DEPARTMENT OF WATER RESOURCES
Division of Operations and Maintenance
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

BUREAU OF RECLAMATION
Central Valley Operations Office
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

March 18, 2022

Ms. Eileen Sobeck
Executive Director
California State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Subject: Temporary Urgency Change Petition Regarding Delta Water Quality

Dear Ms. Sobeck,

The U.S. Bureau of Reclamation (Reclamation) and Department of Water Resources (DWR) are submitting this Temporary Urgency Change Petition (TUCP) to request the State Water Resources Control Board (State Water Board) modify certain terms of the Central Valley Project (CVP) and State Water Project (SWP) (collectively Projects) water rights permits from what is currently provided in Water Rights Decision 1641 (D-1641) during the period from April 1 through June 30, 2022. Reclamation and DWR are requesting to modify certain terms as the Projects' storage and inflow may not be sufficient to meet D-1641 requirements and additional operational flexibility of the Projects is needed to support Reclamation and DWR's priorities, which include: operating the Projects to provide for minimum health and safety supplies (defined as minimum demands of water contractors for domestic supply, fire protection, or sanitation during the year); preserve upstream storage for release later in the summer to control saltwater intrusion into the Sacramento-San Joaquin Delta (Delta); preserve cold water in Shasta Lake and other reservoirs to manage river temperatures for various runs of Chinook salmon and steelhead; maintain protections for State and federally endangered and threatened species and other fish and wildlife resources; and meet other critical water supply needs. These modifications are urgently needed because the extraordinarily dry conditions of water year (WY) 2020, WY 2021, and January through March of WY 2022, in combination with the potential for low precipitation and associated low reservoir storage in the future, necessitate the proactive management of water resources for the April 1 through June 30 period of WY 2022. The TUCP will support Reclamation and DWR in balancing the competing demands on water supply and is critical to provide some protection of all beneficial uses of the Delta, including for fish and wildlife, salinity control, and critical water supply needs.

On December 1, 2021, Reclamation and DWR submitted a TUCP for the February through April 2022 period based on the extremely low storages in CVP and SWP reservoirs at the end of WY 2021. October and December 2021 storm events created a significant boost to Oroville and Folsom storages which, at the time, indicated that these reservoirs would be able to meet Delta outflows without a TUCP even under very dry conditions. Reclamation and DWR subsequently withdrew the TUCP request in mid-January. Unfortunately, the conditions seen in January and February 2022 were the driest on record throughout California. This caused the projected inflows to Oroville and Folsom for the January through March 2022 period to drop significantly below the driest conditions analyzed at the time the TUCP was withdrawn. With this decrease in expected inflow, these reservoirs can no longer support Delta outflows under D-1641 and there is not adequate storage in other CVP/SWP reservoirs to meet critical water supply needs without a TUCP in place. As a result, this TUCP is requesting relief on Delta requirements for the April 1 through June 30, 2022 period primarily to preserve storage in Oroville and Folsom to support Reclamation and DWR's priorities described above. This request is being submitted in March 2022, therefore there is still uncertainty with potential improvements in hydrology in late March through May 2022 period, which could eliminate or reduce the need for relaxation in the summer months of July and August, 2022. Reclamation and DWR will re-evaluate the observed and forecasted precipitation and inflow in early May 2022 to determine if a subsequent TUCP for the summer months is warranted. This approach allows for the conservation of critical spring storage, which is beneficial for temperature management later in the spring and summer, and avoiding relaxation if improved conditions can support D-1641 throughout the summer. The forecasts included in this TUCP are assuming conservative hydrology throughout the summer and reflect minimal potential precipitation improvement in the March through May 2022 period.

The emergency proclamation (Emergency Proclamation) issued on May 10, 2021 by Governor Newsom based on drought conditions in the Delta and other watersheds is still in effect. The continuation of extremely dry conditions in the Delta watershed has resulted in inadequate water supply to meet water right permit obligations for instream flows and water quality under D-1641.

As described in the attached TUCP and consistent with Directive 4 of the Emergency Proclamation, Reclamation and DWR are therefore petitioning the State Water Board to modify specific standards of the Projects' water rights permits from what is currently provided in D-1641 from April 1 through June 30, 2022, as summarized in Table 1.

