BUREAU OF RECLAMATION

Water Year 2022 Seasonal Report for Old and Middle River Flow Management

Central Valley Project, California

California-Great Basin Region

U.S. Department of the Interior

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Water Year 2022 Seasonal Report for Old and Middle River Flow Management

Central Valley Project, California

California-Great Basin Region

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U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Wildlife

Cover Photo: View from Bill Jones Pumping Plant - Bureau of Reclamation

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Purpose

The Water Year (WY) 2022 Seasonal Report for Old and Middle River (OMR) Flow Management describes Delta operations and actions and recommends adjustments to the OMR Flow Management Guidance Document (OMR Guidance Document) and the Delta Cross Channel Operations and Fall/Winter Closures Guidance Document (DCC Guidance Document) for WY 2023. This Seasonal Report fulfills commitments under the 2020 Record of Decision (ROD) for the Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP). It also fulfills the California Department of Water Resources (DWR's) reporting commitments for the Smelt Monitoring Team (SMT) and Salmon Monitoring Team (SaMT) to summarize major actions taken to implement the Incidental Take Permit (ITP) Conditions of Approval (COAs) for Long-Term Operation of the SWP in the Sacramento-San Joaquin Delta (Permit No. 2081-2019-066-00, ITP Conditions 8.1.1 and 8.1.2).

This Seasonal Report will be used to support the development of Reclamation's 2022 Annual Report on the Long-Term Operation of the Central Valley Project and State Water Project (Annual Report), as well as DWR's 2022 Annual Status Report (ITP Condition 7.2). Finally, this document will inform the Four-Year Review Panels adopted under the ROD and identified in the SWP actions (ITP Condition 3.13.8). Reclamation and the DWR will charter an independent panel to review OMR management, among other actions., in 2024 and 2028. The purpose of the independent reviews will be to evaluate the efficacy of actions undertaken under the LTO to reduce the adverse effects on listed species. Compliance with National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2019 Biological Opinions' Reasonable and Prudent Measures and associated Terms and Conditions adopted by the aforementioned ROD will be documented and discussed in the Annual Report and not in this document.

The SaMT and SMT prepare weekly assessments of fish distribution and the likelihood of entraining fish into the central and south Delta and export facilities. SaMT provides an evaluation of the likelihood of exceeding a salvage threshold that would automatically restrict OMR operations, and Reclamation and DWR can use that information to assist in decision making regarding changes to export operations. The procedures used by both monitoring teams are described in the Old and Middle River Flow Management Guidance Document (Appendix A).

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Background

The Sacramento–San Joaquin River Delta (Delta) is formed by the confluence of the Sacramento and San Joaquin Rivers. Reclamation's C.W. "Bill" Jones Pumping Plant and DWR's Harvey O. Banks Pumping Plant (hereafter referred to as the CVP and SWP export facilities) divert water south through the Delta-Mendota Canal and the California Aqueduct, respectively. The proximity of the CVP and SWP export facilities to the Old and Middle Rivers is shown in Figure 1.

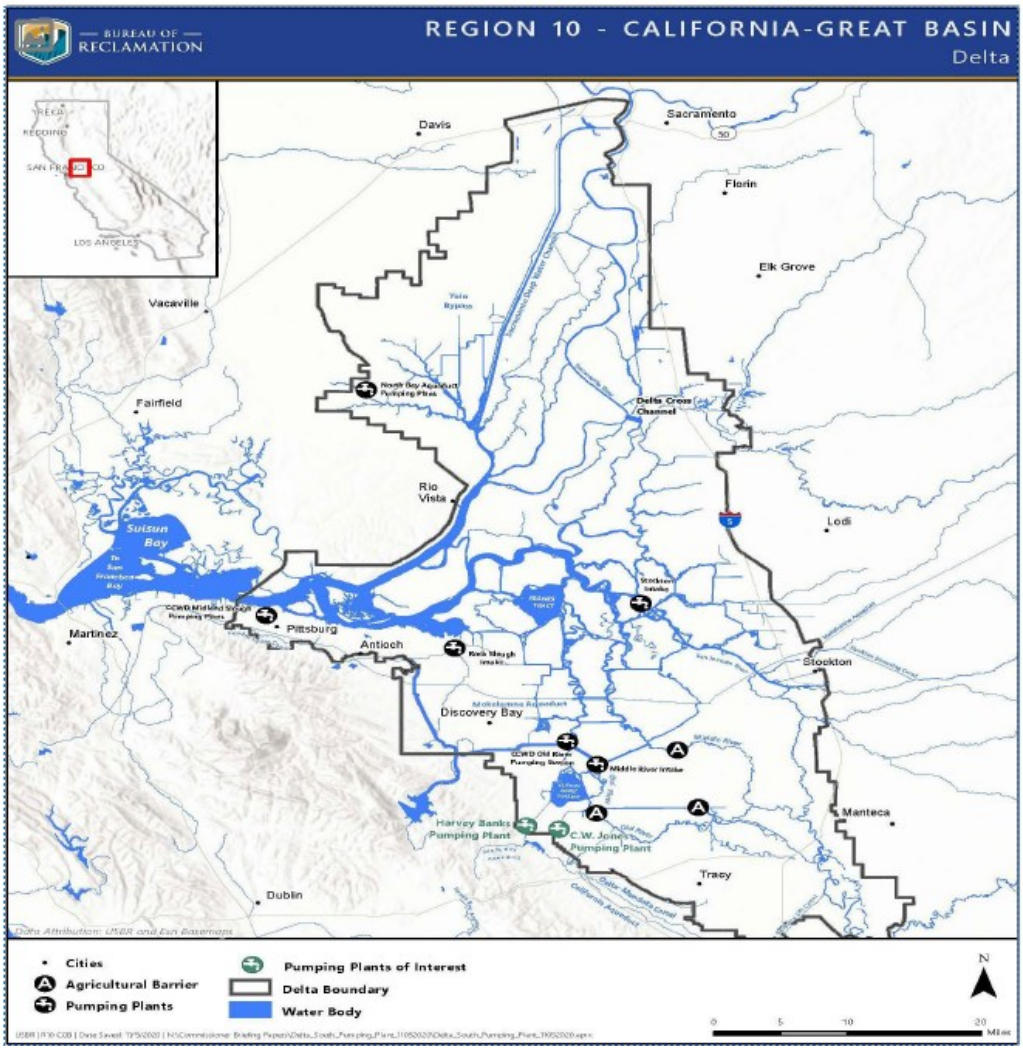

Figure 1. Map of the Delta with CVP and SWP infrastructure. SWP infrastructure also includes Barker Slough Pumping plant labeled here as North Bay Aqueduct Pumping Plant.

Net flow within the OMR corridor to the north of the CVP and SWP export facilities provides a surrogate indicator for how export pumping influences hydrodynamics in the South Delta. The management of OMR flow, in combination with other environmental variables, can minimize or avoid the entrainment of fish into the South Delta and at the fish salvage facilities. Reclamation and DWR manage exports by incorporating real-time monitoring of fish spatial distribution, turbidity, water temperature, and current application of hydrodynamic and entrainment models to support decision making for the management of OMR flows to minimize entrainment of fish when necessary and provide flexibility when possible. The five agencies, through SaMT and SMT, develop risk assessments to determine the need to reduce adverse effects of Delta operations of the CVP and SWP export facilities to salmonids and smelt.

Reclamation consulted under the Endangered Species Act (ESA) with the USFWS and NMFS on potential effects of the Proposed Action on threatened and endangered species and designated critical habitat. The USFWS and NMFS issued their Biological Opinions of the Proposed Action on October 21, 2019. OMR management and DCC gate operations are a part of the Delta Operations described in the Proposed Action. Early Winter Pulse Protection ("First Flush") and net OMR flows no more negative than -5,000 cfs are actions expected to minimize adverse effects to Delta Smelt (Hypomesus transpacificus), Sacramento River winter-run Chinook Salmon (Oncorhynchus tshawytscha), Central Valley (CV) spring-run Chinook Salmon (O. tshawytscha) and California Central Valley (CCV) steelhead (O. mykiss). Other OMR management actions expected to reduce or minimize negative effects to Delta Smelt include protections for adult Delta Smelt based on turbidity (Turbidity Bridge Avoidance) and protections for recruitment of larvae and juveniles based on proportional entrainment loss from the Delta Smelt Life Cycle Model. Another OMR management action expected to reduce adverse effects to winter-run Chinook Salmon and steelhead is the management of OMR to avoid exceeding single-year and cumulative loss thresholds for natural and hatchery winter-run Chinook Salmon, Sacramento River origin steelhead, and San Joaquin River origin steelhead. The NMFS Biological Opinion incidental take statement (ITS) requires monitoring salvage at the Delta fish salvage facilities for the southern Distinct Population Segment (sDPS) of North American green sturgeon (Acipenser medirostris). Fall-run Chinook Salmon are not an ESA-listed species but are relevant because they comprise a large portion of the Southern Resident killer whale diet, which is an ESA-listed species. Young-of-year (YOY) spring-run Chinook Salmon, steelhead, and YOY fall-run Chinook Salmon have considerable overlap in migration timing and residency through the Delta. Therefore, an OMR value of no more negative than -5,000 cfs and other actions that minimize effects to spring-run Chinook Salmon and steelhead should have similar effects to fall-run Chinook Salmon.

Under the California Endangered Species Act (CESA), DWR consulted with the California Department of Fish and Wildlife (CDFW) to obtain a separate Incidental Take Permit (ITP) for Long-Term Operation of the SWP. DWR submitted an application to CDFW in December 2019 and, on March 31, 2020, CDFW issued an ITP (2081-2019-066-00) to DWR that covers four CESA-listed species: Longfin Smelt (Spirinchus thaleichthys), Delta Smelt, CV spring-run Chinook Salmon, and Sacramento River winter-run Chinook Salmon. The project description in the ITP application and Conditions of Approval listed in the ITP included many of the same

measures identified in the federal ESA consultation for the management of OMR to reduce the risk of entrainment of listed fish species, as well as some additional measures.

State Water Resources Control Board's (SWRCB) Decision 1641(D-1641) influences operations of the CVP and SWP export facilities, including OMR management. Obligations under D-1641 include protections for fish and wildlife, Municipal and Industrial (M & I) water quality, agricultural water quality, and Suisun Marsh salinity. Under the ROD, DCC gates are closed when fish triggers are met in October and November, and closed beginning on December 1 unless water quality concern criteria are exceeded in the Delta in December and January, which allow limited gate operations. The ROD includes D-1641 requirements including gate closures from February 1 through mid-May, and gate closures up to 45 days from November 1 through January.

All data used to create figures in this report are provided in Appendix C. As a note, natural winter-run Chinook Salmon reported in these figures are based on length-at-date (LAD) measurements.

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New in WY2022

Transition to Interim Operations Plan (IOP)

After issuing its decision on March 11, 2022, the United States District Court for the Eastern District of California ordered the implementation of an interim operations plan (IOP) for the CVP and SWP for WY 2022 on March 14, 2022. The IOP is specific to WY 2022 and apply through September 30, 2022. Certain provisions of the IOP relate to Old and Middle River management. The IOP states that Reclamation shall adopt the following provisions of the SWP's ITP:

8.1.4 Water Operations Management Team (WOMT) Process

8.17 Export Curtailments for Spring Outflow.

8.5.2 Larval and Juvenile Delta Smelt Protection

8.6.1 Winter-run Chinook Salmon Single-year Loss Threshold

8.6.2 Early-season Natural Winter-run Chinook Salmon Discrete Daily Loss Threshold

8.6.3 Mid- and Late-season Natural Winter-run Chinook Salmon Daily Loss Threshold

8.6.4 Daily Spring-run Chinook Salmon Hatchery Surrogate Loss Threshold

8.7 OMR Flexibility During Delta Excess Conditions

8.8 End of OMR Management

9.1.3.1 Summer-Fall Action Plan

Delta Smelt Experimental Release

In WY 2022, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, California Departments of Water Resources and Fish and Wildlife, U.S. Geological Survey, and University of California, Davis, conducted the first Experimental Release of ≥ 200 days post hatch captively cultured Delta Smelt. Five releases were completed between December 2021 and February 2022. A total of 55,733 fish, either adipose fin clipped or Visible Implant Elastomer (VIE) tagged, were released across three different sites (Table 1). Of these fish, 76 were subsequently recaptured in regular monitoring Figure 2. Map of WY 2022 Experimental Release sites and subsequent recaptures of released Delta Smelt in regular monitoring (Figure 2). For the purposes

of OMR management for both the CVP and SWP, there is no difference between a wild Delta Smelt and a cultured Delta Smelt. Given historically low observations of wild origin Delta Smelt, these releases influenced the expected distributions of adult fish in assessing the likelihood of entrainment during the preparation of the weekly assessments. The observations of all Delta Smelt are summarized in the Delta Smelt Detections section.

Experimental Releases of Delta Smelt

Table 1. WY 2022 Delta Smelt Experimental Release events

Date	Location	Adipose Fin Clipped	VIE Tagged	VIE Color	Total Fish Released
12/14/2021–12/15/2021	Sacramento River at Rio Vista	~89%	~11%	Red	12,800
01/11/2022–01/12/2022	Sacramento River at Rio Vista	~97%	~3%	Red	12,800
02/03/2022–02/03/2022	Sacramento Deepwater Ship Channel	~56%	~44%	Red	6,400
02/09/2022–02/10/2022	Suisun Marsh-Montezuma Slough at Belden's Landing	~99%	~1%	Red	12,800
02/16/2022–02/17/2022	Sacramento Deepwater Ship Channel near channel marker 53	~100%	~0%	Red	10,933

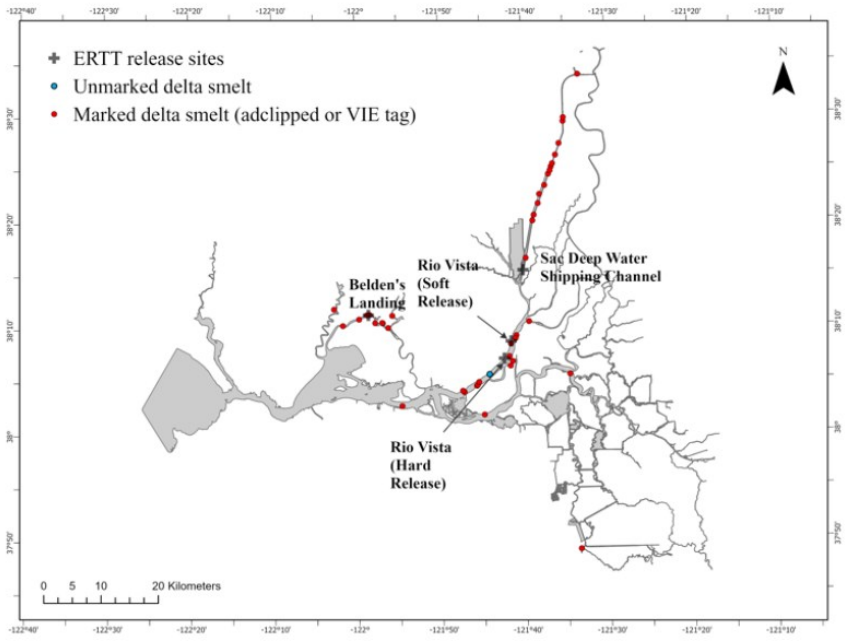


Figure 2. Map of WY 2022 Experimental Release sites and subsequent recaptures of released Delta Smelt in regular monitoring

Seasonal Operations

WY 2022 conditions began with a surge of precipitation in late October, producing the first Central Valley Index above average precipitation for October and November since 2018 (CNRFC 2021). However, dry weather returned in November, deepening ongoing drought conditions. December rebounded with record snow and rainfall in some locations in the Sierra, improving water supply outlooks with colder and low elevation snowstorms. Despite December storms, late January precipitation totals languished, adding to record breaking multi-year dry streaks (CNRFC 2022, January). Spring offered little relief to drought conditions. CNRFC (2022, April) reported "the driest calendar year on record (since 1922) for the first four months of the year," and attention was shifted to declining snowpack and snowmelt runoff efficiency). April storm events supplemented water supply, particularly in the Feather and American river watersheds, but long-term deficits persisted across much of California in the spring. Although WY 2021 is the driest in terms of runoff and WY 2022 yielded the most runoff in the last three years, the runoff in the past three years is approximately only half of average runoff, resulting in a deficit of over thirty-seven million acre-feet for the Central Valley Index (CNRFC 2022, April). Given the persistent runoff deficits, reservoir conditions remain suppressed in basins with lower refill potentials.

Like WY 2021, prior year deficits, poor storage, and continuing drier than normal conditions exacerbated the need for available resources to meet water system needs. The CVP and SWP were again challenged in meeting D-1641 standards, while drought conditions sustained from the prior year's gubernatorial declaration of drought emergency. As early as February, existing hydrology adjustment criteria under D-1641 began relaxation of the Vernalis flow requirements. In March, CVP and SWP submitted a Temporary Urgent Change Petition (TUCP) to the SWRCB to relax specific requirements for Delta conditions; this petition was awarded April 4, 2022. The approved Order (TUCO[1]) relaxed the minimum Delta outflow requirement from April 4, 2022 through June 30, 2022 to 4,000 cfs for a 14-day running average. For the same period, a relaxation of the Western Delta Agricultural salinity water quality requirement from Emmaton to Threemile Slough on the Sacramento River, and a relaxation for the minimum monthly average flow requirement on the San Joaquin River at Vernalis to 710 cfs. These relaxations, in concert with the early season voluntary actions by the Sacramento River Settlement Contractors, afforded the CVP/SWP water system demands to continue operations in

[1] https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/2022/20220404_tuco_swrcb.pdf

the Delta without jeopardizing high priority reservoir storage, which may be needed later in the year, for health and safety purposes or environmental protection.

As of May 2022, critically dry conditions in the Delta watershed persisted, and Reclamation and DWR managers continued to meet with SWRCB staff to consider additional modifications of D-1641 water quality and flow objectives and to coordinate management of water supplies through the course of the declared drought emergency. Although multiple adjustments were made or pursued to accommodate drought conditions, another TUCP was not pursued.

Delta Cross Channel Operations

Figure 3. Delta Cross Channel Gates (Bureau of Reclamation/Todd Plain).

The DCC gates operation schedule is described in the ROD, which includes the D-1641 operations requirement. The DCC gates were operated to the "open on weekend and closed on weekday" cycles in October and November for the D-1641 Delta flow Rio Vista and Delta water quality/salinity requirements and afforded weekend recreational opportunities. In WY 2022, Knights Landing Catch Index (KLCI) or Sacramento Catch Index (SCI) exceedances (>3.0 fish per day) required action responses of DCC gate closures October 29, 2021 through November 5, 2021 and November 13, 2021 through November 19, 2021 (Figure 4). The DCC gates were closed for the season (as defined in Old and Middle River Flow Management), starting on November 30, 2021. A brief, one-hour opening and closing of the DCC gates was required on

April 6, 2022 for annual maintenance to assure facility functionality. The DCC gates were again re-opened, consistent with D-1641, for the Memorial Day weekend, May 27, 2022 through May 31, 2022. Due to the ongoing drought conditions, the DCC gates remained closed through June to protect Delta salinity conditions.

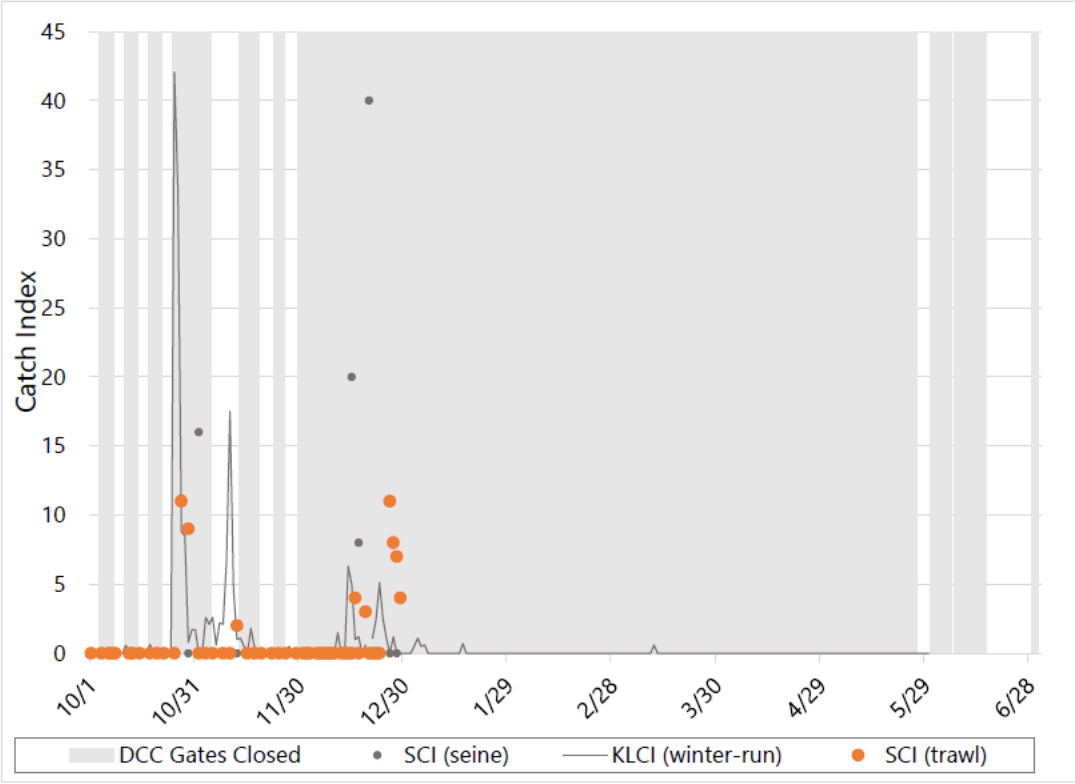


Figure 4. DCC Gate closures, Knights Landing Catch Index (KCLI) and Sacramento Catch Index at beach seines (SCI - seine) and Sacramento Catch Index trawl (SCI – trawl) for natural winter-run Chinook Salmon.

Old and Middle River Flow Management

Old and Middle River Flow Management for the WY 2022 management season spanned January 3, 2022 to June 28, 2022. OMR index values (1-day, 5-day, and 14-day) for WY 2022 are plotted in Figure 5. In WY 2022, the OMR flow management season was initiated at the end of the Integrated Early Winter Pule Protection (see Onset of OMR Flow Management). While OMR flow management limits were in effect during WY 2022, often other D-1641 Delta, IOP, and TUCO requirements were operated to instead (Figure 6, Appendix C). From January 1, 2022 through June 28, 2022, the daily OMR index was more positive than -5,000 cfs 168 out of 181 days (Figure 4; mean: -2,000 cfs; range of -363.46 cfs to -5,214 cfs).

