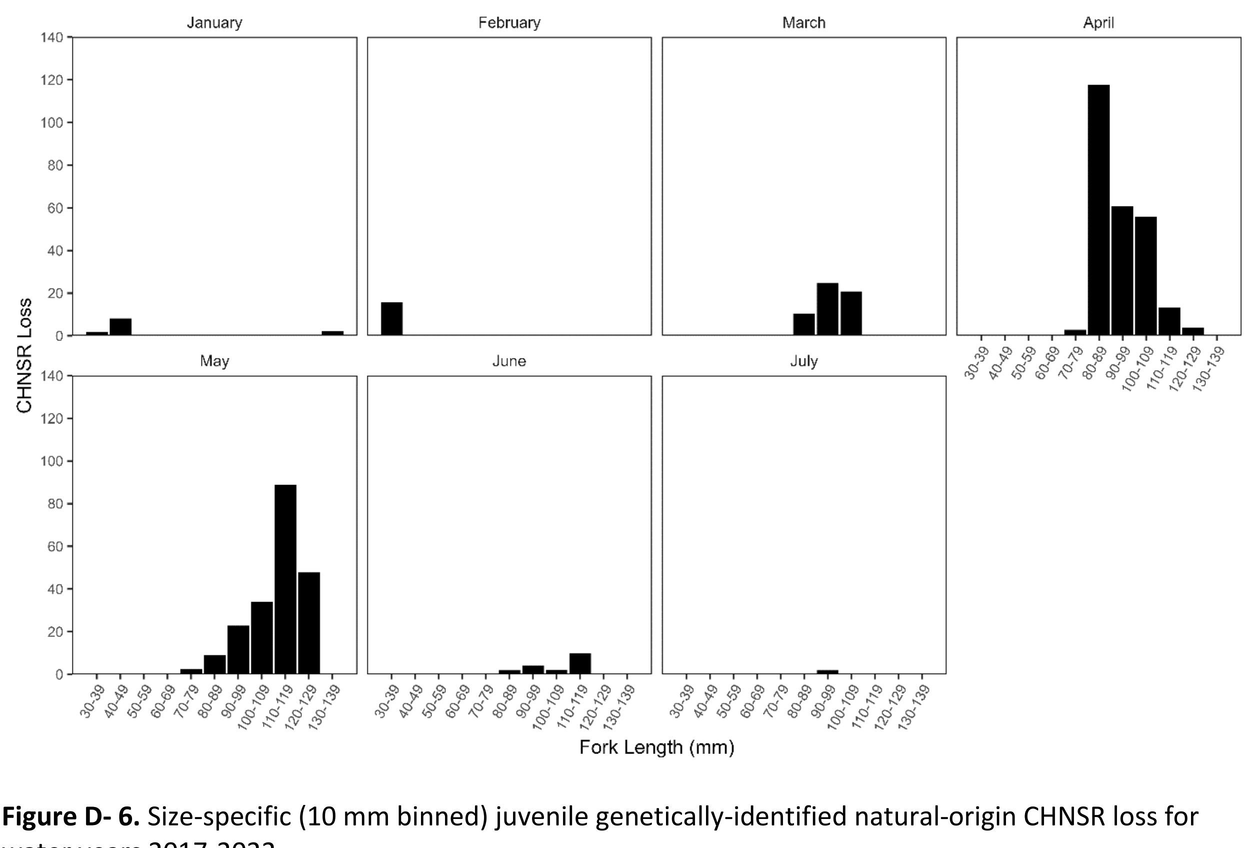

Figure D- 6. Size-specific (10 mm binned) juvenile genetically-identified natural-origin CHNSR loss for water years 2017-2022.

Based on USFWS Delta Juvenile Fish Monitoring Program Chinook life stage determinations, fry- and parr-sized genetically-identified natural-origin CHNWR and CHNSR between 25 and 60 mm, are not frequently seen in salvage (Table D- 3). It is likely that smaller sized CHNWR and CHNSR are entrained into the south Delta; however, these fish may not be well represented in salvage because of morbidity factors, including predation and stress from warm water temperatures (NMFS 2016a, 2016b). Conditions are difficult for entrained salmonids in CCF when temperatures reach 22°C or higher in late-spring and summer. Water temperatures above 22°C are shown to cause decreased juvenile salmonid growth, impair smoltification, increase predation, and generally deter salmonids from the area (Carter 2008).

There are limited genetic data available for smaller CHNWR and CHNSR in Delta monitoring. Smaller sized fish are often not well represented in modeling analyses (e.g., STARS and ECO-PTM) due to limited data supporting modeling assumptions. This lack of information leads to greater modeling uncertainties when applying modeling outputs to smaller sized CHNWR and CHNSR behaviors. The difficulty of tagging small salmonids greatly limits our understanding of through-Delta survival for smaller sized fish, which can exhibit different behaviors than larger fish that migrate more quickly out of the Delta. Through-Delta survival estimates should be used to inform smolt survival and are not representative of rearing survival of CHNWR and CHNSR in the Delta (Simenstad et al. 2017). The STARS model and ECO-PTM rely predominantly on data from acoustic tagging studies of hatchery smolts greater than 140 mm in size, which migrate quickly into and through the Delta (see 5.1.3.1 – Survival, Travel Time, and Routing Simulation Analysis [STARS]; 5.1.3.2. – Ecological Particle Tracking Model [ECO-PTM]). Fry and parr sized fish are not represented sufficiently in either model. Additionally, smaller genetically-identified natural-origin CHNWR and CHNSR are rarely observed in salvage (Table D- 3). Conclusions regarding changes in salvage and loss of CHNWR and CHNSR that may result under the Proposed Project scenarios compared to Baseline Conditions (see Section 5.2.1.3 – Salvage-Density Method) should be approached with caution given the limited dataset available for analyses (see Section 5.2.1.2 – Historical Loss of Juvenile Chinook Salmon).

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