Table 1: DWR and Reclamation Request Change Summary for the 2022 Spring/Summer TUCP

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
April 1 – April 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	4,000 cubic feet per second (cfs) based on a 14-day average	Max exports 1,500 cfs when not meeting D-1641.	The 4,000 cfs outflow modification was assessed in the biological review submitted in the December 2021 TUCP submittal. (14-day average is smaller averaging period than previous proposed to address Temporary Urgency Change Order (TUCO) issuance during the month of April).
May 1 - June 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	If the May 1 90% Sacramento River Index is not less than 8.1 million acre-feet (MAF): 14-day running average of 4,000 cfs outflow as described in D-1641 Table 3, footnote 10.	Max exports 1,500 cfs when not meeting D-1641	May 2021, the 90% Sacramento River Index was below 8.1 MAF, therefore there was no TUCP requested as we triggered the natural offramp of spring X2 and operated to a 14-day average NDOI of 4,000 cfs. In June 2021, requested a change from 4,000 cfs to 3,000 cfs on a 14-day average.
April 1 - June 30	San Joaquin River at Airport Way Bridge, Vernalis	Stanislaus will be operated to the Stepped Release Plan, which includes a spring pulse flow. Stanislaus releases will be increased, if necessary, to meet Vernalis base flow of 710 cfs.	Not applicable.	Modification was assessed in the biological review submitted in the December,1 2021 TUCP submittal.

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
April 1-June 30	Western Delta Agriculture Compliance point - Emmaton	Relocate Western Delta Agriculture compliance point from Emmaton to Threemile Slough.	Max exports 1,500 cfs when not meeting D-1641.	The relocation of the Emmaton Western Ag compliance point started June 1, 2021; and was assessed as part of the June 2021 TUCP biological review.

In support of the TUCP, Reclamation and DWR have prepared a Biological Review (Attachment 2 of the TUCP Petition) in compliance with the Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code), which establishes California's statutory authority for the protection of water quality. The beneficial uses protected in the Regional Water Quality Control Boards' Basin Plans include fish and wildlife, rare, threatened, or endangered species, and their habitats. As described in the TUCP, the proposed changes in operations will not injure other lawful users of water; will not unreasonably affect public trust resources such as fish and wildlife or other instream beneficial uses; and are in the public interest.

DWR and Reclamation have been consistently coordinating with NMFS, USFWS, CDFW, and the State Water Board to discuss various TUCP Biological Review approaches and analyses methodologies since preparation of the 2021 TUCP. On October 21 and October 22, 2021, Reclamation and DWR met with the NMFS, USFWS, CDFW, and the State Water Board, to receive input and discussion on a proposed 2022 TUCP that was developed and submitted, but ultimately retracted in January of 2022. DWR and Reclamation utilized this previous coordination in addition to a dedicated agency staff discussion meeting on March 14, 2022 to develop this TUCP Biological Review.

In addition, from April 1 through June 30, 2022, DWR and Reclamation will meet and confer weekly with the State Water Board to coordinate Project operations and water management. DWR and Reclamation will use the Water Operations Management Team (WOMT) and the Long-term Operations Agency Coordination Team, comprised of staff from Reclamation, DWR, NMFS, USFWS, CDFW, and the State Water Board, for this coordination effort. The WOMT meets weekly to provide hydrology and operations updates, coordinate Project operations and will discuss TUCP actions and other drought actions, as appropriate. In addition, as part of this petition, DWR and Reclamation will continue to coordinate with Long-term Operation Agency working groups to continue the robust monitoring programs in the 2022 Drought Contingency Plan. DWR shall also provide the State Water Board an updated harmful algal blooms (HABs) report in March 2023.

If sufficient precipitation were to occur to recover upstream storage in the April through June period, then Reclamation and DWR could resume operating to the D-1641 objectives and this TUCP would not be required. However, this is unlikely without a significant change in hydrology. Therefore, this TUCP will provide DWR, Reclamation, and the State Water Board an important tool for proactive and prudent management of scarce water supplies during the April through June period.

We urge the State Water Board to approve this TUCP and look forward to cooperatively working with the State Water Board and its staff during this challenging period to manage Delta water resources for the benefit of the people and natural resources of the state of California.

Karl [signature]　　　　Ernest Conant

Karla A. Nemeth
Director
Department of Water Resources

Ernest A. Conant
Regional Director
United States Bureau of Reclamation

Please indicate County where your project is located here:

Various

MAIL FORM AND ATTACHMENTS TO:
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Tel: (916) 341-5300 Fax: (916) 341-5400
http://www.waterboards.ca.gov/waterrights

PETITION FOR CHANGE

Separate petitions are required for each water right. Mark all areas that apply to your proposed change(s). Incomplete forms may not be accepted. Location and area information must be provided on maps in accordance with established requirements. (Cal. Code Regs., tit. 23, § 715 et seq.) Provide attachments if necessary.