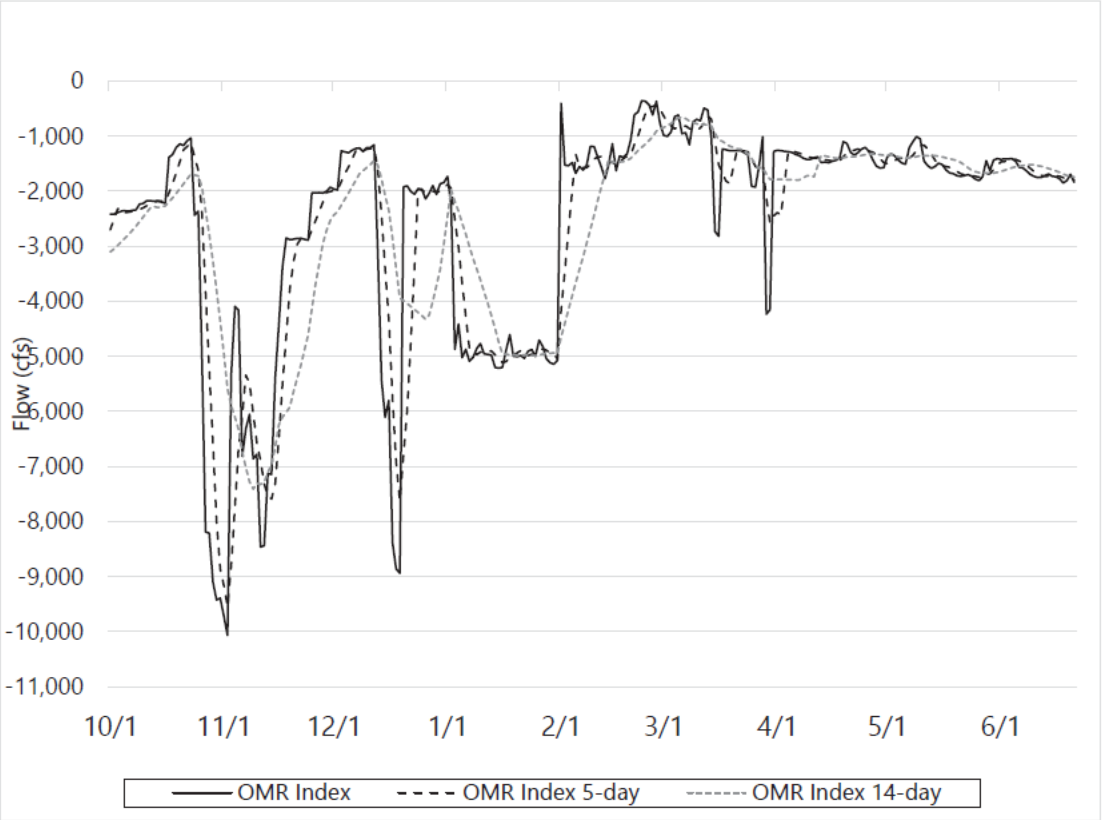


Figure 5. OMR index values measured in cubic feet per second [cfs] (1-day, 5-day, and 14-day) in WY 2022.

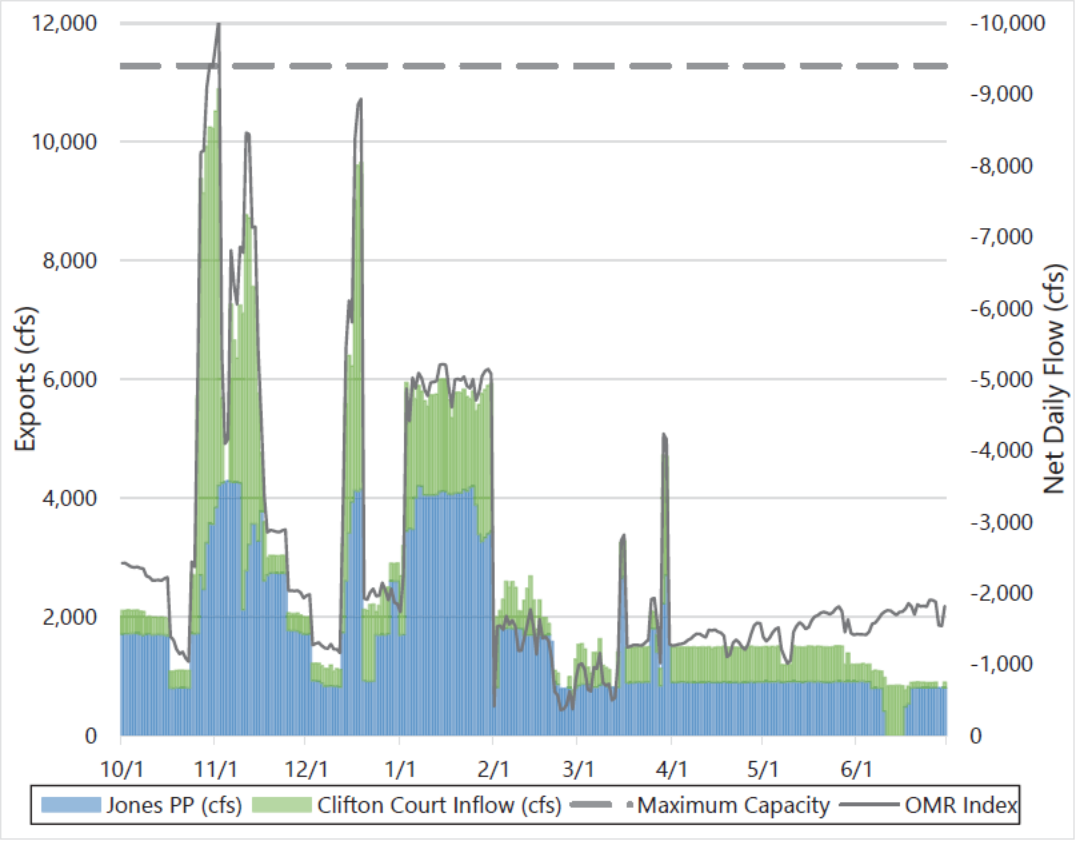


Figure 6. Exports from Clifton Court Forebay Index (for the SWP) and Jones PP (for the CVP) plotted over 1-day OMR index values for WY 2022. Maximum capacity is the combination of the maximum permitted capacity for both facilities per United States Army Corps Engineers (CVP: 4,600 cfs; SWP: 6,680 cfs).

Seasonal operations to manage OMR may occur in conjunction with additional controlling factors that change throughout the season. Controlling factors can also overlap in time and may only occur for short periods. Seasonal changes in controlling factors are summarized in Figure 6. The factors controlling export operations at the start of WY 2022 were generally to meet D-1641 outflow and water quality requirements, including fall Rio Vista outflow standards. With the exception of a few storm events, poor hydrology and storage conditions limited much of the flexibility of export operations, and OMR controlled operations in late December through the end of January (Figure 7). Spring and summer export operations were again controlled by outflow and water quality as a result of poor hydrology in a Critically Dry water year. Exports were limited to minimum combined pumping of 1,500 cfs, for health and safety, continuously early April through the end of June under the TUCO. Delta hydrologic conditions also change throughout the season, which can be characterized as either Balanced or Excess conditions, and this impacted management of export operations. As a result of precipitation events, Excess conditions occurred from late October to early November, briefly in mid-November and mid-December through the end of January (Figure 8).

Figure 7. Daily Delta controlling factors for WY 2022. A detailed breakdown of the controlling factors for WY 2022 are provided in Appendix C.

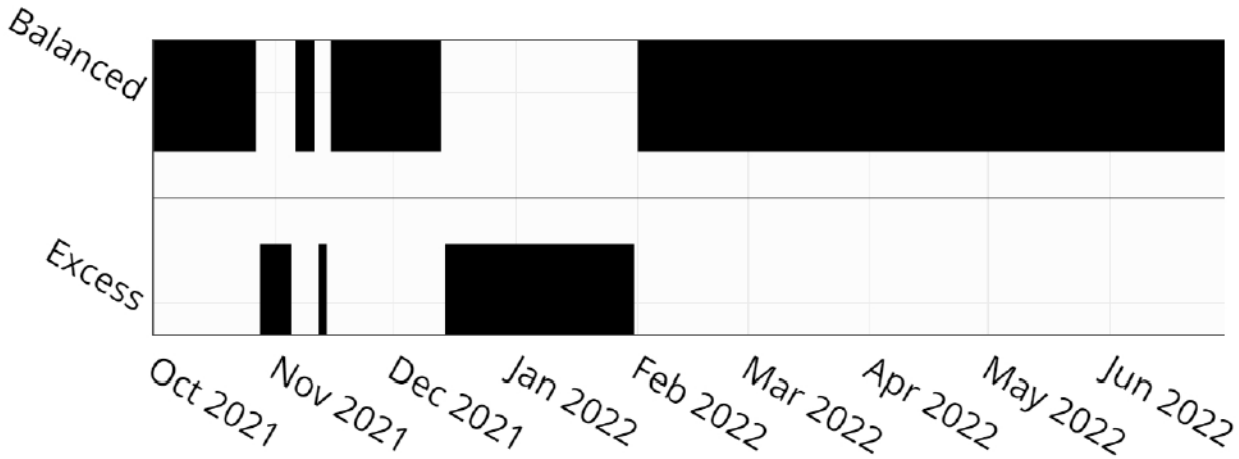


Figure 8. Balanced versus Excess conditions in the Delta for WY 2022

Onset of OMR Flow Management

Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event)

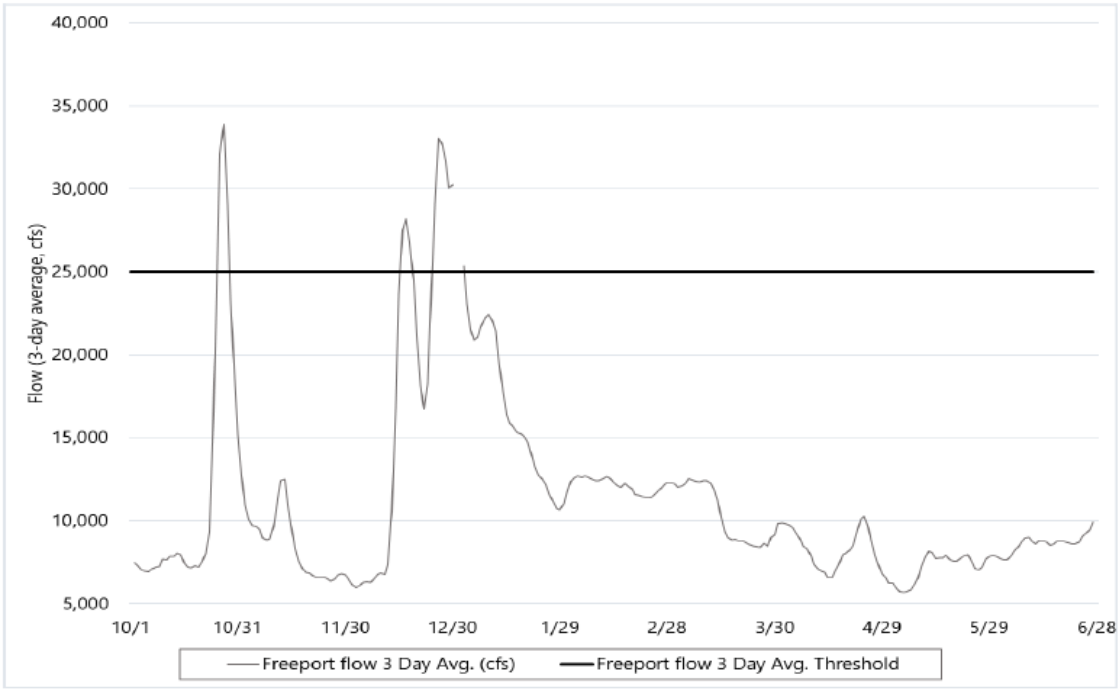
The onset of OMR flow management can be triggered by Integrated Early Winter Pulse Protection (IEWPP) under 'First Flush' conditions, which includes a 3-day daily average flow at Freeport greater than 25,000 cfs and a 3-day daily average turbidity at Freeport equal to or greater than 50 Nephelometric Turbidity Unit (NTU) between December 1 and January 31. The SWP has an additional trigger for OMR management to begin if the SMT determines that real

time monitoring of biotic and abiotic factors indicates a high risk of Delta Smelt migration and dispersal into areas at high risk of future entrainment (ITP COA 8.3.1).

On December 18, 2021, flow and turbidity thresholds were exceeded for IEWPP. These conditions are described as the "first flush" which is a pulse of turbid freshwater following a precipitation event that cues Delta Smelt to begin a rapid, population-scale migration to turbid freshwaters. Between WY 2009 and WY 2022 IEWPP thresholds would have been met in WYs 2012, 2014, 2017, 2019 and 2022. During the WY 2022 IEWPP, Reclamation and DWR managed exports to minimize entrainment of adult Delta Smelt into the central and south Delta. To minimize project influence on Delta Smelt migration, the IEWPP was implemented within three days of the trigger, and the action lasted from December 20, 2021 to January 2, 2022. During this period, Reclamation and DWR reduced exports for 14 consecutive days so that the 14-day averaged OMR index for the period was not more negative than -2,000 cfs. During the IEWPP, turbidity in the OMR corridor did not increase greater than 12 Formazin Nephelometric Unit (FNU) despite flows at Freeport above 25,000 cfs after December 24, 2021(Figure 8).

During WY 2022, a record setting precipitation event occurred in late October resulting in "first flush" like conditions. This event occurred prior to the time period for IEWPP which began on December 1, 2021, and prior to the typical migratory period for Delta Smelt.

A.



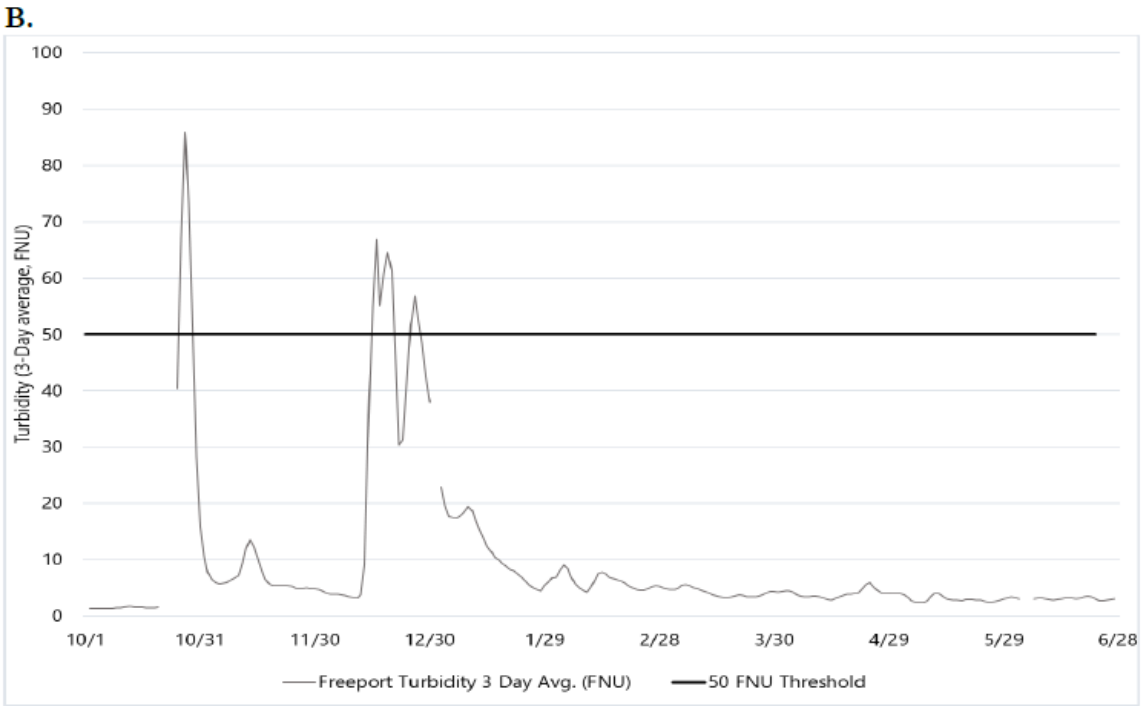


Figure 9. 'First Flush' conditions in WY 2022; A. 3-day running average flow (cfs) at Freeport. B. 3-day running average turbidity (FNU) at Freeport.

Salmonid Presence: Distribution Estimates

Distribution estimates of salmonids are developed weekly by SaMT members. The first distribution estimates for WY 2022 were made on October 5, 2021, for natural young-of-year spring-run and winter-run Chinook Salmon and natural steelhead. The PA states that OMR management season would start if after January 1, more than 5 percent of any one or more salmonid species are estimated to be present in the Delta. Over 5% of winter-run Chinook Salmon were estimated to be in the Delta as of 11/2/2021. As such, in WY 2022, on-ramping of OMR management season for salmonids began after 1/1/2022. The first distribution estimates for hatchery winter-run Chinook Salmon were made on February 15, 2022, soon after the first releases of hatchery winter-run Chinook Salmon.

Multiple sources are considered to produce distribution estimates including catch at targeted locations (e.g., Feather River rotary screw traps [RST] GCID RST, Tisdale Weir RST, Knights Landing RST, Sacramento regional Beach Seines, lower American River RST, lower Sacramento RST, Caswell RST, Sacramento trawls, Chipps Island trawls, and Mossdale Kodiak trawl), historic and current water year salvage numbers, movements of acoustic tagged fish from the current water year, and historic migration patterns at targeted locations (see Proposed Action U.S. Bureau of Reclamation 2019a). In WY 2022, SaMT weekly distribution estimates relied heavily on historical migration patterns because of limited detection of listed salmonids from the aforementioned sampling locations, and other surveys more typically used to inform distribution estimates for the listed salmonids (Appendix C, see Supporting Information section). Some

monitoring surveys were disrupted during periods in WY 2022, due to weather, flow conditions, or boat issues (Figure 10).

Figure 10. WY 2022 sampling disruptions by monitoring team for surveys and fish salvage facilities. Partial disruptions represent interruptions such as, but not limited to, only a single boat being off the water or partial surveys. Some surveys were added during the season and their full seasonal activity may not have been captured in the figure. These data reflect the information captured in each weekly outlook during the season. See Appendix F for weekly tables of sampling interruptions and cancellations.

Distribution estimates made by SaMT in WY 2022 for natural Chinook Salmon, natural Steelheads, natural young-of-year spring-run Chinook Salmon, and hatchery winter-run Chinook Salmon are depicted in Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, Figure 16. See Table 2 for data sources used by SaMT to determine the distribution estimates.

Table 2. Calculations and data sources used to estimate population distributions for winter-run Chinook Salmon based on monitoring for comparison with the weekly SaMT distribution estimates.

Distribution	**Natural-Origin Winter-Run Chinook Salmon**	**Hatchery-Origin Winter-Run Chinook Salmon (Acoustic Tag Data)**
Yet to Enter the Delta	100% minus cumulative % Knights Landing RST catch	100% minus cumulative % AT detection at Butte City Bridge array

Distribution	Natural-Origin Winter-Run Chinook Salmon	Hatchery-Origin Winter-Run Chinook Salmon (Acoustic Tag Data)
In Delta	Cumulative % combined Sacramento Trawl & beach seines catch minus cumulative % Chipps Island Trawl catch	Cumulative % AT detection at Tower Bridge array (after 50%, 100% minus cumulative %)
Exited the Delta	Cumulative % Chipps Island Trawl catch	Cumulative % AT detection at Benicia Bridge (east) array

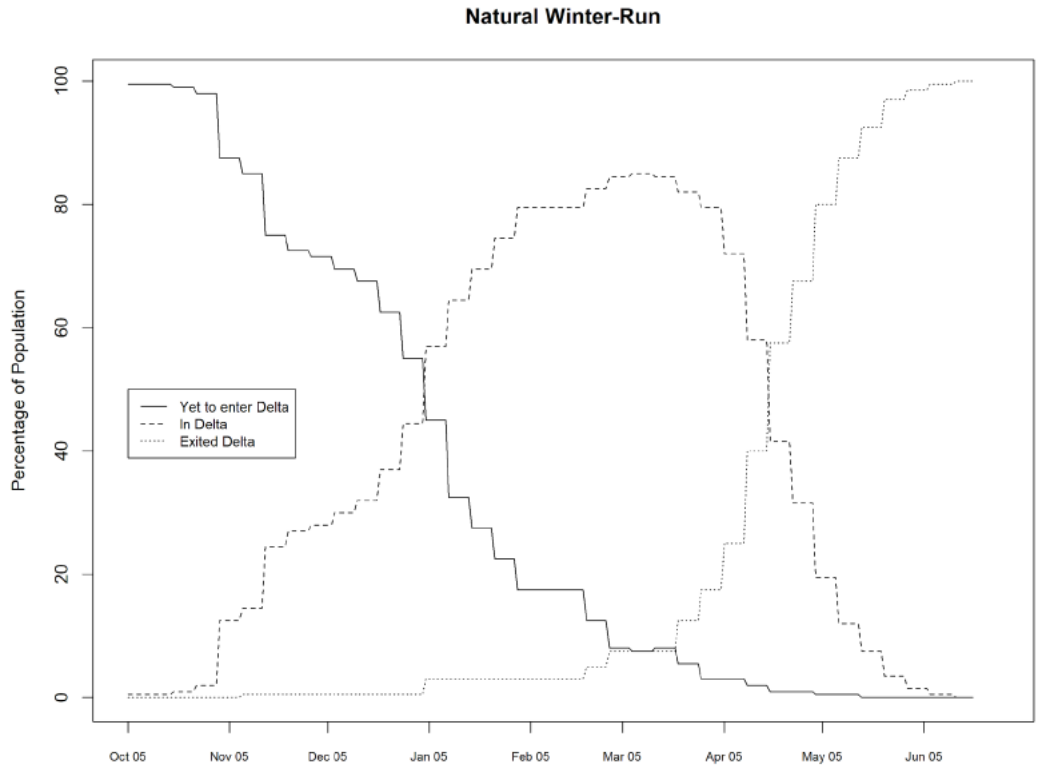


Figure 11. SaMT distribution estimates for natural winter-run Chinook Salmon in WY 2022.