☐ **Point of Diversion** Wat. Code, § 1701
☐ **Point of Rediversion** Cal. Code Regs., tit. 23, § 791(e)
☐ **Place of Use** Wat. Code, § 1701
☐ **Purpose of Use** Wat. Code, § 1701
☐ **Distribution of Storage** Cal. Code Regs., tit. 23, § 791(e)
☒ **Temporary Urgency** Wat. Code, § 1435
☐ **Instream Flow Dedication** Wat. Code, § 1707
☐ **Waste Water** Wat. Code, § 1211
☐ **Split** Cal. Code Regs., tit. 23, § 836
☐ **Terms or Conditions** Cal. Code Regs., tit. 23, § 791(e)
☐ **Other**

Application Various Permit Various License Various Statement

I (we) hereby petition for change(s) noted above and described as follows:

Point of Diversion or Rediversion – Provide source name and identify points using both Public Land Survey System descriptions to ¼-¼ level and California Coordinate System (NAD 83).
Present: Not requested

Proposed: No change

Place of Use – Identify area using Public Land Survey System descriptions to ¼-¼ level; for irrigation, list number of acres irrigated.
Present: Not requested

Proposed: No change

Purpose of Use
Present: Not requested

Proposed: No change

Split
Provide the names, addresses, and phone numbers for all proposed water right holders.

Not requested

In addition, provide a separate sheet with a table describing how the water right will be split between the water right holders: for each party list amount by direct diversion and/or storage, season of diversion, maximum annual amount, maximum diversion to offstream storage, point(s) of diversion, place(s) of use, and purpose(s) of use. Maps showing the point(s) of diversion and place of use for each party should be provided.

Distribution of Storage
Present: Not requested

Proposed: No change

Temporary Urgency
This temporary urgency change will be effective from 04/01/2022 to 06/30/2022 .

Include an attachment that describes the urgent need that is the basis of the temporary urgency change and whether the change will result in injury to any lawful user of water or have unreasonable effects on fish, wildlife or instream uses.

Instream Flow Dedication – Provide source name and identify points using both Public Land Survey System descriptions to ¼-¼ level and California Coordinate System (NAD 83).
Upstream Location: Not requested

Downstream Location: Not requested

List the quantities dedicated to instream flow in either: ☐ cubic feet per second or ☐ gallons per day:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Will the dedicated flow be diverted for consumptive use at a downstream location? ☐ Yes ☐ No
If yes, provide the source name, location coordinates, and the quantities of flow that will be diverted from the stream.

Waste Water
If applicable, provide the reduction in amount of treated waste water discharged in cubic feet per second.

Will this change involve water provided by a water service contract which prohibits your exclusive right to this treated waste water? ☐ Yes ☒ No

Will any legal user of the treated waste water discharged be affected? ☐ Yes ☒ No

General Information – For all Petitions, provide the following information, if applicable to your proposed change(s).

Will any current Point of Diversion, Point of Storage, or Place of Use be abandoned? ☐ Yes ☒ No

I (we) have access to the proposed point of diversion or control the proposed place of use by virtue of:
☒ ownership ☐ lease ☐ verbal agreement ☐ written agreement

If by lease or agreement, state name and address of person(s) from whom access has been obtained.

Give name and address of any person(s) taking water from the stream between the present point of diversion or rediversion and the proposed point of diversion or rediversion, as well as any other person(s) known to you who may be affected by the proposed change.

All Right Holders Must Sign This Form: I (we) declare under penalty of perjury that this change does not involve an increase in the amount of the appropriation or the season of diversion, and that the above is true and correct to the best of my (our) knowledge and belief. Dated 3/18/2022 at Sacramento, CA .

Karl Stinson (signature)

Right Holder or Authorized Agent Signature

Ernest Conant

Right Holder or Authorized Agent Signature

NOTE: All petitions must be accompanied by:
(1) the form Environmental Information for Petitions, including required attachments, available at: http://www.waterboards.ca.gov/waterrights/publications_forms/forms/docs/pet_info.pdf
(2) Division of Water Rights fee, per the Water Rights Fee Schedule, available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/fees/
(3) Department of Fish and Wildlife fee of $850 (Pub. Resources Code, § 10005)

State of California
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Tel: (916) 341-5300 Fax: (916) 341-5400
http://www.waterboards.ca.gov/waterrights

ENVIRONMENTAL INFORMATION FOR PETITIONS

This form is required for all petitions.

Before the State Water Resources Control Board (State Water Board) can approve a petition, the State Water Board must consider the information contained in an environmental document prepared in compliance with the California Environmental Quality Act (CEQA). This form is not a CEQA document. If a CEQA document has not yet been prepared, a determination must be made of who is responsible for its preparation. As the petitioner, you are responsible for all costs associated with the environmental evaluation and preparation of the required CEQA documents. Please answer the following questions to the best of your ability and submit any studies that have been conducted regarding the environmental evaluation of your project. If you need more space to completely answer the questions, please number and attach additional sheets.

DESCRIPTION OF PROPOSED CHANGES OR WORK REMAINING TO BE COMPLETED

For a petition for change, provide a description of the proposed changes to your project including, but not limited to, type of construction activity, structures existing or to be built, area to be graded or excavated, increase in water diversion and use (up to the amount authorized by the permit), changes in land use, and project operational changes, including changes in how the water will be used. For a petition for extension of time, provide a description of what work has been completed and what remains to be done. Include in your description any of the above elements that will occur during the requested extension period.

The U.S. Bureau of Reclamation (Reclamation) and Department of Water Resources (DWR) are submitting this Temporary Urgency Change Petition (TUCP) to request the State Water Resources Control Board (State Water Board) modify certain terms of the Central Valley Project (CVP) and State Water Project (SWP) (collectively Projects) water rights permits from what is currently provided in Water Rights Decision 1641 (D 1641) during the period from April 1 through June 30, 2022. Reclamation and DWR are requesting to modify certain terms as the Projects' storage and inflow may not be sufficient to meet D-1641 requirements and additional operational flexibility of the Projects is needed. These modifications are urgently needed because the extraordinarily dry conditions of water year (WY) 2020, WY 2021, and January through March of WY 2022, in combination with the potential for low precipitation and associated low reservoir storage in the future, necessitate the proactive management of water resources for the April 1 through June 30 period of WY 2022. The TUCP will support Reclamation and DWR in balancing the competing demands on water supply and is critical to provide some protection of all beneficial uses of the Delta.

As stated in the TUCP, the proposed changes in operations will not injure other lawful users of water, will not unreasonably affect public trust resources such as fish and wildlife or other instream beneficial uses, and are in the public interest. If sufficient precipitation were to occur prior to and/or during the 2022 TUCP period to recover upstream storage, then Reclamation and DWR would re-evaluate the basis for the TUCP and amend the TUCP and/or resume operating to the D-1641 objectives in coordination with the Long-term Operation Agency Coordination Team. This TUCP will provide DWR, Reclamation, and the State Water Board an important tool for prudent management of scarce water supplies during the course of the declared drought emergency.

The TUCP is only for modification to certain terms of the CVP and SWP water right permits from what is currently provided in D-1641 and does not include construction activities, changes in land use, nor changes to how the water will be used.

See Attachment 1 "Supplement to Temporary Urgency Change to Certain DWR and Reclamation Permit Terms as Provided in D-1641," and Attachment 2 "Biological Review for the 2022 April through June Temporary Urgency Change Petition," and Attachment 3 "Summary of Primary Modeling Assumptions for April through June 2022."

Insert the attachment number here, if applicable: 1, 2 and 3

Coordination with Regional Water Quality Control Board

For change petitions only, you must request consultation with the Regional Water Quality Control Board regarding the potential effects of your proposed change on water quality and other instream beneficial uses. (Cal. Code Regs., tit. 23, § 794.) In order to determine the appropriate office for consultation, see: http://www.waterboards.ca.gov/waterboards_map.shtml. Provide the date you submitted your request for consultation here, then provide the following information.

Date of Request

Will your project, during construction or operation, (1) generate waste or wastewater containing such things as sewage, industrial chemicals, metals, or agricultural chemicals, or (2) cause erosion, turbidity or sedimentation? ☐ Yes ☒ No

Will a waste discharge permit be required for the project? ☐ Yes ☒ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable:

Local Permits

For temporary transfers only, you must contact the board of supervisors for the county(ies) both for where you currently store or use water and where you propose to transfer the water. (Wat. Code § 1726.) Provide the date you submitted your request for consultation here.

Date of Contact

For change petitions only, you should contact your local planning or public works department and provide the information below.