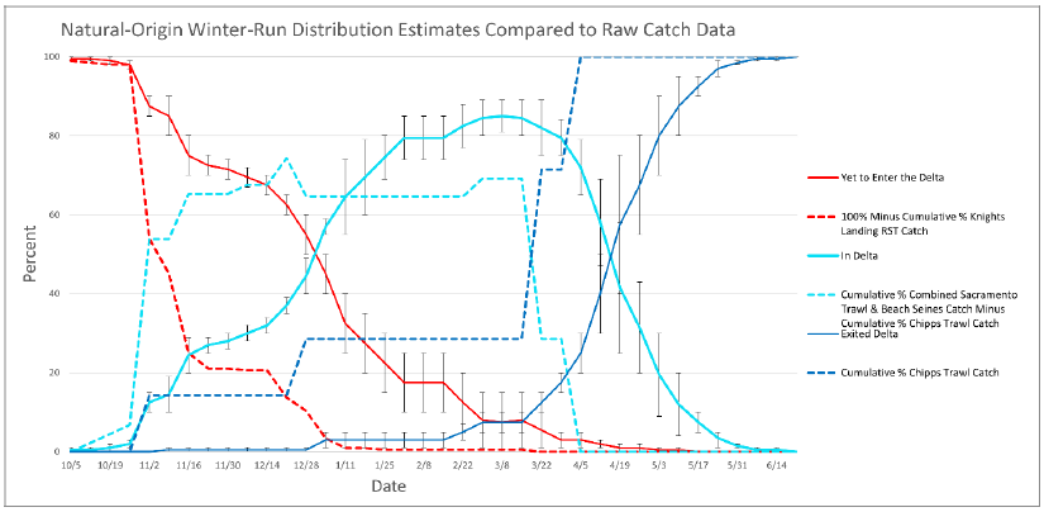


Figure 12. WY 2022 natural-origin winter-run Chinook Salmon weekly SaMT distribution estimates compared to length-at-date winter-run Chinook Salmon observations in monitoring. Solid lines indicate SaMT distribution estimates for "Yet to Enter the Delta," "In Delta," and "Exiting the Delta." Dashed lines indicate cumulative catch data in Delta monitoring as indicated by the legend and Table 2.

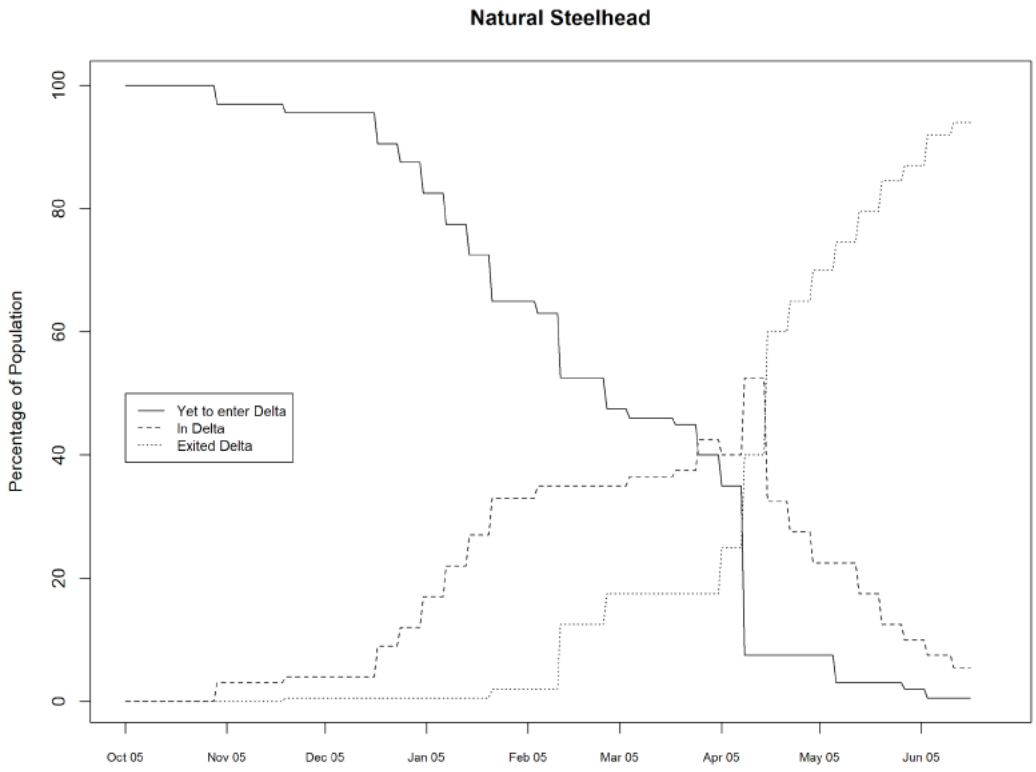


Figure 13. SaMT distribution estimates for natural steelhead in WY 2022.

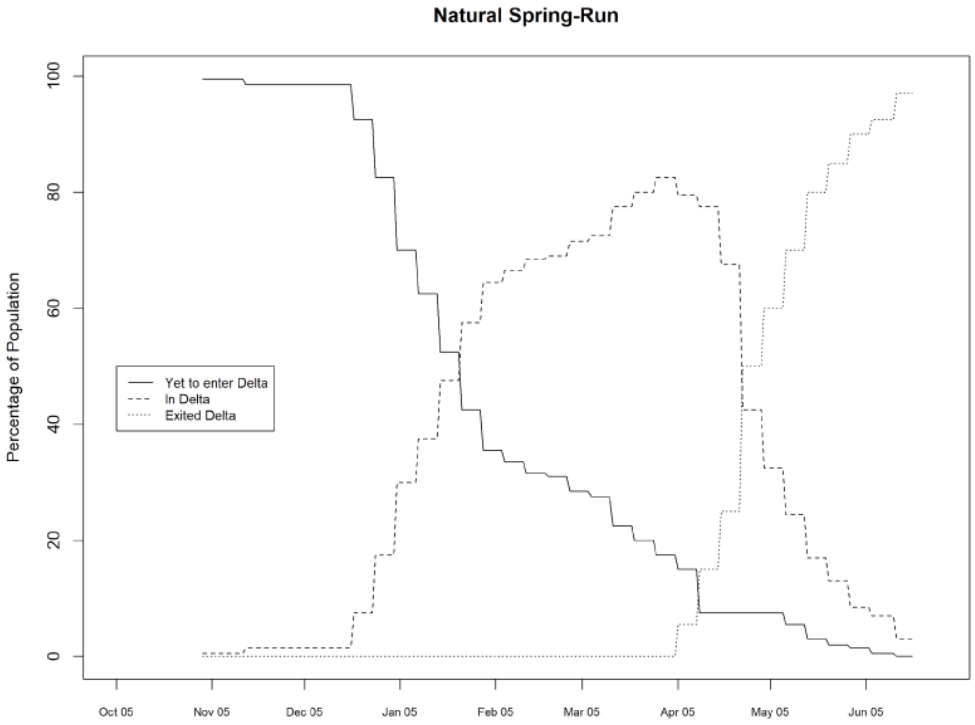


Figure 14.SaMT distribution estimates for natural spring-run Chinook Salmon in WY 2022.

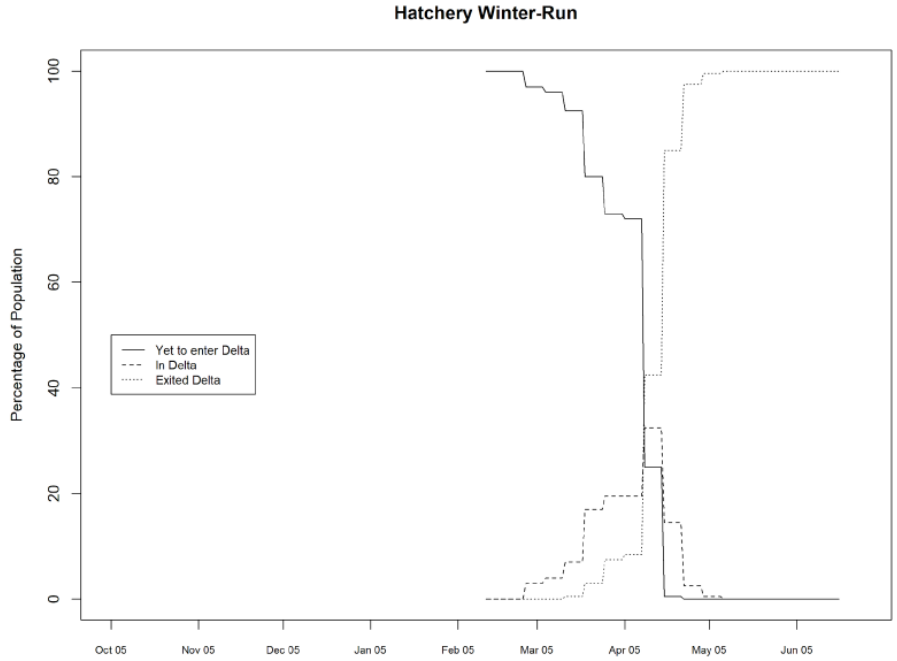


Figure 15.SaMT distribution estimates for hatchery winter-run Chinook Salmon in WY 2022. SaMT began providing estimates beginning 2/15/2022.

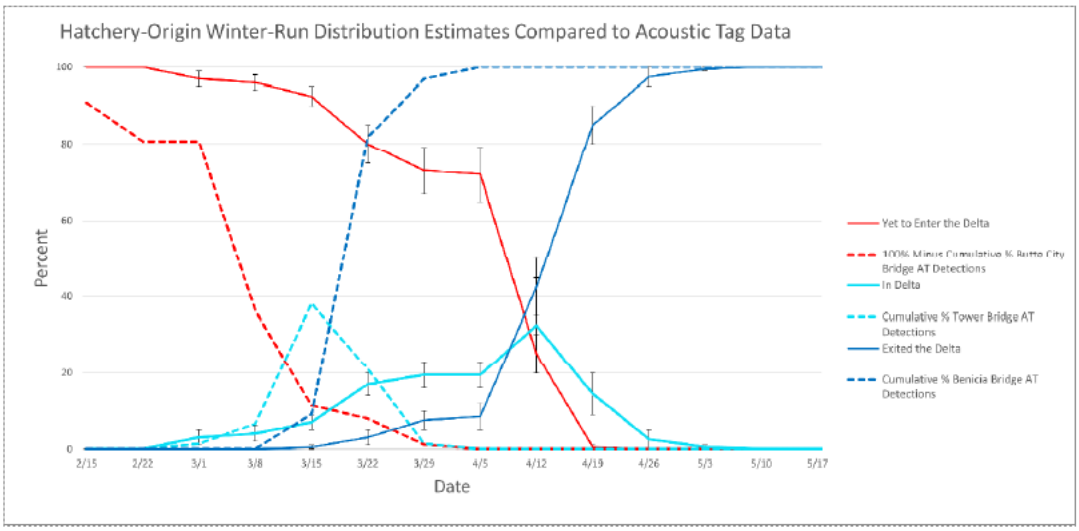


Figure 16. WY 2022 hatchery-origin winter-run Chinook Salmon weekly SaMT distribution estimates compared to acoustic tagged winter-run Chinook Salmon observations in monitoring. Solid lines indicate SaMT distribution estimates for "Yet to Enter the Delta," "In Delta," and "Exiting the Delta." Dashed lines indicate cumulative catch data in Delta monitoring as indicated by the legend and Table 2.

Adult Longfin Smelt Entrainment Protection

The ITP for the SWP includes a third action triggering the onset of OMR management if an Integrated Early Winter Pulse Protection action (COA 8.3.1) has not yet been initiated. After December 1, if cumulative combined Longfin Smelt expanded salvage exceeds a threshold or real-time monitoring of abiotic and biotic factors indicates Longfin Smelt movement into areas at high risk for future entrainment, DWR reduces south Delta exports to maintain a 14-day average OMR index no more negative than -5,000 cfs (ITP COA 8.3.3). The salvage threshold is calculated based on the most recent Fall Mid Water Trawl (FMWT) index for Longfin Smelt. For WY 2022, the threshold was 32, based on a 2021 FMWT index of 323. No adult Longfin Smelt were salvaged during WY 2022 operations, so the salvage threshold was not exceeded.

The SMT evaluated real-time monitoring data for biotic and abiotic factors to assess risk of Longfin Smelt migratory movement into areas of high entrainment risk. Adult Longfin Smelt catch of ≥60 mm (fork length) from the Chipps Island Survey (Figure 17) and hydrologic data were used as an early warning for migration into the south and central Delta. For the Chipps Island Survey, Longfin Smelt detections in WY 2022 began in the fall, with regular detections from November through June (Figure 17). Abiotic factors used in the evaluation of risk for this COA include OMR flows (Figure 5), OBI turbidity (Figure 18), QWEST (Figure 19), and Clifton Court Forebay (CCF) water temperature (Figure 28). The SMT did not make any recommendations to Water Operations Management Team (WOMT) during this period regarding the need for adult Longfin Smelt protections.

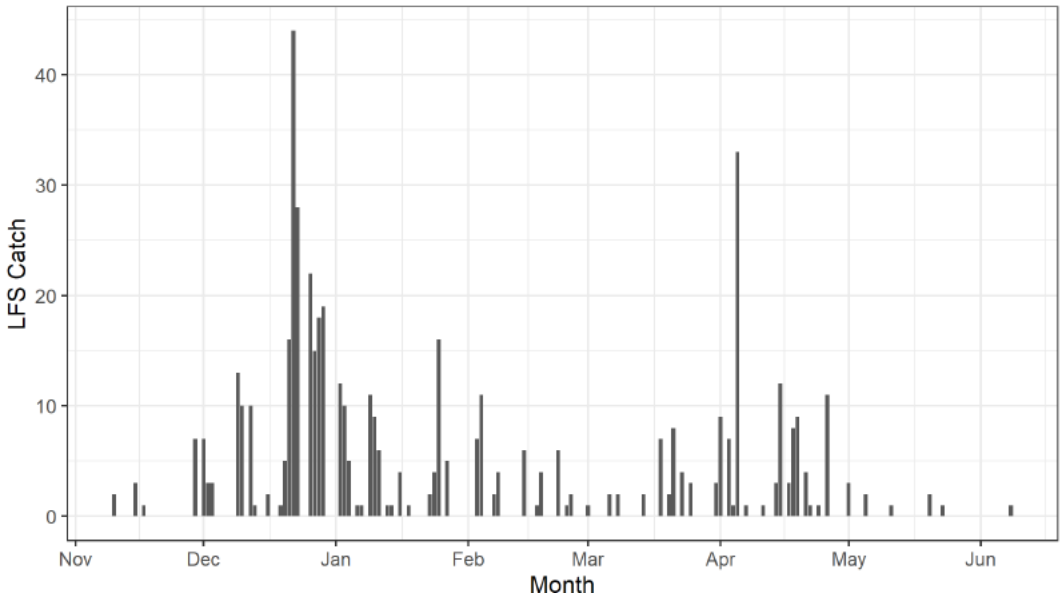


Figure 17. Adult Longfin Smelt (≥60mm) catch from the Chipps Island Trawl from October 2021 through June 2022. June 8 was the last day an adult Longfin Smelt (>60mm) was detected.

Additional Real-time OMR Restrictions and Performance Objectives

Delta Smelt

Adult Delta Smelt Protections The purpose of Turbidity Bridge Avoidance ("South Delta Turbidity") is to minimize the risk of adult Delta Smelt entrainment in the Old and Middle rivers into the south Delta export facilities. During this period, Reclamation and DWR operate to maintain a daily average turbidity at OBI at a level of less than 12 NTU (currently using FNU units due to instrumentation capabilities). The SMT clarified that the daily average turbidity at OBI would be calculated beginning on February 1st of each year, functionally making the first daily average turbidity at OBI available on February 2nd at 12:00 am. For the CVP, this action continues until April 1, or until a ripe or spent female is detected, whichever is first (see Proposed Action U.S. Bureau of Reclamation 2019c). For the SWP, this action continues until April 1 (ITP COA 8.5.1). Turbidity Bridge Avoidance ("South Delta Turbidity") began on January 3, 2022, at the end of the IEWPP. This action continued until April 1, 2022. A ripe female Delta Smelt was collected by Spring Kodiak Trawl (SKT) on March 17, 2022, which off-ramped turbidity bridge avoidance for the CVP. ITP COA 8.5.1 does not contain an offramp for the detection of a ripe female Delta Smelt, so the turbidity bridge avoidance action for the SWP did not offramp until April 1, 2022. In addition, Delta Smelt OMR Management requirements were not controlling at that time. Turbidity conditions are always considered by the SMT in developing the assessments of fish distribution and risk of entrainment.

Forecasted wind conditions in the Delta are considered at each meeting of the SMT because of its potential to temporarily increase turbidity within waterways of the Delta. Typically, these

wind driven increases in turbidity are isolated to only a few of the water quality stations, but large widespread increases in turbidity can occur and may potentially influence the distribution of Delta Smelt. There were no times in which the daily average turbidity at OBI exceeded 12 FNU in WY 2022. Increases in turbidity in the Delta were observed over the course of the season by the SMT and turbidity values are always considered when assessing the likelihood of entrainment. Under the drought conditions of WY 2022, notable increases in turbidity at OBI were driven by wind events rather than large precipitation events or runoff during the Turbidity Bridge avoidance period (Figure 18).

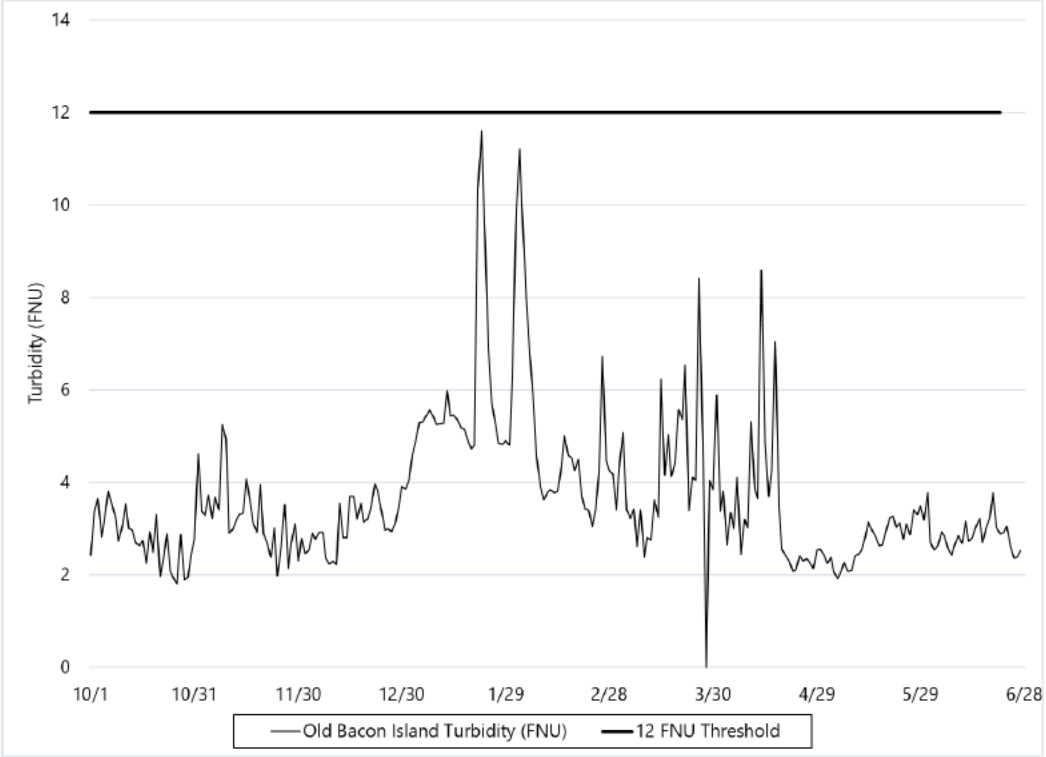


Figure 18. Daily average turbidity (FNU) at Old River at Bacon Island (OBI) in WY 2022.

Larval and Juvenile Delta Smelt Protections Under the ITP COA 8.5.2, if the five-day cumulative salvage of juvenile Delta Smelt at the CVP and SWP facilities is greater than or equal to one plus the average prior three years FMWT index (rounded down), DWR and Reclamation (under the IOP) shall restrict south Delta exports for seven consecutive days to maintain a seven-day average OMR index no more negative than -5,000 cfs. During WY 2022, no larval or juvenile Delta Smelt were detected at either the SWP or CVP in regular salvage or qualitative larval sampling.

The final particle tracking models for WY 2022 were run on March 22, 2022 because operations became constrained by D-1641 (TUCO) which meant only a single scenario (health and safety minimum exports) could be run in the model, and the results would remain the same until

operations were no longer restricted or OMR management would end. See additional information on particle tracking models for Longfin Smelt.

Additionally, from March 1 through June 30 of dry and critical water years, DWR operates the Barker Slough Pumping Plant to protect larval Delta Smelt (ITP COA 8.12; Figure 19). For WY 2022, two larval Delta Smelt were detected by 20mm Survey 1 at station 716 on March 21, 2022, triggering Barker Slough Pumping Plant restrictions under COA 8.12 and limiting exports to <60 cfs. 20mm Survey 2, and later 20mm surveys, did not detect any larval Delta Smelt at 716, and BSPP restrictions ended on April 12, 2022. COA 8.12 off-ramped on June 30, 2022.