Person Contacted: Not Applicable

Date of Contact:

Department:

Phone Number:

County Zoning Designation:

Are any county permits required for your project? If yes, indicate type below. ☐ Yes ☒ No

Grading Permit   Use Permit   Watercourse   Obstruction Permit

Change of Zoning   General Plan Change   Other (explain below)

If applicable, have you obtained any of the permits listed above? If yes, provide copies. ☐ Yes ☐ No

If necessary, provide additional information below:

Not Applicable

Insert the attachment number here, if applicable:

Federal and State Permits

Check any additional agencies that may require permits or other approvals for your project:

☐ Regional Water Quality Control Board ☐ Department of Fish and Game

☐ Dept of Water Resources, Division of Safety of Dams ☐ California Coastal Commission

☐ State Reclamation Board ☐ U.S. Army Corps of Engineers ☐ U.S. Forest Service

☐ Bureau of Land Management ☐ Federal Energy Regulatory Commission

☐ Natural Resources Conservation Service

Have you obtained any of the permits listed above? If yes, provide copies. ☐ Yes ☐ No

For each agency from which a permit is required, provide the following information:

Agency	Permit Type	Person(s) Contacted	Contact Date	Phone Number
Not Applicable				

If necessary, provide additional information below:

Insert the attachment number here, if applicable:

Construction or Grading Activity

Does the project involve any construction or grading-related activity that has significantly altered or would significantly alter the bed, bank or riparian habitat of any stream or lake? ☐ Yes ☒ No

If necessary, provide additional information below:

Insert the attachment number here, if applicable:

Archeology

Has an archeological report been prepared for this project? If yes, provide a copy. ☐ Yes ☒ No

Will another public agency be preparing an archeological report? ☐ Yes ☒ No

Do you know of any archeological or historic sites in the area? If yes, explain below. ☐ Yes ☒ No

If necessary, provide additional information below:

Not Applicable

Insert the attachment number here, if applicable:

Photographs

For all petitions other than time extensions, attach complete sets of color photographs, clearly dated and labeled, showing the vegetation that exists at the following three locations:

☐ Along the stream channel immediately downstream from each point of diversion

☐ Along the stream channel immediately upstream from each point of diversion

☐ At the place where water subject to this water right will be used

Maps

For all petitions other than time extensions, attach maps labeled in accordance with the regulations showing all applicable features, both present and proposed, including but not limited to: point of diversion, point of rediversion, distribution of storage reservoirs, point of discharge of treated wastewater, place of use, and location of instream flow dedication reach. (Cal. Code Regs., tit. 23, §§ 715 et seq., 794.)

Pursuant to California Code of Regulations, title 23, section 794, petitions for change submitted without maps may not be accepted.

All Water Right Holders Must Sign This Form:
I (we) hereby certify that the statements I (we) have furnished above and in the attachments are complete to the best of my (our) ability and that the facts, statements, and information presented are true and correct to the best of my (our) knowledge. Dated 3/18/2022 at Sacramento, CA.

[illegible]

Water Right Holder or Authorized Agent Signature

Ernest Conant

Water Right Holder or Authorized Agent Signature

NOTE:

- **Petitions for Change may not be accepted unless you include proof that a copy of the petition was served on the Department of Fish and Game. (Cal. Code Regs., tit. 23, § 794.)**
- **Petitions for Temporary Transfer may not be accepted unless you include proof that a copy of the petition was served on the Department of Fish and Game and the board of supervisors for the county(ies) where you currently store or use water and the county(ies) where you propose to transfer the water. (Wat. Code § 1726.)**

ATTACHMENT 1:
SUPPLEMENT TO APRIL 1 THROUGH JUNE 30, 2022 TEMPORARY URGENCY CHANGE TO CERTAIN DWR AND RECLAMATION PERMIT TERMS AS PROVIDED IN D-1641

California Department of Water Resources

Application Numbers 5630, 14443, 14445A, 17512, 17514A, Permits 16478, 16479, 16481, 16482, 16483

U.S. Bureau of Reclamation Permits for the Central Valley Project

Application Numbers: 23, 234, 1465, 5626, 5628, 5638, 9363, 9364, 9366, 9367, 9368, 13370, 13371, 14858A, 14858B, 15374, 15375, 15376,15764, 16767, 16768, 17374, 17376, 19304, 22316

License Number 1986 and Permit Numbers: 11885, 11886, 12721, 11967, 11887, 12722,12723, 12725, 12726, 12727, 11315, 11316, 16597, 20245,11968,11969, 11970, 12860, 11971, 11972, 11973, 12364, 16600, 15735