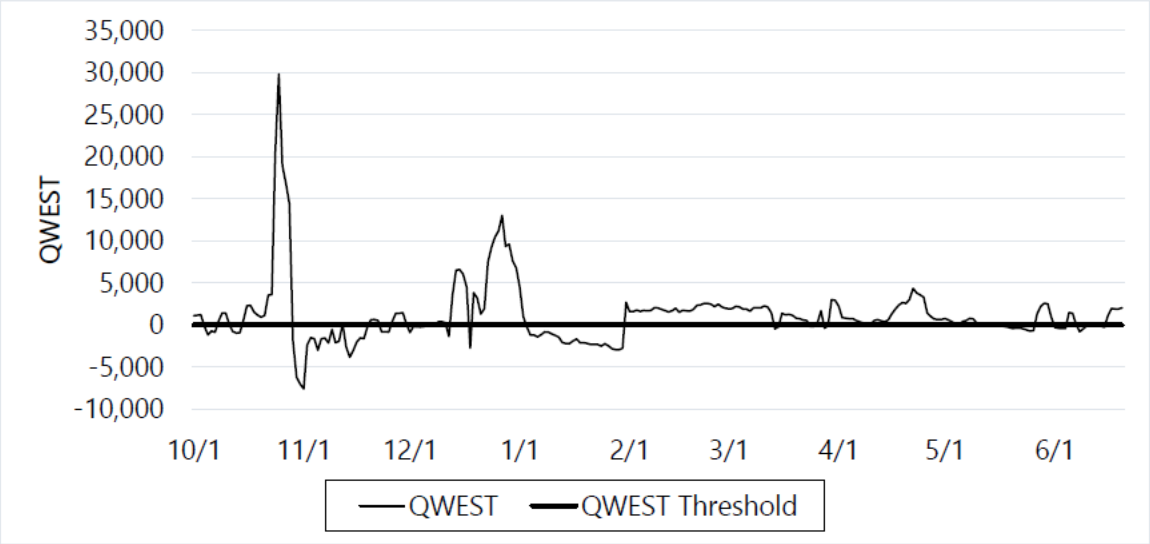
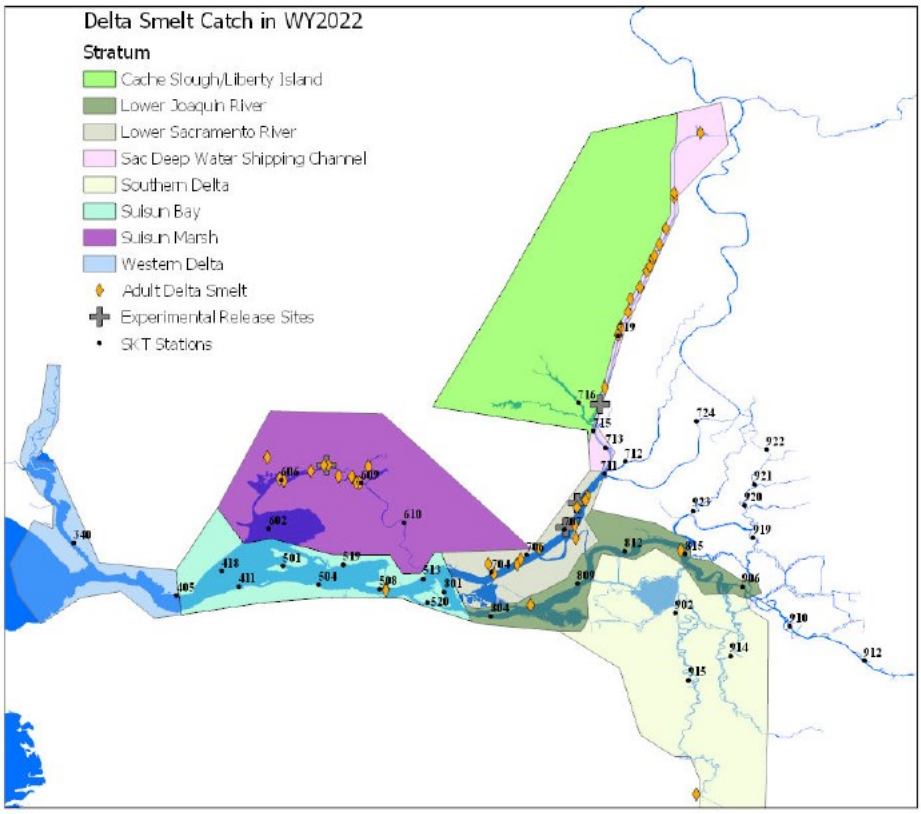


Figure 19. QWEST (cfs) in WY 2022.

Delta Smelt Detections All Delta Smelt catch data were reported to the SMT (catch and salvage locations shown in Figure 17) and considered each week. In WY 2022, 79 adult and sub-adult Delta Smelt and 28 larval and juvenile Delta Smelt were reported to the SMT. As would be expected the majority of Adult Delta Smelt catch came in areas close to where the experimental releases occurred. Notably a marked adult Delta Smelt was observed at the TFCF on January 16, 2022, after the first release event near Rio Vista and later an adult was observed at station 815 in the Lower San Joaquin River. EDSM detected a marked adult on December 23, 2021, near the mouth of the Mokelumne River, and another marked adult on February 4, 2022, near the Antioch Bridge. Larval and juvenile Delta Smelt observations occurred most frequently in the Sacramento Deep Water Ship Channel but also occurred near the confluence, and at stations 815 on the Lower San Joaquin and 902 in the South Delta.

A.


Delta Smelt Catch in WY2022
Stratum
Cache Slough/Liberty Island
Lower Joaquin River
Lower Sacramento River
Sac Deep Water Shipping Channel
Southern Delta
Suisun Bay
Suisun Marsh
Western Delta
Adult Delta Smelt
Experimental Release Sites
SKT Stations

B.

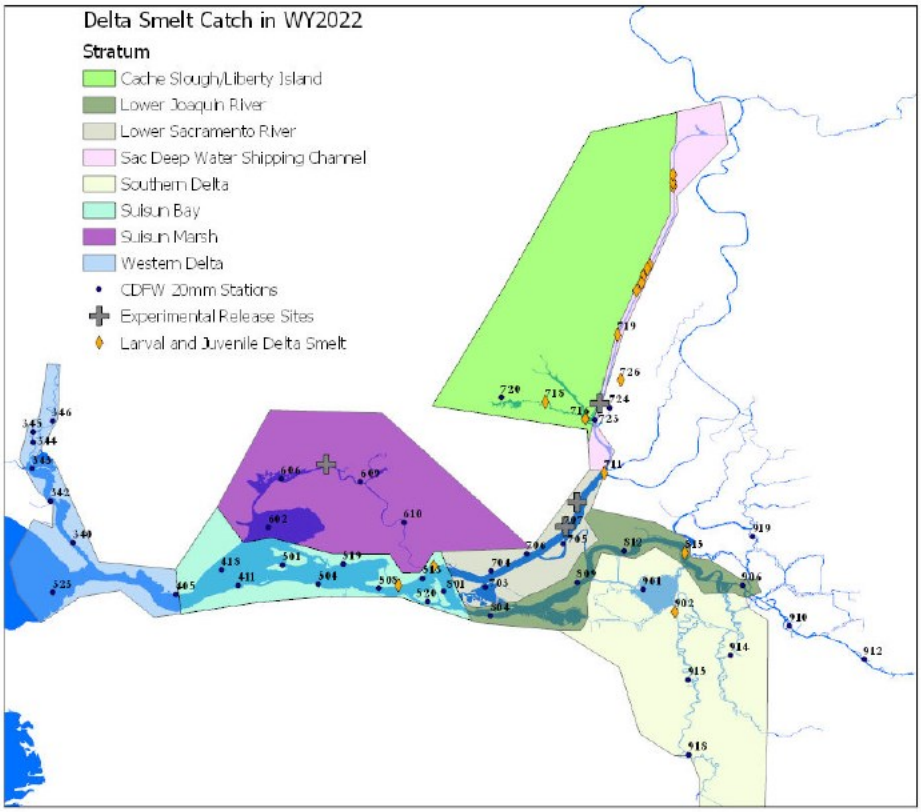


Figure 20. Delta Smelt seasonal catch locations in WY 2022 (all reported between November 1, 2021–June 30, 2022). EDSM Stratum shown as colored polygons. A) Adult Delta Smelt catch by EDSM and SKT B) Larval and juvenile Delta Smelt catch from SLS, 20mm and EDSM. Some larval and juvenile identifications were under QA/QC, and the final data should be sought from the specific survey. EDSM Stratum shown as colored polygons. Life stages targeted by surveys are included in the figure legend.

Longfin Smelt

Adult Longfin Smelt Protections SWP includes protections for adult Longfin Smelt from the onset of OMR management through February 28 (ITP COA 8.4.1). However, during WY 2022, the SMT did not make recommendations for OMR management based on COA 8.4.1. The opportunity for 8.4.1 to be activated off-ramped on December 20, 2021, prior to the onset of OMR management, with the detection of Longfin Smelt larvae in the December Smelt Larva Survey #12 (ITP COA 7.6.1).

Larval and Juvenile Longfin Smelt Protections Between January 1 and June 30, or until the temperature offramp occurs, when real-time monitoring surveys (SLS or 20mm) reach thresholds for detection of Longfin Smelt larvae and juveniles, DWR implements ITP COA 8.4.2. During WY 2022, COA 8.4.2 distribution and/or density triggers were exceeded in SLS surveys #1, #2, #4, #5, & #6 and 20mm Survey #1, #2, & #3 (Figure 18A). Following SLS #5, the SMT made a

recommendation to WOMT for an OMR index no more negative than –1,250 CFS under the guidance of 8.4.2. This recommendation was made during the March 11, 2022, SMT meeting, and was restated during the March 15, March 29, April 5, April 12, April 19, April 26, and May 3 SMT meetings. SMT recommendation was temporarily lifted from March 22 to March 29 but was otherwise continuous during the period of March 11 to May 10, 2022. During the period of this advice, Longfin Smelt OMR management did not control south Delta operations, as concurrent Delta water quality standards, TUCO operations, and dry hydrology were generally keeping project operations at health and safety minimum exports (ITP COA 8.3).

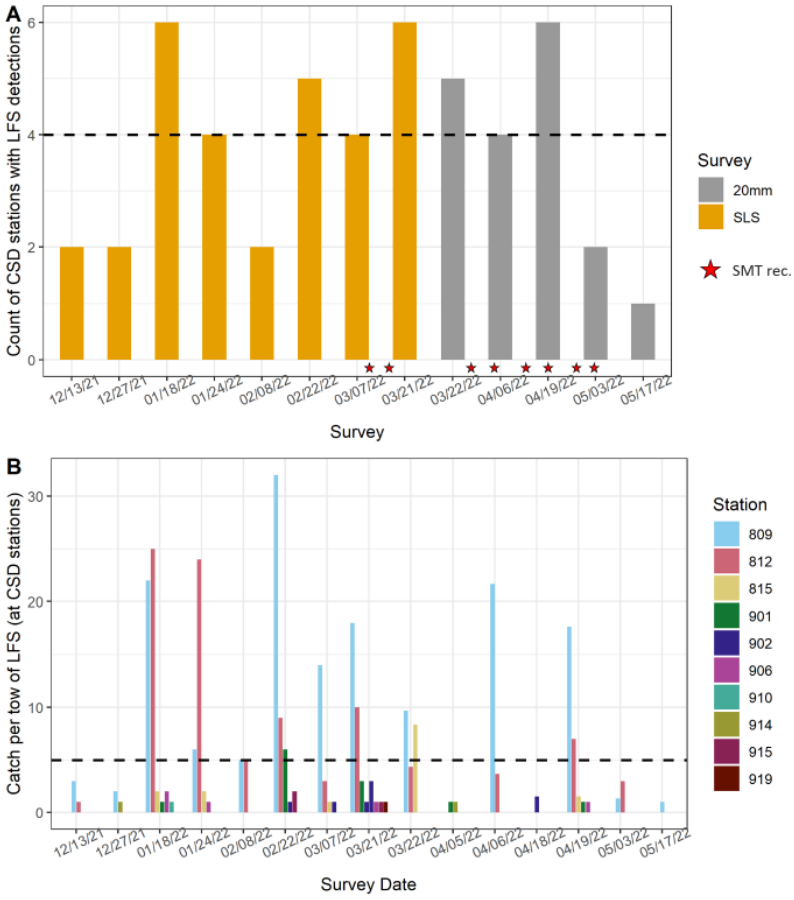


Figure 21. A. Number of Central and South Delta (CSD) stations with Longfin Smelt detections from the Smelt Larva Survey (SLS) and 20mm Survey (20mm), and B. catch per tow of Longfin Smelt at the 12 CSD stations (809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, and 919). The black dashed lines indicate thresholds (ITP COA 8.4.2) of A 4 or more of 12 CSD station Longfin Smelt detections or B for 5 Longfin Smelt catch per tow at 2 CSD stations (as the average of three tows for 20mm). Red stars along the x-axis in A indicate when the SMT made a recommendation. Plot only includes data which had undergone initial data entry verification by 7/5/2022; processing is ongoing.

Additionally, from January 15-March 31 of dry and critical water years, DWR operates the Barker Slough Pumping Plant to protect larval Longfin Smelt and from March 1 to June 30 for Delta Smelt (ITP COA 8.12). During WY 2022, COA 8.12 for BSPP was in effect from February 8, 2022 to March 31, 2022 for Longfin Smelt, and March 1, 2022 to June 30, 2022 for Delta Smelt. During this period, larval Longfin Smelt were detected at Station 716 during SLS Surveys #2, 3, and 5 and 20mm Survey #2, triggered 8.12 at the February 15, February 22, March 15, and March 22 SMT meetings, limiting BSPP restrictions to <60 cfs (Figure 22). Delta Smelt were detected at station 716 during 20mm Survey #1, triggering 8.12 during the March 29 and April 5 SMT meetings.

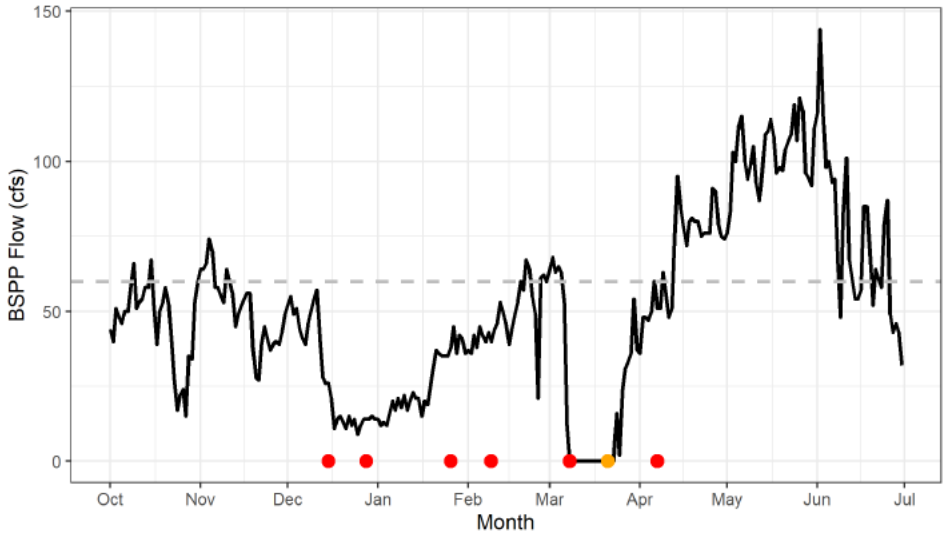


Figure 22. Flow (cfs) at Barker Slough Pumping Plant for WY 2022. Dates of SLS or 20mm detections at station 716 are denoted (red points for Longfin Smelt, orange for Delta Smelt). The gray dashed line indicates the pumping threshold of <60 cfs when detections at 716 occurred. BSPP ceased operations from March 8, 2022 to March 25, 2022 to conduct annual maintenance.

Larval and Juvenile Longfin Smelt Detections During WY 2022, larval Longfin Smelt sampling started on December 13, 2021, in compliance with ITP COA 7.6.1, which directed DWR to fund additional Smelt Larva Surveys (SLS) in the Central and South Delta in December. This additional sampling is meant to more completely cover the period of larval Longfin Smelt presence, as SLS previously did not begin until the first week in January. Starting in WY 2022, these December SLS surveys were extended to the full suite of 35 regular SLS stations, per coordination with the Longfin Smelt Technical Team (ITP COA 7.6.3). December sampling in WY 2022 detected larval Longfin Smelt starting on December 13, 2021, highlighting the potential that the initiation of hatching may have been missed in previous years. Throughout the WY 2022 Longfin Smelt spawning season, the majority of larvae and juveniles detected in regular monitoring were in Sacramento River System stations, with Suisun Bay and West being the second most prevalent region for catch (Figure 20). Despite substantial detection in salvage (Figure *29*), regular larval and juvenile fish monitoring detected the lowest numbers of Longfin

Smelt catch in the Central and South Delta, compared with other regions of the estuary (). April saw the highest catches of larval Longfin Smelt in regular monitoring, with May and March having the second and third highest catch, respectively.

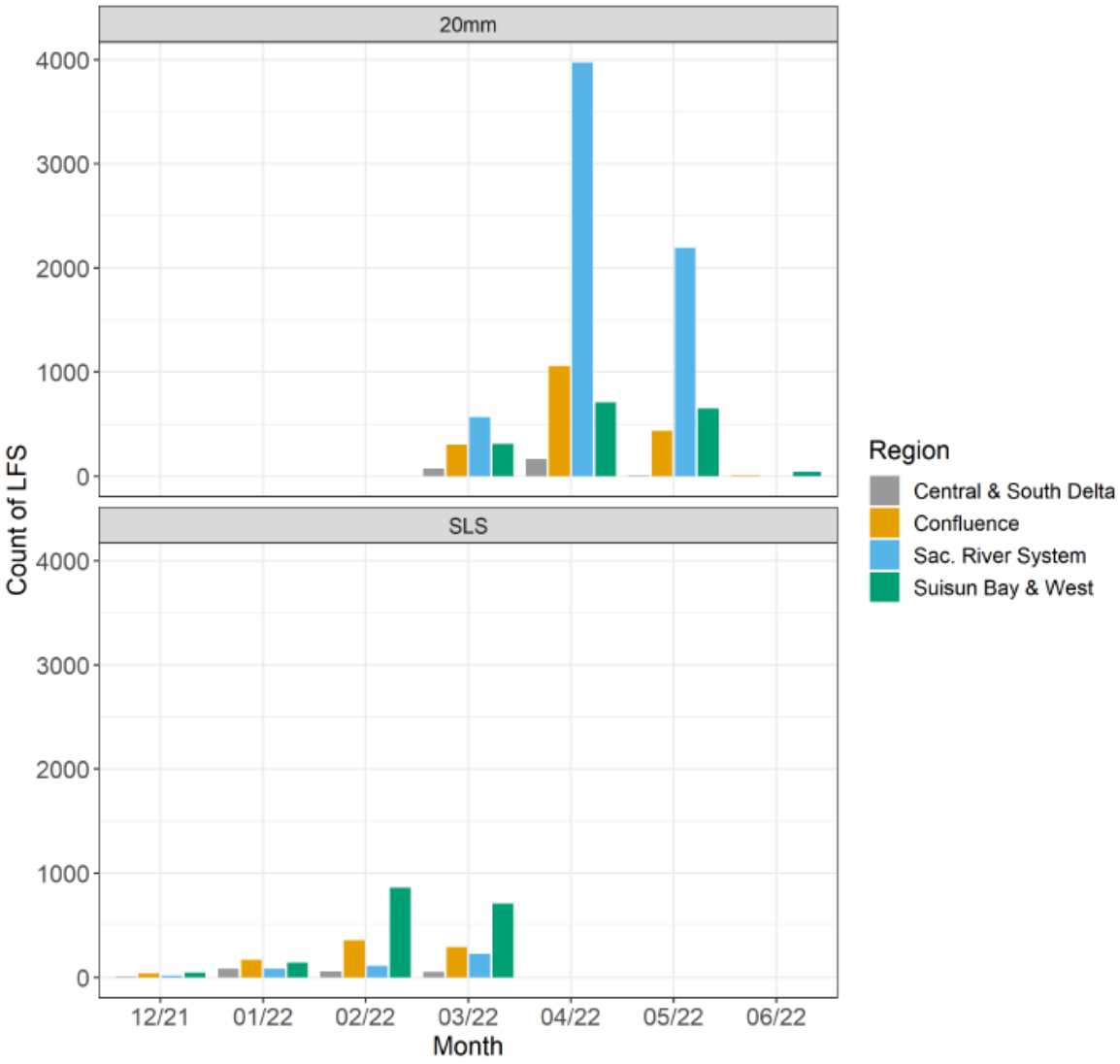


Figure 23. Catch of larval Longfin Smelt in the Smelt Larva Survey and 20mm Survey during WY 2022 sampling. Plot only includes data which had undergone initial data entry verification by 7/5/2022; processing is ongoing.

Winter-run Chinook Salmon

Daily Loss The ITP includes a separate daily loss threshold for winter-run Chinook Salmon for each month of the migratory season from November through May, described in COA's 8.6.2 and 8.6.3. The November and December Early-season Natural Origin Winter-run Chinook Salmon Discrete Daily Loss Thresholds set fixed thresholds for loss of older juvenile Chinook Salmon. The January through May Mid- and Late-season Natural Winter-run Chinook Salmon

Daily Thresholds are calculated each year as set percentages of the winter-run Juvenile Production Estimate (JPE) for that management season:

- January 1–January 31: 0.00635% of the winter-run Chinook Salmon JPE (7.94)
- February 1–February 28: 0.00991% of the winter-run Chinook Salmon JPE (12.39)
- March 1–March 31: 0.0146% of the winter-run Chinook Salmon JPE (18.26)
- April 1–April 30: 0.00507% of the winter-run Chinook Salmon JPE (6.34)
- May 1–May 31: 0.0077% of the winter-run Chinook Salmon JPE (9.63)

The ITP Early-season Natural Origin Winter-run Chinook Salmon Discrete Daily Loss Thresholds are intended to minimize water project operations impact on the earlier migrating juvenile winter-run Chinook Salmon to preserve life history diversity at the leading edge of the migration timing distribution. The ITP Mid- and Late-season Natural Winter-run Chinook Salmon Daily Loss Thresholds are intended to minimize entrainment, salvage, and take of natural winter-run Chinook Salmon during the peak and end of their migration through the Delta. Exceedance of a daily threshold requires restriction of south Delta exports for five days to achieve a five-day average OMR index no more negative than -5,000 cfs for Early-season thresholds, and -3,500 cfs for Mid- and Late-season thresholds. Note that proportional share (the SWP proportion of any effects that may be a result of joint operation of SWP and CVP, as defined in Appendix H, Attachment 1-5: Estimation of SWP Proportion of Effects in Draft Environmental Impact Report for Long-Term Operations of the California State Water Project) applies to DWR daily threshold triggers that occurred before the adoption of the IOP on March 14, 2022. In WY 2022, daily loss thresholds were triggered multiple days for winter-run Chinook Salmon in April, which had an extremely low threshold triggered by only a single observed winter-run size Chinook Salmon. The daily loss thresholds were triggered on 4/12/2022 (loss of 17.57), 4/16/2022 (loss of 17.57), and 4/27/2022 (loss of 17.52); however, it was later discovered on May 10th through genetic determination that the fish observed on 4/16/2022 was a steelhead. None of these events required alteration of water operations because requirements to maintain water quality in the Delta were already more restrictive (exports already limited to 1,500 cfs per the TUCO).

Single Year Loss The ROD and ITP COA 8.6.1 set the same single-year threshold loss values for natural and hatchery winter-run Chinook Salmon. These values are calculated as 1.17 percent of the JPE for natural origin winter-run Chinook Salmon, equal to 1,463 for WY 2022, and 0.12 percent of the JPE for each hatchery production group, equal to 182 for the Sacramento River release and 11 for the Battle Creek release in WY 2022. However, the SWP ITP does not include Battle Creek releases as a threshold for ITP COA 8.6.1.

Combined natural winter-run Chinook Salmon (LAD) loss for WY 2022, (October 1, 2021–July 1, 2022) was 73.04 fish. This loss equaled 5 percent of the single-year loss threshold. Total loss of hatchery winter-run Chinook Salmon was 6.71 fish for the Sacramento River release and 0 fish from the Battle Creek release (Table *3*). In WY 2022, neither LAD natural winter-run

Chinook Salmon (Figure *24*, Figure *26*) nor the hatchery winter-run Chinook Salmon single-year loss threshold was triggered.

Table 3. Confirmed hatchery (adipose-fin clipped and marked with CWT) hatchery winter-run Chinook Salmon loss observed at SWP and CVP for WY 2022

Release Date	CWT Race	Hatchery	Count	Loss	CWT Tag Code	CWT Release Type	CWT Release Start	CWT Release End	Release Site
03/26/2022	Winter	LSNFH	1	3.52	055858	Production	2022-02-09	2022-02-09	Sacramento River, Caldwell Park; Redding, CA
03/30/2022	Winter	LSNFH	1	3.19	055858	Production	2022-02-09	2022-02-09	Sacramento River, Caldwell Park; Redding, CA

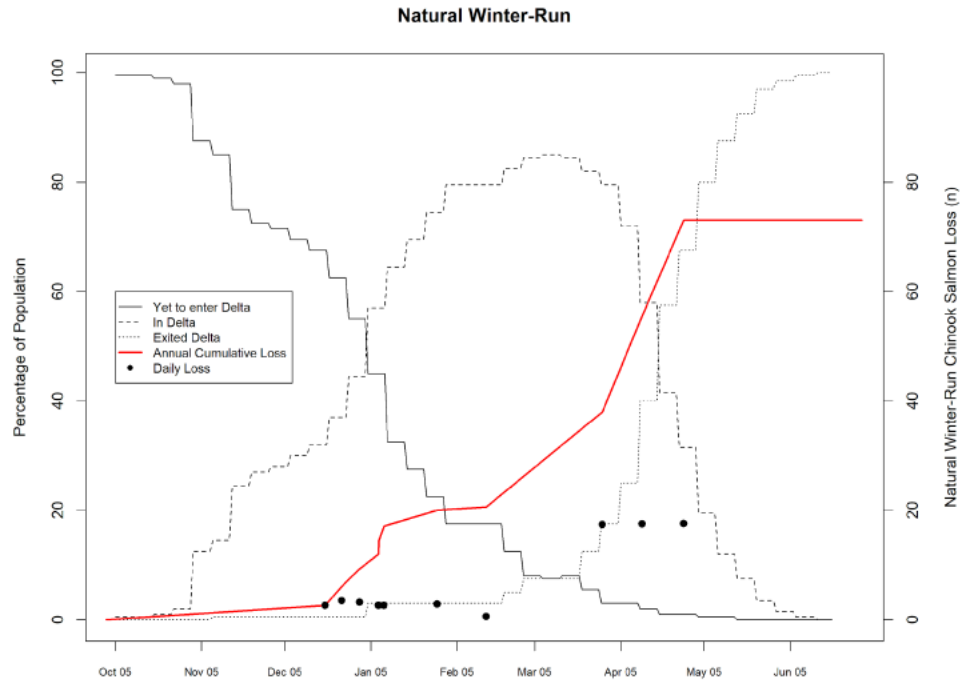


Figure 24. Combined loss of natural winter-run size Chinook Salmon in WY 2022 (28% occurred at SWP, 72% occurred at CVP)

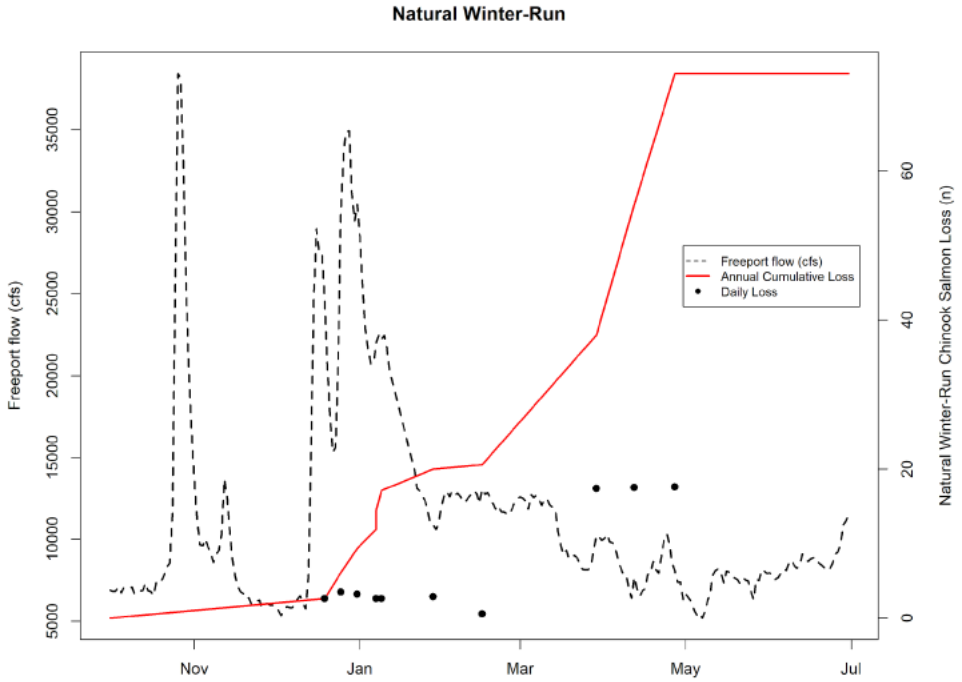


Figure 25. Freeport flows (cfs) and combined natural winter-run size Chinook Salmon loss at the CVP and SWP fish salvage facilities for WY 2022

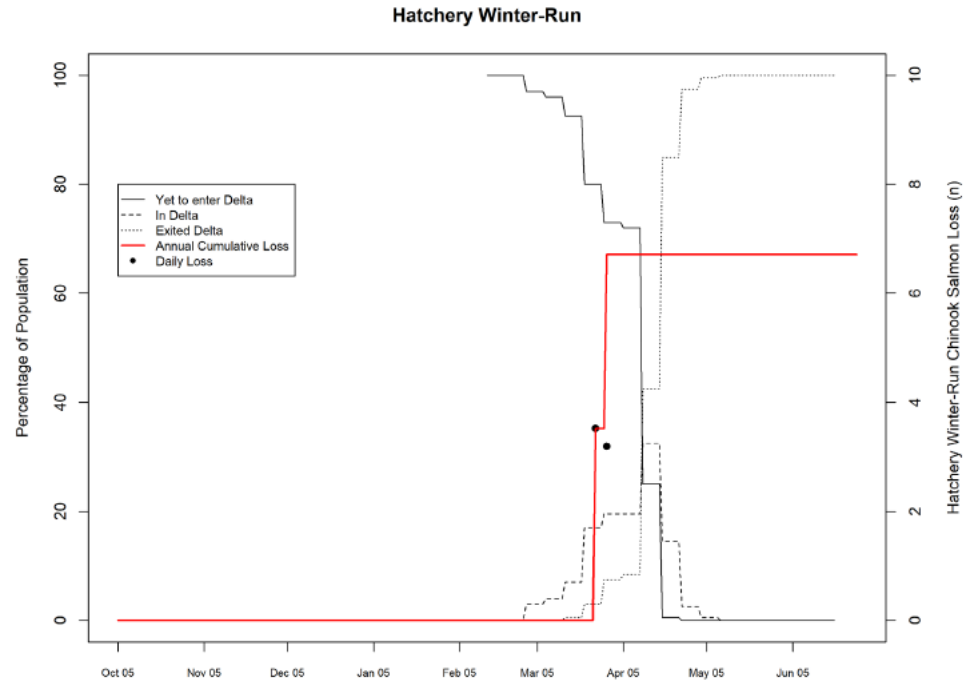


Figure 26. Combined loss of hatchery-origin winter-run Chinook Salmon in WY 2022

Cumulative Loss The cumulative loss threshold for natural winter-run Chinook Salmon over the duration of the ROD and the SWP ITP (ITP Project Description 3.5) is 8,738 fish. Total cumulative loss to date (calculated here as total since February 19, 2020) of natural winter-run Chinook Salmon over the duration of the ROD and ITP (10 years) is 264.2 fish, or 3.02 percent of the threshold (Figure 28). The cumulative loss threshold for hatchery winter-run Chinook Salmon over the duration of the ROD and the ITP is 5,356 fish. Total cumulative loss to date of hatchery winter-run Chinook Salmon over the duration of the ROD is 6.71 fish, or 0.13 percent of the threshold. Neither cumulative loss thresholds were triggered in WY 2022.

Spring-Run Chinook Salmon

ROD Spring-Run Chinook Salmon Surrogates As part of the NMFS 2019 Biological Opinion, the incidental take statement's annual loss threshold for late fall-run hatchery release groups serving as yearling spring-run Chinook Salmon surrogates is 1% of each release group (Section 13.3.5.3). During WY 2022, three groups of brood year 2021 late-fall-run Chinook Salmon were released into Battle Creek from the Coleman National Fish Hatchery.

The first group of 84,343 fish was released on December 15, 2021 (loss threshold = 843). The second group of 82,626 fish was released on December 22, 2021 (loss threshold = 826). The third group of 77,325 fish was released on January 6, 2022 (loss threshold = 773). Combined loss for WY 2022 was 48.18 fish (5.7% of the loss threshold) for the first release group, 17.61 fish (2.1% of the loss threshold) for the second release group, and 20.04 for the third release group (2.6% of the loss threshold). Therefore, during WY 2022 no spring-run Chinook Salmon surrogate loss thresholds were exceeded and no OMR restrictive action was required (Table Table 4).

Table 4. Confirmed hatchery (adipose-fin clipped and marked with CWT) spring-run yearling surrogate Chinook Salmon loss observed at SWP and CVP for WY 2022.

Release Date	CWT Race	Hatchery	Release Site	Release Type	Loss	CWT Number Released	% CWT Marked of Total Number Released	% Loss CWT Number Released	First Loss	Last Loss
12/15/2021	Late-Fall	Coleman National Fish Hatchery	Battle Creek	Spring Surrogate	48.18	84343	100.0	0.058	2022-01-01	2022-01-11
12/22/2021	Late Fall	Coleman National Fish Hatchery	Battle Creek	Spring Surrogate	17.61	82626	100.0	0.021	2022-01-03	2022-01-18
01/06/2022	Late Fall	Coleman National Fish Hatchery	Battle Creek	Spring Surrogate	20.04	77325	100.0	0.026	2022-01-16	2022-03-20

ITP Spring-Run Chinook Salmon Surrogates

To minimize entrainment of emigrating natural juvenile spring-run Chinook Salmon from the Sacramento River and tributaries, including the Feather and Yuba rivers, into the channels of the central Delta, south Delta, Clifton Court Forebay, and the Banks Pumping Plant, the ITP (COA 8.6.4) requires DWR to restrict exports based on the presence of hatchery produced spring-run Chinook Salmon surrogate groups at the CVP and SWP fish salvage facilities. These release groups are separate from the three release groups proposed by the ROD. Spring-run Chinook Salmon surrogate groups consist of young-of-the-year fall-run and spring-run surrogate release groups of Chinook Salmon from the Coleman National Fish Hatchery, Feather River Hatchery, and the Nimbus Fish Hatchery. From February 1 through June 30 of each water year, DWR is required to reduce south Delta exports for five consecutive days to achieve a five-day average OMR index no more negative than -3,500 cfs when Feather River Hatchery coded wire tagged (CWT) spring-run Chinook Salmon surrogates (includes both spring- and fall-run hatchery release groups) cumulative loss at the CVP and SWP fish salvage facilities is greater than 0.25% for each release group OR Coleman National Fish Hatchery and Nimbus Fish Hatchery CWT fall-run, release groups cumulative loss at the at the CVP and SWP fish salvage facilities is greater than 0.25% of the total in-river releases for each release group.

Like WY 2021, drought conditions in WY 2022 induced low flow and high in-river water temperatures and prevented release of several production groups from the Feather River Fish Hatchery and Nimbus Fish Hatchery directly into the rivers adjacent to the hatcheries. Instead, these production groups were transported and released into San Francisco Bay. These production groups were to serve as the spring-run Chinook Salmon surrogate release groups from these hatcheries. Therefore, the second intended Feather River Fish Hatchery release group and the two intended release groups from Nimbus Fish Hatchery did not occur as planned. As replacements, two additional releases of young-of-the-year fall-run Chinook Salmon were released from Coleman National Fish Hatchery on March 31-April 1, 2022 and April 5 and 7, 2022. During WY 2022 no ITP spring-run Chinook Salmon surrogate loss thresholds were exceeded and no OMR action response was required (Table 5).

Table 5. Confirmed SWP and CVP Spring-run Chinook Salmon sub-yearling surrogate loss for WY 2022. Note all spring-run Chinook Salmon loss occurred during predator removal events at the SWP and were therefore not subject to the expansion factor (4 x salvage count) that applies to salvage samples.

Release Date	CWT Race	Hatchery	Release Site	CWT Number Released	Loss Limit	Total Season Loss
03/15/2022	Fall	Coleman	Battle Creek	719,939	1799.60	0
03/18/2022	Fall	Coleman	Battle Creek	749,368	1873.42	0
03/30/2022	Spring	Feather	Feather River	729,199	1822.99	0
03/31/2022-04/01/2022	Fall	Coleman	Battle Creek	1,058,439	2,646.10	4.33 04/18/22

Release Date	CWT Race	Hatchery	Release Site	CWT Number Released	Loss Limit	Total Season Loss
04/05/2022 and 04/07/2022	Fall	Coleman	Battle Creek	339,094	847.74	4.33 04/23/22

Steelhead

Including loss of fish in October and November of 2021 (3.4), a total of 84.28 natural steelhead were lost for the "December to March" period of WY 2022. This loss equals 3 percent of the single-year loss threshold (2,760); and over the duration of the ROD, total cumulative loss of natural steelhead between December and March is 530.2 fish, 8.8 percent of the cumulative loss threshold (Figure 23). From April 1, 2022 to June 15, 2022, an estimated total of 154.38 natural steelhead were lost. This loss equals 5.1 percent of the single-year loss threshold (3,040); and over the duration of the ROD, total cumulative loss of natural steelhead from April 1 to June 15 is 474.5 fish, 8.1 percent of the cumulative loss threshold (Figure 30). Loss did not exceed 50 percent of either of the single-year loss thresholds during WY 2022, and therefore, there was no threshold trigger exceedance that warranted reductions.

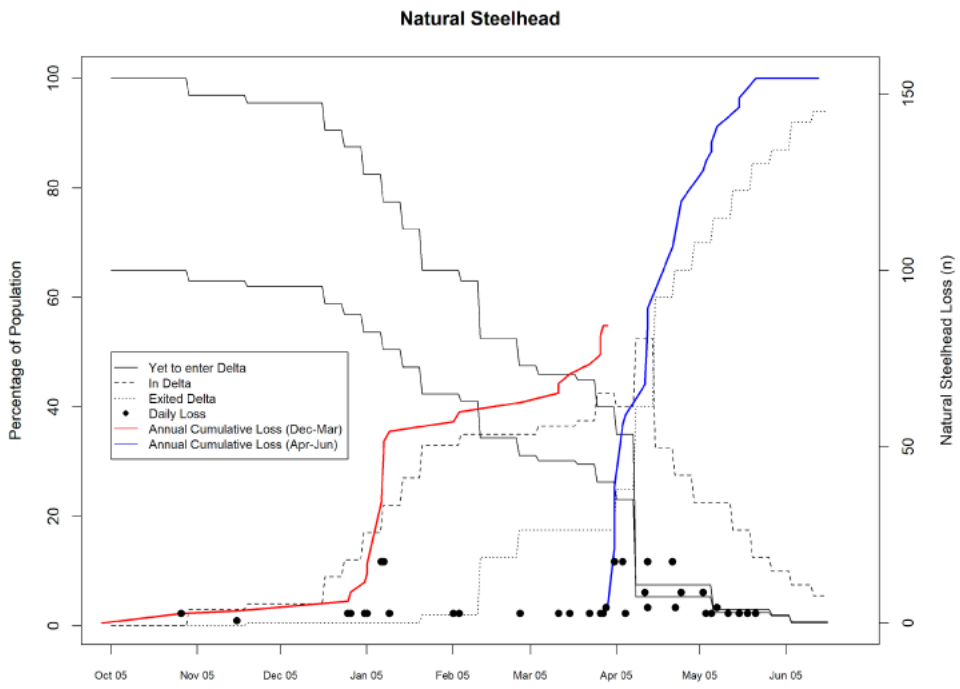


Figure 27. Estimated combined loss of natural steelhead for WY 2022 (December–March: 41% at SWP, 59% at CVP; April–June: 84% at SWP, 16% at CVP)

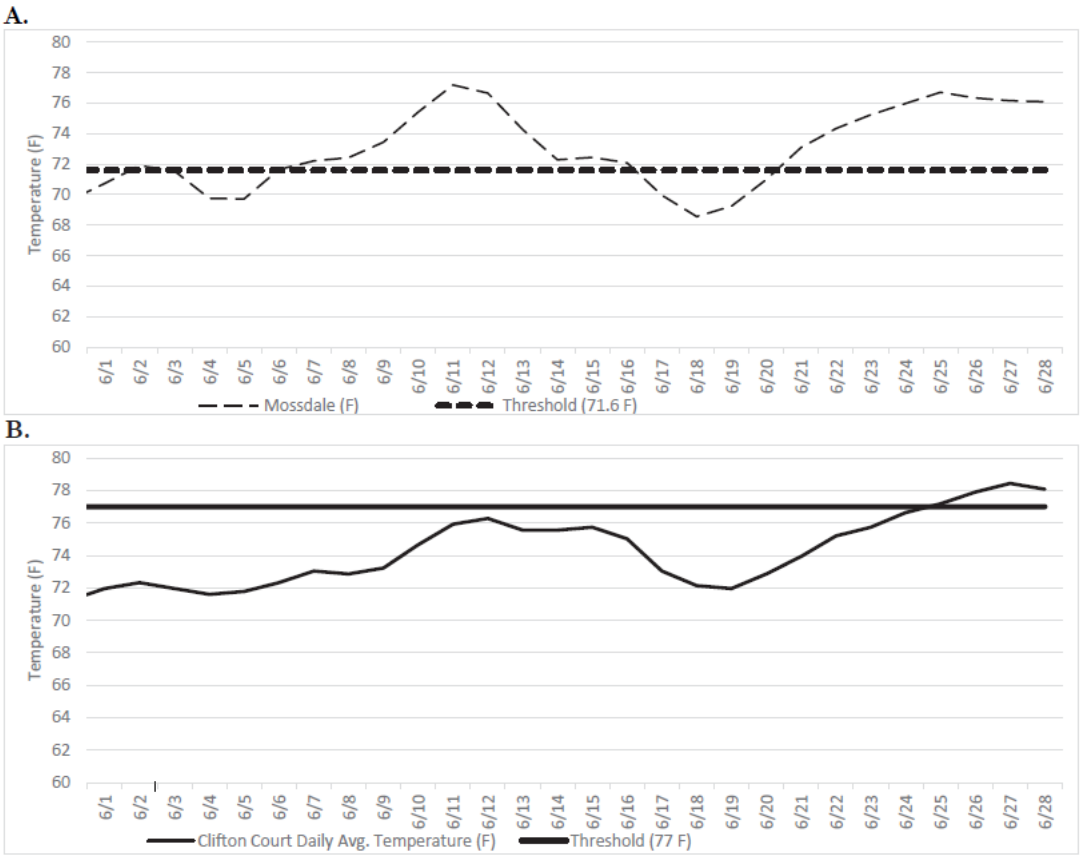
Storm-Related OMR Flexibility

The CVP and SWP can increase exports during the OMR flow management season to capture peak flows in the Delta during storm-related events (see Proposed Acton section 4.10.5.10.3,

U.S. Bureau of Reclamation 2019c, ITP COA 8.7). Reclamation and DWR determined that the Delta outflow index did not increase in response to a storm-related event such that it would indicate a higher level of flow was available for export.

End of OMR Management

The CCF criteria for Delta Smelt and Longfin Smelt were met on June 28, 2022 (Figure 24), and thus ended the OMR flow management season for these species. SaMT estimated that more than 95 percent of YOY natural winter-run and YOY natural spring-run Chinook Salmon had exited the Delta by June 14, 2022, and daily average water temperature at Mossdale and Prisoner's Point met offramp criteria for Chinook Salmon and steelhead on June 16, 2022 (Figure 24), ending the OMR management season for salmonids on June 16, 2022.



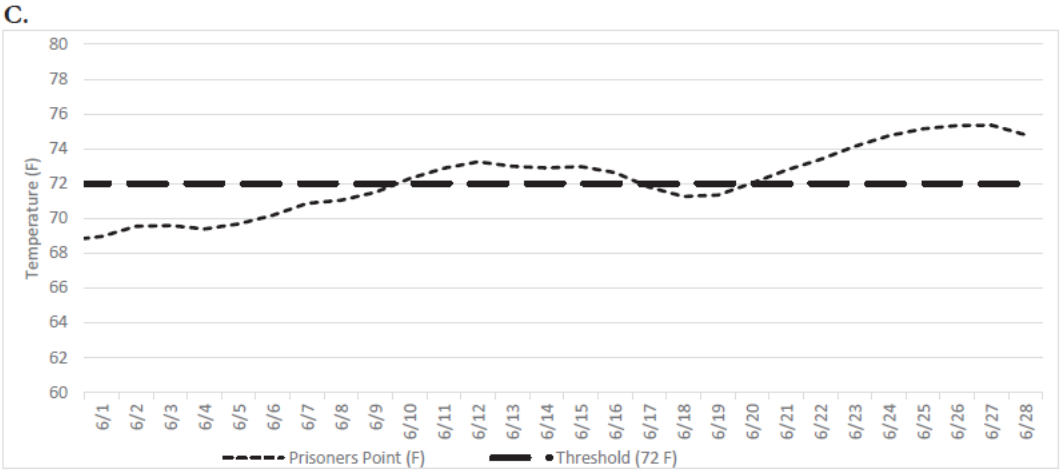


Figure 28. Average daily temperatures (F) at A) Mossdale, B) Clifton Court Forebay, and C) Prisoner's Point in June 2022.