I. Requested Change

The U.S. Bureau of Reclamation (Reclamation) and Department of Water Resources (DWR) are submitting this Temporary Urgency Change Petition (TUCP) to request the State Water Resources Control Board (State Water Board) modify certain terms of the Central Valley Project (CVP) and State Water Project (SWP) (collectively, Projects) water rights permits from what is currently provided in Water Rights Decision 1641 (D-1641) during the period from April 1 through June 30, 2022. Reclamation and DWR are making this request in response to the ongoing drought emergency, as the Projects' storage and inflow may not be sufficient to meet D-1641 requirements while providing for other critical water supply needs in the State. Additional operational flexibility of the Projects is urgently needed to support Reclamation and DWR's priorities, which include: operating the Projects to provide for minimum health and safety supplies (defined as minimum demands of water contractors for domestic supply, fire protection, or sanitation during the year); preserve upstream storage for release later in the summer to control saltwater intrusion into the Sacramento-San Joaquin Delta (Delta); preserve cold water in Shasta Lake and other reservoirs to manage river temperatures for various runs of Chinook salmon and steelhead; maintain protections for State and federally endangered and threatened species and other fish and wildlife resources; and meet critical water supply needs. These modifications are urgently needed because of the extraordinarily dry conditions of water year (WY) 2020, WY 2021, and January through March of WY 2022 in combination with the potential for low future precipitation and low reservoir storage, thereby necessitating proactive management of water resources for the April 1 through June 30 period of WY 2022. The TUCP will support Reclamation and DWR in balancing the competing demands on water supply and is critical to provide some protection of all beneficial uses of the Delta including for health and safety, fish and wildlife, salinity control, and critical water supply needs.

On December 1, 2021, Reclamation and DWR submitted a TUCP for the February through April 2022 period based on the extremely low storages in CVP and SWP reservoirs at the end of WY 2021. October and December 2021 storm events created a significant boost to Oroville and Folsom storages which, at the time, indicated that these reservoirs would be able to meet Delta outflows without a TUCP, even under very dry conditions. Reclamation and DWR subsequently withdrew the TUCP request in mid-January. Unfortunately, the conditions seen in January and February 2022 were the driest on record throughout California. This caused the projected inflows to Oroville and Folsom for the January through March 2022 period to drop significantly below the driest conditions analyzed at the time the TUCP was withdrawn. With this decrease in expected inflow, these reservoirs can no longer support Delta outflows under D-1641 and there is not adequate storage in other CVP/SWP reservoirs to meet critical water supply needs without a TUCP in place. As a result, this TUCP is requesting relief on Delta requirements for the April 1 through June 30, 2022 period primarily to preserve storage in Oroville and Folsom to support Reclamation and DWR's priorities described above. This request is being submitted in March 2022, therefore there is still uncertainty with potential improvements in hydrology in late March through May 2022 period, which could eliminate or reduce the need for relaxation in the summer months of July and August, 2022. Reclamation and DWR will re-evaluate the observed and forecasted precipitation and inflow in early May 2022 to determine if a subsequent TUCP for the summer months is warranted. This approach allows for the conservation of critical spring storage, which is beneficial for temperature management later in the spring and summer, and avoiding relaxation if improved conditions can support D-1641 throughout the summer. The forecasts included in this TUCP are assuming conservative hydrology throughout the summer and reflect minimal potential precipitation improvement in the March through May 2022 period.

Below is a summary of drought conditions, current and previous TUCPs submitted, as well as, the agency coordination that will occur throughout the subject 2022 TUCP period.

I. A. Summary of Current Drought Conditions, 2021 TUCP, and Initial 2022 TUCP

California experienced its warmest statewide monthly average temperatures ever recorded in June and July, 2021[1].In addition, WY 2020 to 2021 period was the second driest two-year period for the Northern Sierra 8-station index.

WY 2021 started with dry conditions, but due to significant and uncharacteristically warm temperatures and deficits in watershed runoff, hydrology in late April 2021 significantly deteriorated, especially in the Sacramento Valley. In spite of well-below average rainfall, the measured snowpack in March 2021 suggested sufficient spring reservoir inflow to meet D-1641 Delta water quality and outflow requirements. Conditions significantly changed in April 2021 when the actual and the forecasted

[1] National Oceanic and Atmospheric Administration's National Centers for Environmental Information, October 2021

reservoir inflows drastically declined. Instead, the snowmelt absorbed into the parched soils or sublimated into the atmosphere and the Sacramento Four River Index 90% exceedance water year forecast decreased by 685 thousand acre-feet (TAF) between April and May 2021. A combination of several factors, including the May 2021 runoff being far lower than anticipated, extremely low rainfall, dry soils, continued dry and historical warm conditions posed significant challenges for the Projects. In addition, the May 1, 2021 Bulletin 120 (B120) hydrological projections indicated significant risks to maintaining minimum health and safety supplies, temperature management, minimum instream flow, power generation, and the ability to manage salinity intrusion in the Delta through the summer and fall of 2021.

On May 10, 2021, Governor Newsom issued an emergency proclamation (Emergency Proclamation) based on drought conditions in the Bay-Delta and other watersheds, stating that the continuation of extremely dry conditions in the Delta watershed had resulted in scarce water supply. It was determined that meeting all water right permit obligations for Delta outflow and water quality requirements under D-1641 would further exacerbate the already low upstream Project storages.

On May 17, 2021, DWR and Reclamation submitted a TUCP to the State Water Board requesting modifications of certain requirements of D-1641. The TUCP was conditionally approved by the State Water Board on June 1, 2021, allowing DWR and Reclamation to conserve upstream storage by modifying Delta outflow and water quality standards set forth in D-1641 for the period of June 1, 2021, through August 15, 2021.

Throughout the spring, summer and fall of 2021, dry and warm conditions persisted and DWR and Reclamation continued to take actions to conserve water and reduce impacts to fish and wildlife and other instream uses. These actions included reducing allocations to CVP agricultural water service contractors (both north-of-Delta and south-of-Delta) to 0%[2] and allocations to the 29 long-term SWP Table A contractors to 5%.[3] DWR and Reclamation delayed release and export of CVP and SWP water transfers to retain stored water in Shasta Reservoir, Lake Oroville, and Folsom Reservoir[4] to support temperature management and allow for instream uses and water quality requirements. Per the Emergency Proclamation, the Emergency Drought Salinity Barrier Project (EDB) at West False River was installed in June 2021 to mitigate saltwater intrusion and thereby protect municipal and industrial supplies at the CVP, SWP, and other municipal and industrial diversions in the Delta. On October 1, 2021, the Projects began WY 2022 with one of the lowest combined carryover storage of about 2.0 MAF, less than half of the combined storage at the beginning of WY 2021. At the beginning of WY 2022, storage was 42% of historical average at Shasta Reservoir, 41% of historical average at Lake Oroville, and 47% of historical average at Folsom Reservoir.

---

[2] https://www.usbr.gov/newsroom/#/news-release/3796?filterBy=region&region=California-Great%20Basin

[3] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Management/SWP-Water-Contractors/Files/NTC_21-06_032321.pdf

[4] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Files/ITP/CVP-and-SWP-Drought-PlanUpdate-Aug-2021-simplifieday11.pdf

If dry conditions had persisted, it was projected that by December 31, 2021, Shasta Reservoir storage would have been at 1.1 MAF (40% of historical average), Lake Oroville storage would have been at 1.1 MAF (60% of historical average) and Folsom Reservoir storage would have been at 336 TAF (84% of historical average). This was a projected decrease of approximately 1.05 MAF from the combined reservoir storage of 3.56 MAF on December 31, 2020.

Faced with the potential for continuing dry conditions and extremely low storage conditions, Reclamation and DWR prepared and submitted a TUCP on December 1, 2021, requesting modification to D-1641 standards for the February through April 2022 period. During the preparation of that TUCP, the Northern Sierra 8-Station hydrologic conditions improved as October was the second wettest October on record. Additional precipitation and a building snowpack by the end of December, with 167% of average 8-Station precipitation and 157% of average snowpack, prompted Reclamation and DWR on January 18, 2022, to withdraw the petition. Upon the TUCP withdrawal, DWR and Reclamation committed to continue to assess the need for a TUCP later in the year, should the hydrologic conditions worsen.

I. B. Summary of 2022 Drought Conditions and Anticipated Conditions and Actions for April 1 through June 30, 2022

Unfortunately, hydrologic conditions took a turn for the worse in early 2022. High pressure off the coast of California that set up in early January 2022 has been directing storm systems well to the north. January and February 2022 are historically on average two of the wettest months of the water year, however, combined, January and February 2022 were the driest on record.

The 8-Station Index (Index) is a measure of 8 precipitation stations in the Sacramento Valley watersheds. **Figure 1** shows the cumulative precipitation, where early storms boosted the Index in October and December 2021. Since the end of December 2021, precipitation has been minimal. The following months of January and February 2022 were the driest on record since at least 1920. **Figure 2** shows a ranking of the last 103 years with the lowest precipitation in January and February of 2022.

Snowpack has decreased with intermittent warm weather and minimal precipitation. The resulting runoff from unusual early season snowmelt has incrementally increased outflow requirements in February and March 2022. This is due to the structure of the D-1641 requirement where the previous month's unimpaired flow in the Sacramento and San Joaquin Valleys determines the amount of outflow required the following month. Typically, in January and February, precipitation and natural runoff below reservoirs tend to be a big driver of these unimpaired flow values. In addition, the Projects would have in part met outflow requirements through the natural runoff in the system, however, increased releases were needed. This year with low precipitation and runoff below the reservoirs, it was the unusually high snowmelt runoff into the reservoirs that drove outflow requirements higher. This snowmelt runoff would have otherwise been stored but instead were released to meet outflow requirements.