Export Curtailments for Spring Outflow

Export curtailments during April and May are designed to improve Delta Outflow during these months and improve habitat for Delta smelt and Longfin smelt, as well as migratory conditions for winter-run and spring-run Chinook salmon.

The daily export rate for the SWP is the daily inflow to CCF minus the daily Byron Bethany Irrigation District (BBID) diversion from the CCF. For 2022, the BBID diversion varied daily, but the monthly average was approximately 64 cfs/day in April and 72 cfs/day in May.

The ITP issued by the CDFW (ITP COA 8.17) for SWP operations specifies that "Permittee shall reduce exports from April 1 to May 31 each year to achieve the SWP proportional share of export reductions established by the ratio of Vernalis flow(cfs) to combined CVP and SWP exports, scaled by water year type "In a critically dry year, the ratio of Vernalis flow to CVP and SWP combined exports shall be 1 to 1." ITP Section 3.8 specifies that "…combined CVP and SWP export rates will not be required to drop below 1,500 cfs and SWP exports will not be required to drop below 600 cfs." However, under the March 11, 2022, Court Order for the Interim Operations Plan, Reclamation is also required (for 2022) to comply with the export limits set forth in COA 8.17 of the ITP in certain water year types.

DWR and Reclamation submitted a TUCP in December to be applied April through June that was subsequently and conditionally approved by the SWRCB in a TUCO. However, the petition did not request nor modify the existing export constraints in D-1641 or CDFW's ITP for the months of April and May. During WY 2022 (classified as Critically Dry), the 31-day pulse flow period was from April 18–May 18.

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Issues Elevated in WY 2022

The SMT and the SaMT did not elevate any issues to WOMT during WY 2022; however, recommendations to WOMT made under COA 8.4.2 and 8.12 are discussed in "Additional Real-time OMR Restrictions and Performance Objectives."

No WOMT member elevated OMR flow management concerns to directors during WY 2022 (Sees Supporting Information Sections).

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Performance

Delta Cross Channel Gate Closures

During WY 2022 there was testing of the DCC gates on April 6, 2022, which led to a brief one-hour gate opening for the day when the gates were required to be closed. As measured by the California Data Exchange Center water quality station (Station ID: DLC) located in Snodgrass Slough, the cycling of the DCC gates resulted in a small change in water elevation and velocity; however, it did not result in a measurable change to Sacramento River flow. Reclamation determined that the short duration of the required maintenance and testing of the DCC gates in WY 2022 did not result in greater hydrological alteration and stressors to federally listed fish species than previously analyzed in the NMFS 2019 Biological Opinion.

For winter-run Chinook Salmon, Figure 4 shows the KLCI from October 1, 2021 through May 30, 2022 and the SCI seine data and trawl data for October 1, 2021 through December 31, 2021 Trapping ended on June 7, 2022 at Knights Landing due to river temperatures reaching >70°F. During WY 2022, KLCI and SCI values were relatively high during October and November 2021, which led to DCC gate closures prior to December 1, 2021. These high older juvenile Chinook Salmon catch indices were postulated to be due to a large storm event that occurred in mid-October of 2021. The DCC gates were closed for the majority of the OMR flow management season during WY 2022. Therefore, fish were likely protected from routing through the DCC into the Central and South Delta regions overall, except for the brief opening in April for maintenance and testing. Salmonid presence was evaluated by the SaMT and is addressed in the Seasonal Operations section above. Additionally, a process was implemented between CDFW (KLCI indices), USFWS (SCI indices), and SacPAS (University of Washington) staff for daily reporting of indices for agency biologists and the interested public.

Salvage and Loss Performance

Delta Smelt Salvage

Adult and Juvenile Salvage

One cultured sub-adult Delta Smelt (adipose fin clipped) was salvaged during the OMR flow management season, resulting in an expanded salvage of four. No adult or juvenile wild Delta Smelt were salvaged during the OMR flow management season. Hatchery origin was genetically confirmed for the salvaged fish. CVP and SWP operations do not distinguish between wild and cultured Delta Smelt for salvage based thresholds.

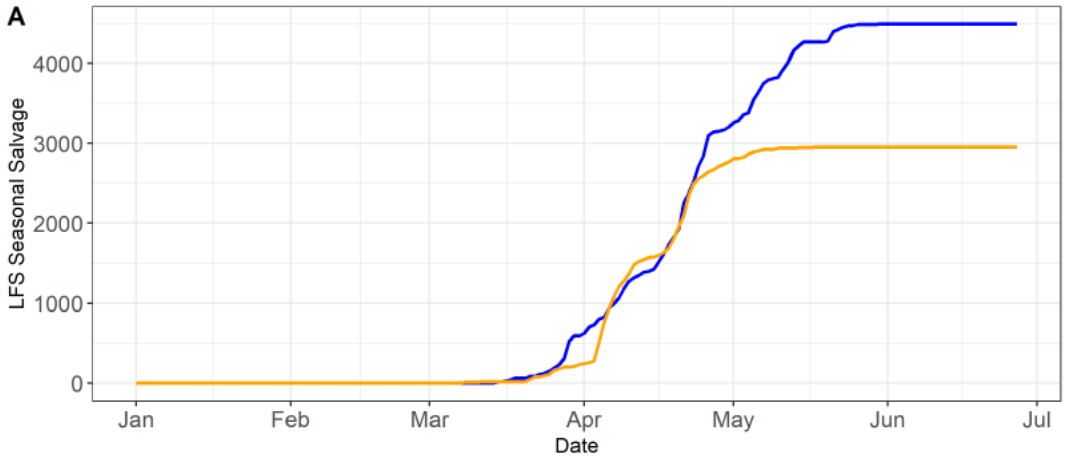
Qualitative Larval Sampling

Larval Delta Smelt sampling methods began at the CVP and SWP on February 7, 2022. No larval Delta Smelt were detected at the TFCF or the Skinner Delta Fish Protection Facility during WY 2022. On May 24, 2022, the SMT began evaluating if the labor-intensive process of the larval sampling would continue every week. The TFCF ended larval sampling methods on June 7, 2022, and the Skinner Delta Fish Protection Facility ended larval sampling methods on June 6, 2022.

Longfin Smelt Salvage

Adult and Juvenile Salvage

Across the entire WY 2022, there was zero salvage of adult Longfin Smelt. Salvage of juvenile (>20mm) Longfin Smelt began on March 8, 2022, at the CVP fish salvage facility and March 14, 2022, and the SWP fish salvage facility (Figure 29). Once salvage at the salvage facilities began, it rapidly increased, peaking in early April and again in late April. Salvage of Longfin Smelt then slowed in May until May 30, when the last Longfin Smelt salvage was observed at the SWP. For WY 2022, total Longfin Smelt salvage was 7,448 fish with 4,494 fish at the SWP and 2,954 fish at the CVP. WY 2022 Longfin Smelt salvage was considerably higher than in recent years, and it was the highest seasonal salvage total since 2002 (Figure 36).



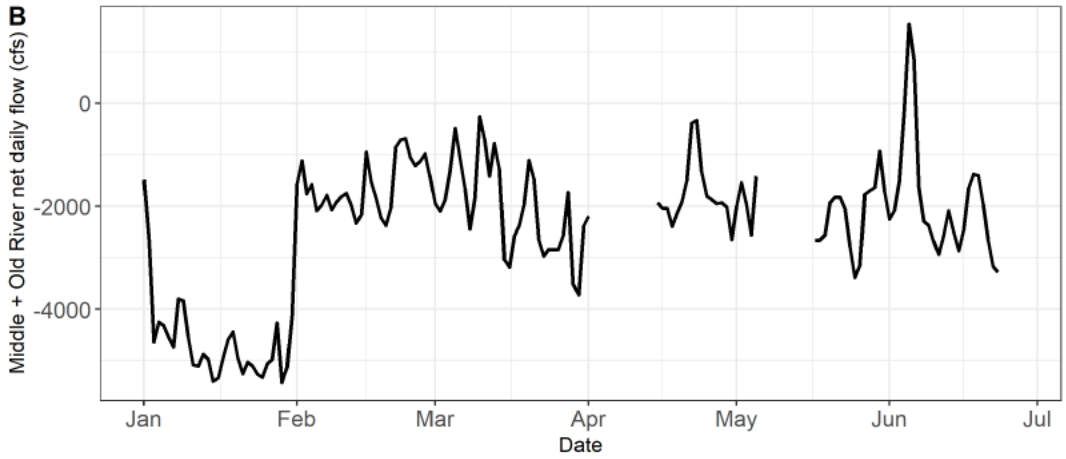


Figure 29. A) Cumulative Longfin Smelt seasonal salvage for SWP (blue line) and CVP (orange line). B) Corresponding Middle plus Old River net daily flow.

Qualitative Larval Sampling

Longfin Smelt qualitative larval sampling began at both the SWP and CVP on February 7, 2022. Larval Longfin Smelt were detected at the CVP on 31 days between March 4, 2022, and April 23, 2022 and at the SWP on nine days between March 8, 2022 and April 23, 2022. On May 24, 2022, the SMT began evaluating if the labor-intensive process of the larval sampling would continue every week. The TFCF ended larval sampling methods on June 7, 2022, and the Skinner Delta Fish Protection Facility ended larval sampling methods on June 6, 2022.

Winter-run Chinook Salmon

Daily Loss

The early-season Natural Winter-run Chinook Salmon Discrete Daily Loss Threshold was not met in November and December of 2021. In April of 2022, daily loss thresholds were triggered for 3 days for winter-run Chinook Salmon, triggered by a single observed LAD winter-run Chinook Salmon for each day (see previous sections). For one of the three days, it was later determined through genetic analysis that the fish sampled was a steelhead instead of a Chinook Salmon. None of these LAD winter-run Chinook Salmon were determined to be genetically winter-run based on genetic analysis. These events did not require alteration of water operations because requirements to maintain water quality in the Delta were more restrictive.

Single Year Loss

Total natural winter-run Chinook Salmon (LAD) loss for WY 2022 (October 1, 2021 through June 30, 2022) was 73.04 fish which represents 5 percent of the single-year loss threshold (1,931 fish) (Figure 30). An estimated 6.7 hatchery winter-run Chinook Salmon were lost in WY 2022. No hatchery winter-run Chinook Salmon single-year loss threshold was triggered in WY 2022. Weekly plots were produced through SacPAS, which incorporate both current and historic loss data: current cumulative WY 2022 loss to the creation date of the plot and historic loss added to the current cumulative loss to visualize historic loss from the creation date of the plot to the end

of the season. In WY 2022, all loss of LAD natural winter-run Chinook Salmon salvage occurred between December 19, 2021 and April 27, 2022, according to LAD criteria. No genetic winter-run Chinook Salmon were observed at the fish salvage facilities in WY 2022; however, 2 of the LAD WR Chinook Salmon failed to be assigned to a run. There was also less passage of LAD winter-run Chinook Salmon at Chipps Island in WY 2022, which suggests that juveniles that reared in the Delta may not have survived through Delta exit. Overall, there were low numbers of LAD winter-run Chinook Salmon observed at the various monitoring programs and the fish salvage facilities in WY 2022.

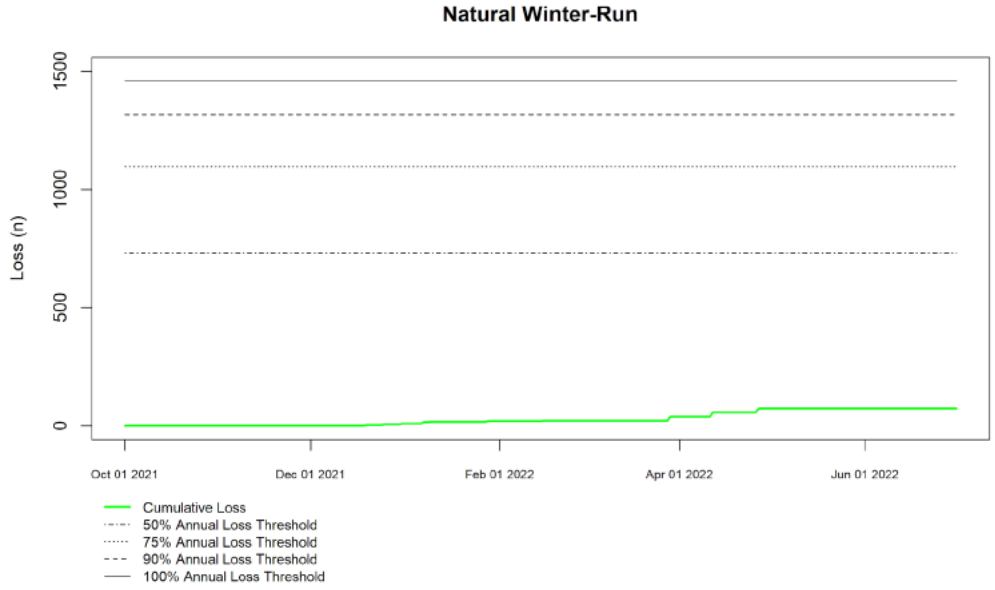


Figure 30. Total natural winter-run Chinook Salmon (LAD) loss for WY 2022.

Cumulative

The cumulative loss threshold for natural winter-run Chinook Salmon over the duration of the ROD is 8,738 fish. At the end of the OMR flow management season in WY 2022, cumulative loss (calculated here as total since February 19, 2020) is 3.02 percent of total loss limit over the duration of the ROD (Figure 27, Figure 28).

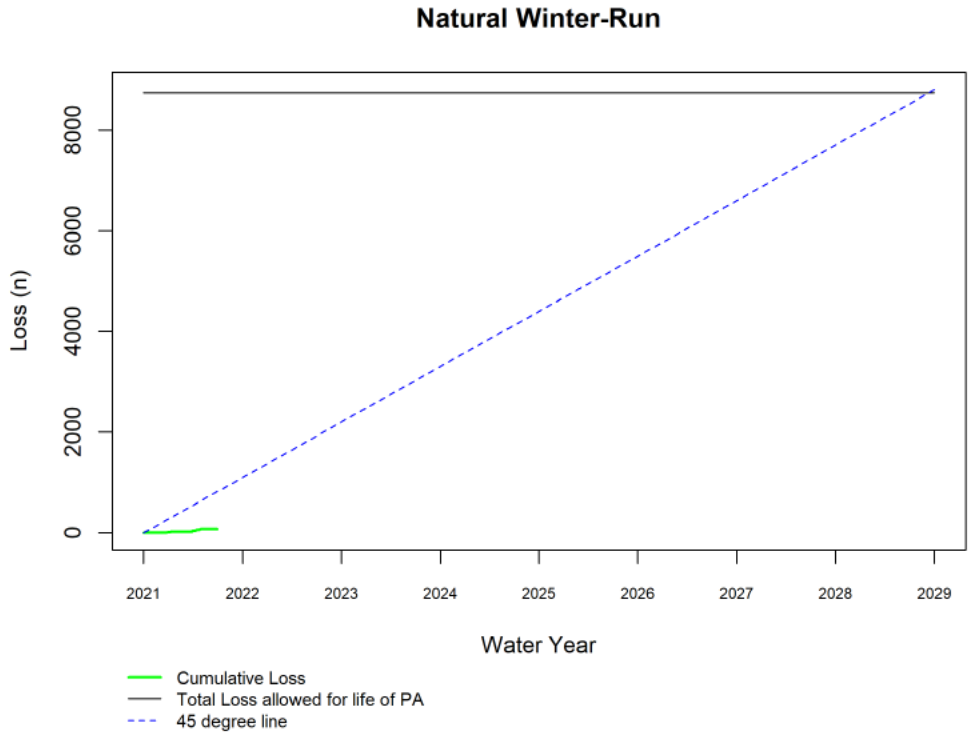


Figure 31. Cumulative loss threshold for natural winter-run Chinook Salmon up to WY 2022. A 45-degree line is superimposed to track the trajectory of natural winter-run Chinook Salmon loss over the duration of the ROD if we are to assume that each year's loss is equal.

Steelhead

Combined loss of natural steelhead was 84.28 fish for the "December 1 and March 31" period (fish losses in October and November of 2021 were included in the tally), which represents 3 percent of the single-year loss threshold (2,760 fish). Combined loss of natural steelhead for WY 2022 was 154.38 for the "April 1 and June 15" period, which represents 5.1 percent of the single-year loss threshold (3,040 fish). On March 29, 2022, the SaMT estimated the distribution of natural steelhead within the Delta to be 35–50 percent, and distribution of natural steelhead that had exited past Chipps Island to be 15–20 percent. Unlike most previous water years, April–June steelhead loss was higher than December–March loss in WY 2022 (Figure 32).

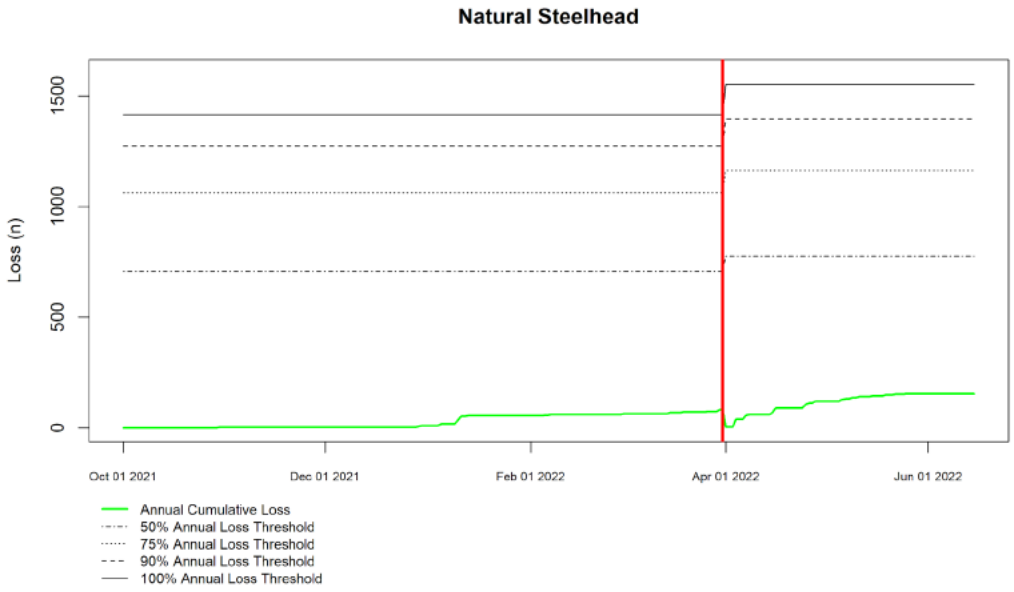


Figure 32. Trajectory of the annual cumulative loss for natural steelhead for WY 2022 for the two time periods (December–March, April–June), with their respective annual loss thresholds.

At the end of the 2021–2022 OMR flow management season, the loss for the first three "seasons" is 8.8 percent of the 10-year duration cumulative total loss for this December–March period (Figure 33). A total of 154.38 natural steelhead fish were lost in WY 2022 from April 1, 2022 to June 15, 2022. At the end of WY 2022, the loss for the first three "seasons" is 8.1 percent of the cumulative total loss for this April–June period (Figure 33).

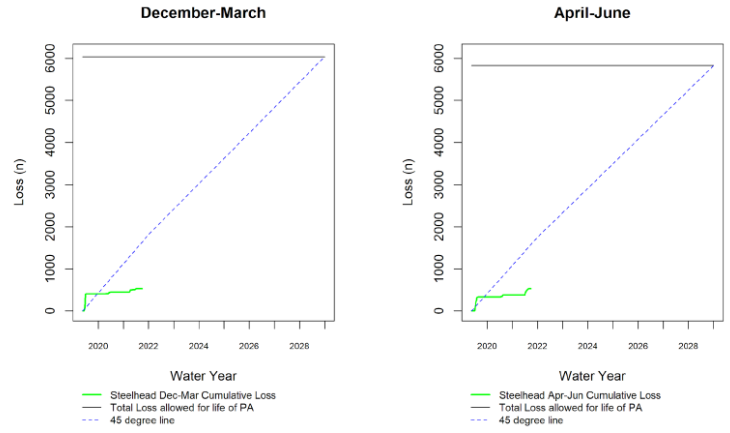


Figure 33. Cumulative loss for natural steelhead for December 1–March 31 and April 1 and June 15. 45-degree lines are superimposed to track the trajectories of natural steelhead loss over the duration of the ROD, assuming each year's natural steelhead loss is equal.

Salmonids and Historic Performance

Historic natural winter-run Chinook Salmon LAD loss by month by year (2009 – 2022), with loss shown as percentage of total water year loss, is shown in Figure 31. The highest percentage of historic loss occurs in March. In WY 2022, the majority of loss occurred in the month of April.

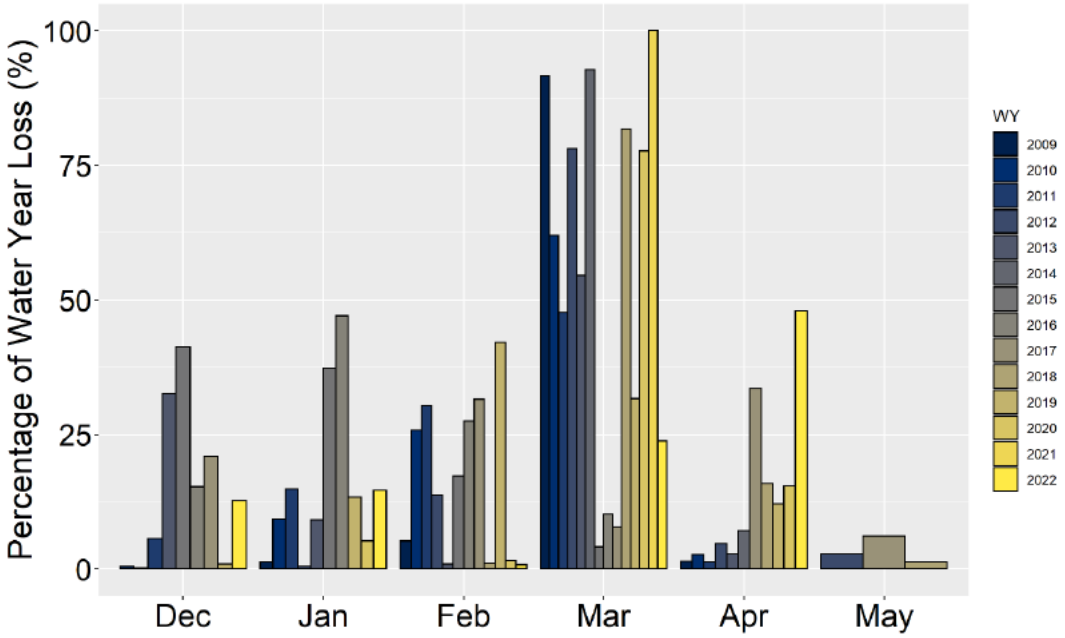


Figure 34. Historic natural winter-run Chinook Salmon (LAD) loss by month by WY (2009–2022).

Historic natural steelhead loss by season and water year is shown in Figure 32, with loss shown as percentage of total water year loss. Historic loss occurred more frequently from December 1 to March 31 than from April 1 to June 15 in 8 of the last 14 years (2009–2022).

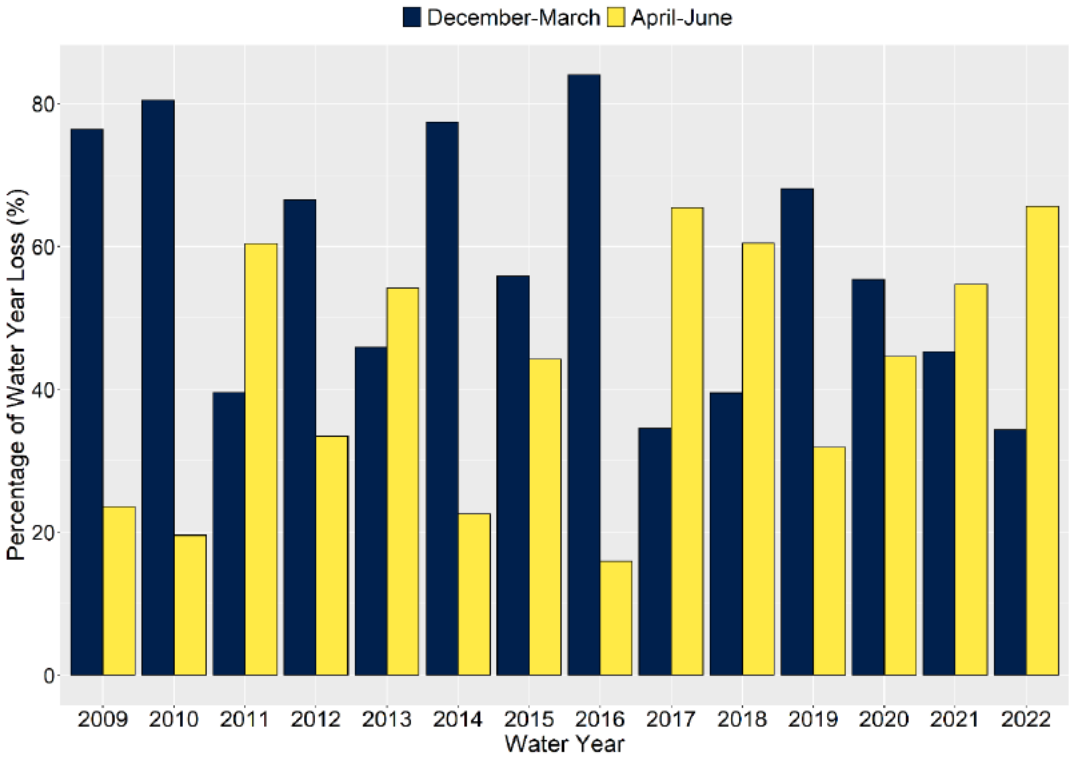


Figure 35. Historic natural steelhead loss by action period "season" (December 1–March 31, April 1–June 15) by water year (2009–2022). Loss shown as percentage of combined loss per water year.

Discussion

Delta Cross Channel

Out-migrating Sacramento River Basin origin salmonids traveling downstream through the Sacramento River have the potential to encounter the junction with the DCC gates. When the DCC gates are open salmonids are vulnerable to entrainment into the interior Delta and potentially farther into the South Delta. Survival within the South Delta, as estimated from tagged fish studies, is less than survival through the Sacramento River to Chipps Island. Throughout the WY 2022 OMR flow management season, the DCC gates remained closed per the ROD during time periods of highest risk for juvenile salmonids, except for a brief opening in April for maintenance and testing. Historic migration patterns at Knights Landing RST show an average of 50 percent of natural winter-run Chinook Salmon by December 26th and an average of 75 percent of natural winter-run Chinook Salmon by January 7th (2006–2019). In WY 2022, the first natural winter-run Chinook Salmon was observed at Knights Landing on September 29, 2021, and the last on March 19, 2022. The action of briefly closing the DCC gates based on KLCI and SCI triggers (Figure 3) during late October to mid-November 2021, and the seasonal closure starting November 30, 2021, provided a high level of protection for juvenile salmonids out-migrating down the Sacramento River.

Integrated Early Winter Pulse Protection ("First Flush")

During the IEWPP the turbidity field from the first flush did not include the south delta despite flows at Freeport above 25,000 cfs after December 24, 2021 (Figure 8). Spatially, the furthest that the turbidity field reached into the central and south delta was at Frank's Tract and Holland Tract on December 25–26, 2021. Notably, the turbidity field did not reach Old River at Bacon Island which is used to monitor the formation of a turbidity bridge after IEWPP ends. When turbidity of more than 12 NTU is present in Old and Middle rivers, adult Delta Smelt may be more likely to move into these channels and become entrained (Grimaldo et al 2009). During the IEWPP no Delta Smelt were salvaged at the fish salvage facilities and fish monitoring programs did not detect Delta Smelt in the south Delta.

Turbidity Bridge Avoidance ("South Delta Turbidity")

Turbidity data at Old River at Bacon Island (OBI) is used to assess the formation of a turbidity bridge within the Old River corridor between the San Joaquin River shipping channel and the CVP and SWP fish salvage facilities. The turbidity threshold of 12 FNU did not occur during the period of the Turbidity Bridge Avoidance Action. (Figure 15). While no turbidity bridge was formed a experimentally release Delta Smelt was observed at the Tracy Fish Collection Facility

on January 16, 2022. The SMT did recommend an OMR index of -1250 cfs after the March 29, 2022 meeting due to the observation of a Delta Smelt at station 815 in the Lower San Joaquin but was not continued after the next meeting.

Delta Smelt Protections

During the period of Larval and Juvenile Delta Smelt protection, the SMT received daily salvage reports, the DWR Delta Turbidity Conditions Report, and available catch data each week to assess the likelihood of larval and juvenile entrainment. No larval or juvenile Delta Smelt were observed at either fish salvage facilities. Drought operations maintained less negative OMR indexes (Figure 4) in this period and turbidity remained stable across the south Delta. During this period a Delta smelt was observed on the Lower San Joaquin on March 22, 2022 and in the OMR corridor on April 5, 2022.

Longfin Smelt Protections

During the period of adult Longfin Smelt entrainment protections, no salvage of adult Longfin Smelt was observed in WY 2022. Adults were detected in regular monitoring in the Central and South Delta, though these detections were sporadic and occurred after adult Longfin Smelt protection actions had off-ramped. The later presence of substantial numbers of larvae and juveniles in salvage indicate adults were likely present in the central and south Delta for spawning.

For larval and juvenile Longfin Smelt entrainment protections, substantial salvage occurred at both export facilities, particularly the SWP, despite a fully implemented IEWPP action, largely health and safety minimum exports due to drought conditions and TUCO (after February 1, 2022), and the full implementation of the 2020 ITP. However, a general upstream distribution of Longfin Smelt is to be expected during dry conditions experienced in 2022, and thus a generally higher risk of entrainment is to be expected. It is notable that salvage was substantially elevated from the previous WY 2020 and WY 2021 seasons and was the highest salvage since 2002 (Error! Reference source not found.). Due to the generally reduced export operations from the IEWPP in December and D-1641 water quality restrictions after February 1, plus TUCO health and safety minimum exports after April 1, there was likely little additional impact that ITP conditions could have had to reduce the Longfin Smelt salvage trends in WY 2022. Further analysis and modeling will be helpful to understand patterns in Longfin Smelt entrainment during drought years, as well as evaluating the data for any indication that the October atmospheric river played a role in subsequent spawning distribution. Additional years of data will be necessary to analyze the full effectiveness of ITP actions over a broad range of OMR flows and hydrologies.

Qualitative Larval Fish Sampling at Salvage Facilities

During the WY 2022 season, similar to recent years, qualitative larval fish sampling at the SWP and CVP fish salvage facilities began in February in recognition of the earlier larval entrainment period for Longfin Smelt relative to Delta Smelt. Despite the early start to qualitative larval sampling, and the presence of Longfin Smelt spawning in the Central and South Delta, the first month of qualitative larval sampling did not detect any Longfin Smelt larvae. However, by the second week of March 2022, larval Longfin Smelt were detected at both the SWP and CVP, ahead of when they would have been detected in prior years with a qualitative larval sampling start date around mid to late March. Given the life history of Longfin Smelt, proper management of larval entrainment would benefit from earlier data relative to Delta Smelt, though improvements in quantitative larval entrainment monitoring have the potential to provide substantially higher quality information on larval smelt presence compared to qualitative sampling in the facilities (see below).

Quantitative Larval Smelt Sampling near Clifton Court Forebay

During WY 2022, a new pilot larval smelt entrainment monitoring program (Larval Entrainment Pilot Study (LEPS), ITP COA 7.6.2) sampled in West Canal, near the radial gates for Clifton Court Forebay. Sampling was conducted by CDFW and occurred from January to May 2022, using both SLS (early season) and 20mm (late season) gears. Aside from regular diurnal sampling, CDFW also conducted several 24-hour sampling events to get data on larval smelt entrainment patterns during nighttime. While data are not yet available from this pilot effort, CDFW and DWR plan to continue refining the study design and evaluating additional sampling methods, such as eDNA sampling, with the goal of improving our understanding of larval smelt entrainment into Clifton Court Forebay. It is possible that in the future, initiation of qualitative larval sampling at the SWP and CVP could be tied to detections in this new monitoring program, or otherwise be coordinated, to make most efficient use of monitoring resources and meet the needs of real-time OMR management for the protection of Longfin Smelt and Delta Smelt.

Salmonid Presence-Based OMR Onramp and Offramp

OMR flow management season ended on June 16, 2022 for Chinook Salmon due to the meeting of the temperature and Delta distribution off-ramp criteria pursuant to the IOP. Note that steelhead OMR flow management season ended earlier, on June 15, 2022, as that is the date cutoff for the species. The last natural LAD winter-run Chinook Salmon was salvaged on April 27, 2022. The last natural steelhead was salvaged on May 5, 2022. Salvage occurrences for steelhead were slightly skewed towards the April to June period despite the counting of salvage occurrences in October and November towards the December to March period (35 percent from October 30, 2021 through March 31, 2022, and 65 percent from April 1, 2022 through June 15, 2022). The last juvenile LAD winter-run Chinook Salmon and steelhead were salvaged well

before the end of the OMR flow management season. During the OMR flow management season under the IOP, losses stayed within the annual and cumulative limits described in the ROD as well as the annual take limits from the ITS in the NMFS Biological Opinion and limits set in the SWP ITP for natural steelhead and/or natural winter-run Chinook Salmon.

OMR was more positive than -5,000 cfs during the period when the majority of salmonids were estimated by the SaMT to be present in the Central and South Delta regions, primarily due to other controlling factors related to drought conditions (e.g., TUCO) (Figure 6).

Average daily water temperatures are tracked at two sites (Mossdale, and Prisoner's Point) to evaluate the end of the OMR flow management season. Daily average water temperatures to meet offramp criteria at Mossdale (72° F in the NMFS 2019 Biological Opinion and 71.6° F in Reclamation's ROD, 22.2° C in the ITP) and Prisoners Point (22.2° C in the ITP) were met for winter-run and spring-run Chinook Salmon on June 16, 2022 in WY 2022 (Figure 28).The distribution estimates of greater than 95 percent for both natural YOY winter-run Chinook Salmon and natural YOY spring-run Chinook Salmon juveniles exited past Chipps Island was met by June 14, 2022.

Real-Time Decision-Making Tools

The SaMT and SMT utilize real-time data and various modeling tools to provide information for consideration by Reclamation for OMR flow management. These real-time decision-making tools are discussed in this section.

Salmonids

Distribution estimates of salmonids are provided by the SaMT weekly. The distributions are grounded in real-time operations data (i.e., KLCI, Mossdale Trawl, salvage and loss numbers, acoustically tagged juveniles, etc.) and modeling tools (Delta Simulation Model II (DSM2) model runs, STARS model predictions, entrainment model predictions). During WY 2022 before the DCC gate closures on November 30, 2021, weekly reports of KLCI and SCI values were received from CDFW and USFWS and Reclamation (Figure 3).

DSM2

Throughout the OMR flow management season, weekly DSM2 runs were modeled (model outputs available in weekly assessment files on https://www.usbr.gov/mp/bdo/water-year-2022.html). During WY 2022, drought conditions often affected the ability to run one or two scenarios to compare with a baseline OMR scenario. The potential scenarios, in meeting regulatory requirements, were constrained, and could not be varied by a value of 1,000 cfs. Operational differences less than 1,000 cfs are below the sensitivity of the DSM2 model. Accordingly, when the Base case was constrained by D-1641 meeting the X2 requirement via outflow, the IOP for April and May under ITP section 8.17 (Vernalis 1:1), and bound by the minimum combined export of 1,500 cfs through June under the TUCO only a single scenario could be modeled. For weeks when two OMR scenarios representing an operational range were available, they were compared to a baseline OMR using a Kolmogorov–Smirnov (K-S) statistical

test. The effect of the CVP and SWP export facilities' hydraulic footprint was discussed at the SaMT meetings. To assess the effects of operations, the Delta was subdivided into several regions: (1) the Central Delta from the Sacramento River to the Western Delta; (2) the South Delta from the San Joaquin River to the Central Delta; and (3) facilities in the South Delta. Within each of these regions, fish presence and behavior were considered. DSM2 modeling of potential operational changes indicated hydraulic changes close to the export facilities; however, the likelihood of listed salmonids in those regions was low throughout the water year based on concurrent salvage information, thus, no issues were elevated by SaMT members to WOMT. In WY 2022, DSM2 scenarios were frequently constrained to a single scenario due to drought conditions and operating to D-1641 TUCO. This meant there was no interpretation of DSM2 results which require at least two scenarios to provide alternatives to be interpreted by the SaMT.

SacPAS

SacPAS is a website that provides monitoring, evaluation, and web-based data products for management of salmonids and smelt. The SaMT and SMT rely on this publicly accessible, web-based query system to provide data support for real-time decision making during the DCC Gate operation and OMR flow management season. SacPAS has included data queries and alerts used by multiple work groups and teams on topics including, but not limited to, catch indices, water temperature, salvage, river conditions, escapement, and juvenile monitoring. This season, in addition to previously available tools, species distribution estimates plots and daily natural winter-run Chinook Salmon and natural steelhead loss at the Delta fish facilities were developed.

An entrainment estimation modeling tool (SacPAS Loss and Salvage Predictor, http://www.cbr.washington.edu/sacramento/lossandsalvage/) has been developed and is available on the SacPAS website. SacPAS produced weekly figures for salvage of natural winter-run Chinook Salmon and steelhead layered onto historic loss data (2009–2021). Using these figures, the SaMT evaluated on a weekly basis if the 50 percent single-year loss threshold (natural winter-run Chinook Salmon or natural steelhead) was likely to be exceeded. During WY 2022 OMR flow management season, none of the plots raised concerns that historic loss would cause WY 2022 loss of natural winter-run Chinook Salmon or steelhead to exceed the 50 percent of single-year threshold.

Salmonid Distribution Estimates and Cumulative Salvage

The SaMT provides weekly distribution estimates for three categories: (1) salmonids yet to enter the Delta; (2) salmonids within the Delta; and (3) salmonids that have exited the Delta past Chipps Island. These weekly estimates are made by incorporating the best available real-time data (salvage, hatchery releases, catch at real-time monitoring sites, DSM2 hydrodynamic modeling, etc.). Similar to WY 2020 and WY 2021, estimating fish distribution was difficult in WY 2022 as surveys for real-time fish distribution data were occasionally interrupted (COVID-19, fog, etc.) (Figure 9). Reclamation and DWR provided fish salvage monitoring throughout WY 2022 distributing daily sampling to the SaMT to track the percentage of the annual loss thresholds in conjunction with percentage of fish estimates to be within the Delta and percentage of fish estimated to have exited the Delta. Considering these two pieces of information, historical trends in distribution and salvage, fish behavior and salvage, in conjunction with export levels and hydrodynamic modeling (e.g., DSM2) allowed SaMT to consider risk for fish being routed

into the interior Delta from the Sacramento River or entrained into the fish salvage facilities once in the South Delta (e.g., 15 percent of 50 percent of single year threshold and 40 percent of the population within the Delta would result in less risk than 40 percent of 50 percent of single year threshold and 80 percent of the population within the Delta).

In WY 2022, there were low detections of salmonids at locations SaMT considered when producing distribution estimates (e.g., Knights Landing, Lower Sacramento RST, and Chipps Island), leading the group to rely heavily on historical patterns. Although there was a large number of spawning adults, the production of juvenile winter-run Chinook Salmon was low, as estimated from juveniles migrating past Red Bluff Diversion Dam, presumably due to the possible effects of elevated water temperature during spawning and egg incubation (i.e., temperature dependent mortality), as well as thiamine deficiency. Nevertheless, historic trends would suggest higher numbers of winter-run Chinook Salmon would have been observed at Knights Landing, and given the early migration into the Delta, at the CVP and SWP fish salvage facilities. Acknowledging that low overall juvenile abundance would limit the ability to detect juveniles, some other possible causes for low detection of juvenile salmonids in WY 2022 include assumptions about sampling bias and effort at each survey location, delayed impacts of thiamine-deficiency (Appendix G), and generally lower than expected migration survival and in-Delta survival due to different and unique hydrologic conditions. Hydrology in WY 2022 including, but not limited to, dry river conditions throughout the system, the limited rainfall events leading to lower flows, and low Delta outflows may have had a compounding impact on salmon, resulting in increased mortality of out-migrating juvenile salmon. A decreased number of juveniles in the system due to high mortality is one potential cause of the low observation rate in key downstream and estuarine monitoring locations including the Delta salvage facilities.

Delta STARS Model

The Delta STARS model (survival, travel time, and routing simulation) predicts survival, travel time, and routing of migrating juvenile Chinook Salmon through the Delta. Simulated fish enter the Delta on a given day at Freeport and the model examines conditions fish are likely to encounter. STARS accounts for DCC gates opening and closings and Delta inflow at Freeport and produces estimates of route specific survival through the Delta. STARS does not evaluate potential changes to export operations or changes to OMR. The model is used as a tool similar to historical data providing predictions on fish parameters (survival, travel time, and routing) based on what happened to late-fall Chinook Salmon that migrated through the Delta from November through mid-March 2007–2011. In WY 2022, the STARS model was updated to incorporate winter-run Chinook Salmon information for providing winter-run specific predictions. Results help guide SaMT on what might be expected of out-migrating juveniles based on the past.

Acoustic Tagging

Acoustically tagged salmonids were tracked throughout the Delta in WY 2022 (https://calfishtrack.github.io/real-time/index.html, Table 6). Real-time detections of tagged fish inform routing, entrainment, and survival. Information at critical junctions (Delta fish facilities, Georgiana Slough, Tower Bridge, Old River, Benicia Bridge) helps inform management decisions. The SaMT used tagging project data, along with other datasets (salvage, RST catch at

locations, etc.), to provide weekly distribution estimates for hatchery winter-run Chinook Salmon.

In WY 2022, hatchery-origin winter-run Chinook Salmon survival to Benicia from Caldwell Park was low at 5.8 percent (Table 6 and Table 7). The projected survival rate used for development of the hatchery-origin winter-run Chinook Salmon JPE was 28.18 percent (Appendix G).

Table 6. WY 2022 Acoustic Tagging: project details

Project	Release Date(s)	# of Fish Tagged	Groups (n) and description	Hatchery	Release Location(s)
Hatchery-origin winter-run Chinook Salmon	2/9/2022, 3/2/2022	569	n = 2 release groups 1 – 2	LSNFH	Caldwell Park
Hatchery-origin rice field reared fall-run Chinook Salmon	3/7/2022	315	n = 1	Coleman	Sutter Bypass
6-Year Study San Joaquin River Steelhead - March	3/15/2022	492	n = 3 Durham Ferry, Stockton, HOR	Mokelumne	Durham Ferry, Stockton, HOR
Hatchery-origin Battle Creek winter-run Chinook Salmon	3/16/2022	1200	*n = 3* release groups 1 – 3	Coleman	North Fork Battle Creek
San Joaquin hatchery spring-run Chinook Salmon	3/30/2022	694	*n = 1*	SCARF	Fremont Ford
Hatchery-origin fall-run Chinook Salmon April Paired Release (for COA 8.6.4.)	4/5/2022, 4/7/2022	600	*n = 2* Upstream, Downstream	Coleman	Battle Creek, Butte City
Mill and Deer Creek wild steelhead, Spring Releases	4/12/2022 – 5/10/2022	8	*n = 7* Mill Creek	N/A	Mill Creek
Upper Sacramento spring-run Chinook Salmon surrogates (not counted for COA 8.6.4.)	4/15/2022 - 5/5/2022	599	*n* = 4 release groups 1 – 4	Coleman	Red Bluff Diversion Dam
Natural-origin Red Bluff RST captured Chinook Salmon	4/15/2022 – 5/11/2022	302	*n = 4* release groups 1 – 4	N/A	Altube Island
6-Year Study San Joaquin River Steelhead - April	4/19/2022	484	*n = 3* Durham Ferry, Stockton, HOR	Mokelumne	Durham Ferry, Stockton, HOR

Table 7. WY 2022 Acoustic Tagging: minimum survival, SE, 90 percent confidence intervals (CI) to Benicia Bridge East Span and minimum through-Delta survival (City of Sacramento to Benicia) estimated using a Cormack-Jolly-Seber (CJS) survival model. Updated 6/30/22.

Project	Benecia Bridge – Survival (%)	N/A – SE	N/A – 95% Lower CI	N/A – 95% Upper CI	Through Delta – Survival (%)	N/A – SE	N/A – 95% Lower CI	N/A – 95% Upper CI
Hatchery-origin winter-run Chinook Salmon	5.8	1.0	4.2	8.0	43.4	5.7	32.8	54.7
Hatchery-origin rice field reared fall-run Chinook Salmon	1	0.5	0.3	2.9	9.7	5.3	3.2	26.1
6-Year Study San Joaquin River Steelhead -March Releases	7.7	1.2	5.7	10.5	N/A	N/A	N/A	N/A
Hatchery-origin Battle Creek winter-run Chinook Salmon	0.1	0.1	0	0.6	7.7	7.4	1.1	39.1
San Joaquin hatchery spring-run Chinook Salmon	No detections yet	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hatchery-origin fall-run Chinook Salmon April Release	2.2	0.6	1.3	3.8	25.9	6.3	15.5	39.8
Mill and Deer Creek wild steelhead, Spring Releases	No detections yet	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Upper Sacramento spring-run Chinook Salmon surrogates	0.7	0.3	0.2	1.8	12.9	6.0	4.9	29.7
Natural-origin Red Bluff RST captured Chinook Salmon	1.3	0.7	0.5	3.5	22.2	9.8	8.6	46.5
6-Year Study San Joaquin River Steelhead -April	10.3	1.4	7.9	13.4	N/A	N/A	N/A	N/A

Salmonid Distribution Uncertainty

In previous years, data have been used to validate SaMT's weekly distribution estimates and provide confidence in those estimates. In WY 2022, monitoring observations did not provide clear evidence of winter-run Chinook Salmon presence, especially towards the latter part of the season, and thus SaMT relied heavily on historic migration patterns. Because of the low observations at the salvage facilities (e.g., zero genetically identified winter-run Chinook Salmon) and the various surveys in WY 2022, it remains unclear whether operations drove this result or if significant mortality occurred due to poor drought conditions.

Juvenile Production Estimate (JPE) and Delta Survival

A juvenile production estimate is the number of the annual cohort of juvenile winter-run Chinook Salmon forecasted to enter the Delta, which helps inform an annual Take Limits

associated with the operation of the CVP and SWP (For more information see California Central Valley Water Operations: Biological Opinion Actions | NOAA Fisheries). NMFS issues to Reclamation and DWR hatchery-origin winter-run Chinook Salmon JPEs, utilizing recommendations from the winter-run JPE subteam of the IEP winter-run Chinook Salmon Project Work Team (WR PWT) after reviewing and updating the factors and methods with any new improvements (Appendix G). Recent data from monitoring surveys and survival estimates from acoustically tagged salmonids are incorporated into abundance and survival estimates for the JPE calculations. These data are typically evaluated during the annual WR PWT review of the factors and methods used to calculate a JPE that represents the best available science given the available data.

The JPE varies considerably by water year type and cohort size (Table 6) suggesting that many abiotic and biotic processes affect its value through their influence on both survival (actual Chinook Salmon abundance) and the efficiency of sampling gear (apparent Chinook Salmon abundance). As discussed in the Salmonids and Historic Performance section of this report, annual loss values vary widely by year.

There are many potential factors that may have caused low juvenile survival into the Delta, low observations in key Delta monitoring locations, OMR flows that were more positive than –5,000 cfs, and low salvage in WY 2022. There are observations to support some of these including flow-mediated increase travel times (see "Delta STARS Model", "Acoustic Tagging", and "Salmonid Distribution Uncertainty: Drivers & Empirical vs Model Results" sections above), higher thiamine deficiency in 2022 hatchery broodstock, and monitoring survey suspensions due to Covid-19. In addition, other factors may also reduce survival in the Delta, such as low turbidity resulting in higher predation.

Table 8. Winter-run Chinook Salmon JPE by brood year (BY) and water year type (WYT, 2009 – 2022).

WY	WRCH BY	WR JPE	Sac Basin WYT
2009	2008	JPE: 617,783 Hatchery JPE:82,050	Dry
2010	2009	JPE: 1,179,633 Hatchery JPE: 108,725	Below Normal
2011	2010	JPE 332,012 Hatchery JPE: 66,734	Wet
2012	2011	JPE: 162,051 Hatchery JPE: 96,525	Below Normal
2013	2012	JPE: 532,809 Hatchery JPE: 96,525	Dry
2014	2013	JPE: 1,196,387 Hatchery JPE: 30,880	Critical
2015	2014	JPE: 124,521 Hatchery JPE: 188,500	Critical

WY	WRCH BY	WR JPE	Sac Basin WYT
2016	2015	JPE: 101,716 Hatchery JPE: 155,400	Below Normal
2017	2016	JPE: 166,189 Hatchery JPE: 58,188	Wet
2018	2017	JPE: 201,409 Hatchery JPE 92,904 Battle Creek JPE: 90,924	Below Normal
2019	2018	JPE: 433,176 Hatchery JPE: 86,699 Battle Cr JPE: 82,366	Wet
2020	2019	JPE: 854,941 Hatchery JPE: 94,528 Battle Cr JPE: 67,257	Dry
2021	2020	JPE: 330,130 Hatchery JPE: 97,888 Battle Cr JPE: 37,232	Critical
2022	2021	JPE: 125,038 Hatchery JPE: 151,544 Battle Cr JPE: 7,311	Dry

Particle Tracking Models

Delta Smelt environmental surrogates, such as turbidity and OMR flows, are now used in conjunction with Particle Tracking Models (PTM) because it is impossible to accurately quantify and monitor the amount or number of individuals that are incidentally taken, due to the variability associated with the declining population size of Delta Smelt, and the difficulty in detecting individuals (USFWS 2019 Biological Opinion, p 394). Longfin Smelt risk assessments also use PTM results, in conjunction with in-Delta distributions of Longfin Smelt and other information, to help evaluate potential movement of Longfin Smelt larvae and juveniles between Delta regions resulting from operational scenarios (ITP 8.1.5.2 C and D).

In WY 2022, in order to standardize and streamline the running of weekly PTM scenarios, the SMT established fixed insertion points that could be adjusted if necessary due to larval catch if needed. This reduced the time to run a PTM to several days rather than a week or more. PTMs are used to plot the flow of neutrally buoyant particles from an insertion point in the Delta and estimate the percentage that will be entrained by the operational scenario used in the model. The SMT typically requests a scenario with the expected upper and lower OMR limits for the next week's operations. The PTM runs track particle fate weekly for three weeks, categorizing particles in three regions: entrained by project, OMR corridor, and downstream of Chipps Island. The insertion points used for the buoyant particles within are informed by the latest catch information collected by either SLS or 20 mm surveys. Thus, the very limited larval Delta Smelt catch in the South Delta in this season contributed to the limited utility of PTM runs for that species.

The Smelt Monitoring Team requested PTM runs for the purpose of evaluating the risk of Longfin Smelt larval entrainment on four occasions in WY 22022 on January 21, 2022; March 8, 2022; March 15, 2022; and March 22, 2022, with analyses of the PTM results occurring on January 25, 2022; March 11, 2022; March 22, 2022; and March 29, 2022, respectively. All runs were conducted after the onset of spawning, with particle injection locations at Stations 812, 815, and 902 to simulate larvae in Central and South Delta. The results from these PTM runs were then used in SMT discussions regarding OMR advice for the protection of larval and juvenile Longfin Smelt under ITP COA 8.4.2. Of these four PTM requests, one request (January 21, 2022) informed the SMT to recommend no OMR advice on January 25, 2022; two requests (March 8, 2022 and March 22, 2022) informed the SMT to recommend advice of an OMR no more negative than -1,250 cfs on a 7-day average on March 11, 2022 and March 29, 2022; and one request (March 15, 2022) informed the SMT to lift OMR advice on March 22, 2022. A hindcast PTM forecast was also run to replicate the March 15, 2022 PTM request, but with actual (i.e., non-forecasted) water operations. This hindcast PTM run informed the SMT of particle fate that would have resulted if the SMT recommendation of OMR no more negative than -1,250 cfs on a 7-day average not been lifted on March 22, 2022.

Effects of Operation

Longfin Smelt Salvage Trends

Salvage of larval and juvenile Longfin Smelt in WY 2022 was notably elevated relative to recent salvage trends and was the highest seasonal salvage total since WY 2002 (Error! Reference source not found.). Notably, young of year Longfin Smelt salvage trends have been elevated for the last three years (WY 2020, WY 2021, WY 2022), relative to the previous decade, though this trend is likely the result of a generally upstream distribution of spawning adults, and resultant larvae, due to dry hydrology since 2020 (CDFG 2009, Dege and Brown 2004). While Longfin Smelt salvage significantly increased in WY 2022, compared to WY 2020 and 2021, there may be insufficient data at this time to properly decouple the impacts of persistent dry hydrology from operational changes due to the ITP for the purpose of analyzing the effectiveness of ITP actions. Nevertheless, proposed efforts to develop a larval Longfin Smelt entrainment model (see Improvements section) will be critical for evaluating Longfin Smelt entrainment conceptual models and aiding the SMT in developing their risk assessments.

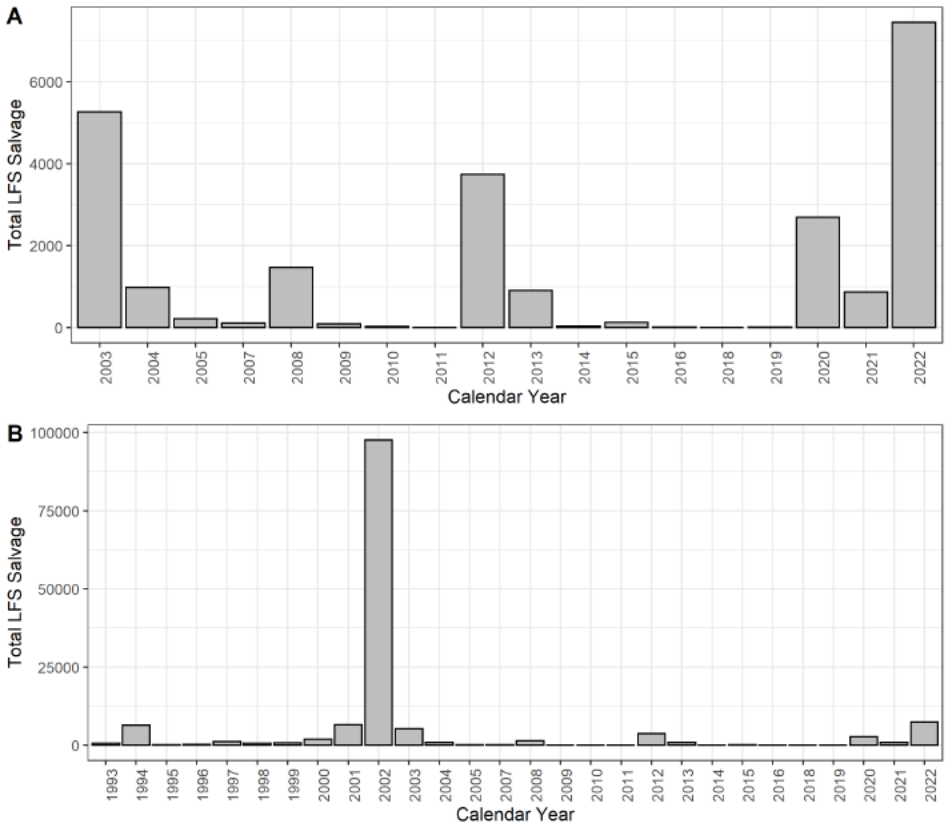


Figure 36. Long-term Longfin Smelt total annual salvage for (A) all years on record and (B) 2003-2022 (for ease of reviewing recent totals). Note that salvage is represented by calendar year, which generally aligns with water year totals as LFS are commonly salvaged in the late winter through spring months

Velocity Density Modeling/Exposure

Weekly DSM2 hydrodynamic modeling was conducted to assess the effects of different OMR scenarios within certain selected channels throughout the Delta region (see text above, see Appendix E). Behavior of fish in different Delta locations (e.g., Western Delta, Central Delta, and South Delta) was considered weekly in light of the hydrologic alteration modeled in the DSM2 modeling. Overall, velocity changes were very small. Rearing salmonids are unlikely to be transported since they spend their time holding and seeking food, but migrating salmonids move with the water. If migrating salmonids move the same amount as passive particles, they would move this distance per day in the South and Central Delta migration corridors. Enhanced particle tracking models are likely to better reflect the biological consequences of hydrologic alteration due to exports, yet these estimates provide one measurement for the modification of travel rates along these corridors toward the South Delta export facilities. Increased travel times exposes juvenile salmonids to increased predation throughout their Delta residency and potentially suboptimal water quality conditions during the spring. None of the model runs during OMR flow management season caused the SaMT concern or identified issues that needed to be elevated to WOMT.

Primary Channel Louver Cleaning Loss Study

Loss of fish through the Tracy Fish Collection Facility (TFCF) primary channel louver array contributes to fish loss at the TFCF (Karp et al. 2017, Wu et al. 2021) and can occur during regular facility operation or during cleaning of the primary channel louvers. While the loss of fish through the TFCF primary channel louvers during regular facility operation has been thoroughly investigated with various fish species and life stages, the extent of fish loss that occurs through the TFCF primary channel louver array when the primary channel louver panels are lifted, sprayed, and reseated for cleaning has not yet been thoroughly researched and/or directly quantified (only Karp et al. 2017 and Wu et al. 2021 briefly discuss this subject matter). Due to this, a study to be funded by the Tracy Fish Facility Improvement Program was proposed to estimate loss of juvenile Chinook Salmon during cleaning of the primary louvers at the TFCF for FY2023. Juvenile Chinook Salmon with surgically implanted predation detection acoustic tags (PDATs) will be used for this study. Until such time that louver cleaning loss is determined and factored into the Chinook Salmon loss equation, the Chinook Salmon loss equation does not consider any loss associated with primary channel louver array cleaning.

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Improvements

Improvements listed in this section may be evaluated as potential future updates to OMR flow management, including the OMR Guidance Document and DCC Guidance Document, which could assist operations in upcoming OMR flow management seasons. Updated versions of the OMR Guidance Document (Appendix A, dated December 1, 2020) and the DCC Guidance Document (Appendix B, dated April 1, 2020) are attached. Improvements may also be considered or evaluated by the four-year independent review panels.

Delta Cross Channel Gate Coordination

Reclamation offices are reviewing a new protocol to potentially be followed during future maintenance activities.

Proposed Drought Actions

To address reducing uncertainty regarding salmon distributions presumably due to poor survival and/or low detection efficiency in current monitoring during drought conditions, DWR has proposed to add Drought Toolkit items which will augment ongoing monitoring with Environmental DNA (eDNA) monitoring at the point of Delta entry. This information is intended to improve understanding of whether salmon are present but undetected in current monitoring, or simply not present. Currently eDNA monitoring cannot distinguish between Chinook Salmon races, and until new assays are developed to overcome these challenges, monitoring will have to be interpreted cautiously until models are developed to characterize the relationship between eDNA detection distribution and probable salmon distributions.

Ecological particle tracking: ePTM and ECO-PTM

Several models are in development for modeling juvenile salmonid survival and migration patterns, ECO-PTM (California DWR) and ePTM (NMFS SWFSC). Unlike DSM2 which tracks neutrally buoyant particles, particle models which incorporate fish behavior can be a more effective tool for quantitatively assessing fish parameters. These models have been calibrated and validated with acoustic tagged fish data. When available, pilot implementation of these models with weekly DSM2 runs may provide additional information of important biological response prediction such as fish reaching Chipps Island, the Central Delta, South Delta, and/or fish Salvage facilities to the SaMT to provide more realistic information regarding effects on migratory juvenile salmonids.

Winter-run Chinook Salmon salvage machine-learning tool

A new IEP-led model to predict winter-run Chinook Salmon salvage is currently in development. This tool, developed by Jeremy Gaeta (IEP CDFW), Trinh Nguyen (IEP CDFW), and Brian Mahardja (Reclamation) takes a machine learning approach (specifically extreme gradient boosting dropout multiple additive regression trees) to predict winter-run Chinook Salmon salvage as a function of numerous potential environmental drivers. This approach is different from the Tillotson et al. (2022) model (currently available on SacPAS) in that it is specifically interested in early-warning indicators to provide information prior to winter-run Chinook Salmon detection in salvage, whereas the Tillotson et al. (2022) model has been shown to accurately predict salvage numbers after winter-run Chinook Salmon are detected. Predictor variables may include, but are not limited to exports, passage at Red Bluff Diversion Dam, catch at Sacramento Trawl, water temperature at multiple locations, and brood day-of-year (DOY). Upon completion, this model may be deployed weekly and provide the SaMT with additional information regarding the likely start and end of winter-run Chinook Salmon observations at the fish salvage facilities.

Larval Longfin Smelt Entrainment Model

A new larval Longfin Smelt entrainment modeling effort is currently underway to develop quantitative tools for describing and forecasting entrainment risk. These tools can then be used to inform real-time operation of water export facilities by describing current larval Longfin Smelt entrainment risk based on a suite of distributional, environmental, and hydrological variables, and, ultimately, ensuring SWP compliance with ITP operational mandates. Additionally, these tools can support expert opinion-based approach to risk assessment and ultimately may provide a more transparent and reproduceable approach to determine appropriate operational constraints. In addition, such tools may facilitate the exploration of alternative operational scenarios to evaluate potential entrainment under different levels of exports.

Conclusion and Management Summary

Exports at the CVP and SWP export facilities and operations of the DCC Gates, with the few exceptions noted, were consistent with the ROD, consistent with implementation of the IOP, and within the effects anticipated by the 2019 USFWS and NMFS Biological Opinions. The CVP and SWP did not exceed the amount of annual take specified in the incidental take statement of listed fish species described in the 2019 USFWS and NMFS Biological Opinions. As detailed above, salmonid entrainment levels did not trigger OMR reverse flow reductions and losses did not exceed thresholds. As detailed above, dry conditions led to a TUCP, and the resulting TUCO controlled much of the CVP and SWP operations and exports, as well as DCC operations. OMR flow management was not primarily controlling in WY 2022. OMR flows did not exceed those prescribed by the incidental take statement in the 2019 USFWS Biological Opinion. No need was identified by the agencies for an independent panel review for WY 2022.

The SMT submitted the items below for consideration and development as part of the Guidance Document review after the WY 2022 OMR Management Season (additional details are available in post season meeting notes from July 12,2022):

- Joint SMT and SaMT operations update at 9:00 a.m.
- Move Delta Monitoring Workgroup (DMW) meetings to Wednesday mornings.
- CDFW to lead conversion of ITP Risk Assessment sections 1-A and 1-B to a tabular format.
- SMT to consider the use of a document sharing platform, e.g., Microsoft Teams, to allow members to view assessments during meetings.
- CDFW to include identification status information and track seasonal catch totals in survey update emails.
- CDFW to support development of sub-group to identify abiotic and biotic factors indicating Delta Smelt (DS) may move into areas at high risk of entrainment in the absence of a first flush.
    - Sub-group to meet in August or September and report back to the SMT in the fall.

The SaMT submitted the items below for consideration and development as part of the guidance document review prior to the WY 2022 OMR Management Season:

- Clarify the ITP off-ramp as it pertains to 95% exit.
- SaMT membership to develop a draft “fish distribution rules & process” document
- Coordinate on start of season presentations regarding the DSM2 and Tillotson/Gaeta et al. models

- Bring back compiled fish monitoring table ahead of the SaMT meeting
- Include salvage tables in ITP risk assessment

Recommendations adopted in WY 2022 from WY 2021

- Automation and standardizing of the PTM requests by the SMT.

Supporting Information

- Salmon Monitoring Team Notes and Proposed Action Assessments: https://www.usbr.gov/mp/bdo/salmon-monitoring-team.html
- Salmon Monitoring Team webpage: http://www.cbr.washington.edu/sacramento/workgroups/salmon_monitoring.html
- Smelt Monitoring Team Notes: https://www.usbr.gov/mp/bdo/smelt-monitoring-team.html
- Smelt Monitoring Team webpage: http://www.cbr.washington.edu/sacramento/workgroups/delta_smelt.html
- Smelt and Salmon Monitoring Teams ITP Risk Assessments: https://wildlife.ca.gov/Conservation/Watersheds/Water-Operations
- Water Operations Management Team Notes: https://www.usbr.gov/mp/bdo/water-operations-management.html
- Bay Delta Live Webpage: https://www.baydeltalive.com/current_conditions/turbidityReferences

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References

CNRFC 2021, CNRFC – WY2022 Water Resources Update November 23, 2021 Fact Sheet.

CNRFC 2022, CNRFC – WY2022 Water Resources Update January 31, 2022 Fact Sheet.

CNRFC 2022, CNRFC – WY2022 Water Resources Update April 29, 2022 Fact Sheet.

CDFG (2009). California Endangered Species Act Incidental Take Permit No. 2081-2009-001-03, California Department of Fish and Wildlife, Bay Delta Region (CDFW), Yountville, CA. Available: http://www.dfg.ca.gov/delta/data/longfinsmelt/documents/ITP-Longfin-1a.pdf.

Dege, M. and L. Brown (2004). Effect of outflow on spring and summertime distributions and abundance of larval and juvenile fishes in the upper San Francisco estuary. In American Fisheries Society Symposium 39, August 20-23 2003, Santa Cruz, CA. In, American Fisheries Society, Bethesda, MD. pp 49-65. F. Feyrer, L. Brown, R. Brown and J. Orsi (editors).

Hobbs, J. A., Lewis, L. S., Willmes, M., Denney, C., & Bush, E. (2019). Complex life histories discovered in a critically endangered fish. Scientific Reports, 9(1).

Grimaldo, L., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. Moyle, B. Herbold and P. Smith (2009). Factors Affecting Fish Entrainment into Massive Water Diversions in a Tidal Freshwater Estuary: Can Fish Losses be Managed?, North American Journal of Fisheries Management. 29: 1253- 1270.

Karp, C., B.J. Wu, and K. Kumagai. 2017. Juvenile Chinook Salmon, steelhead, and adult striped bass movements and facility efficiency at the Tracy Fish Collection Facility. Tracy Fish Collection Facility Studies, Tracy Technical Bulletin 2017-1. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 81 pp.

Sommer, T., Mejia, F. H, Nobriga, M. L, Feyrer, F., & Grimaldo, L. (2011). The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science, 9(2). doi:https://doi.org/10.15447/sfews.2014v9iss2art2

Tillotson M, Hassrick J, Collins A, Phillis C. 2022. Machine Learning Forecasts to Reduce Risk of Entrainment Loss of Endangered Salmonids at Large-Scale Water Diversions in the Sacramento–San Joaquin Delta, California. San Fr Estuary Watershed Sci. 20(2):0–21. doi:10.15447/sfews.2022v20iss2art3.

Wu, B.J., R.C. Reyes, C.L. Hart, K.K. Kumagai, and J.B. Miranda. 2021. Use of predation detection acoustic tags to estimate juvenile Chinook Salmon salvage efficiency and loss. Tracy Fish Collection Facility Studies, Tracy Series Volume 56. U.S. Bureau of Reclamation, California-Great Basin Region. 106 pp.