Figure 3 shows the progression of snow water content for 2021-2022 as compared to 1982-1983, 2014-2015, and 2020-2021.

Attachment 1. Supplement to April - June 2022 Temporary Urgency Change

Figure 1. 8-Station Index

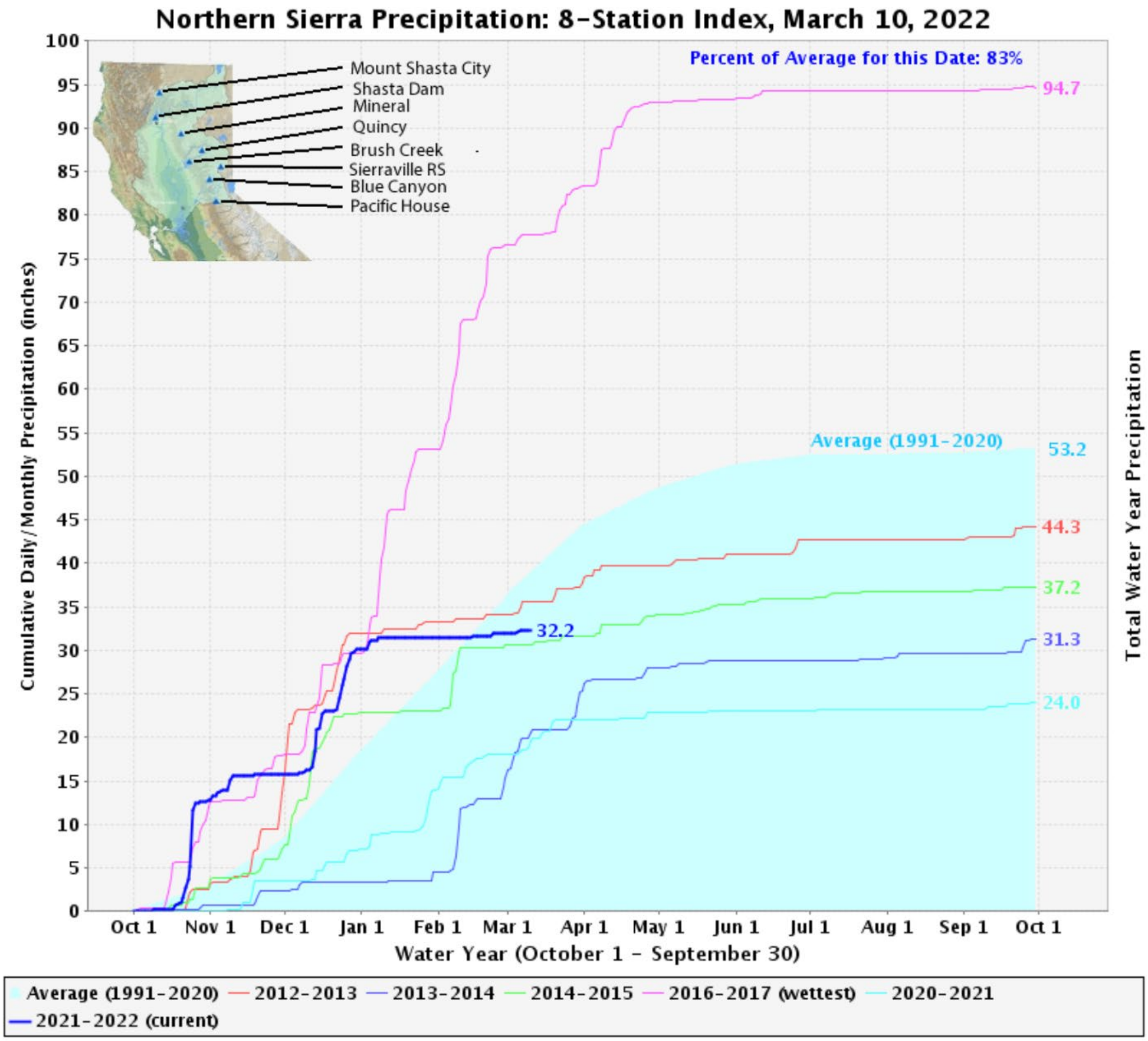


Figure 2. Total January and February 8-station precipitation ranked over 103 years

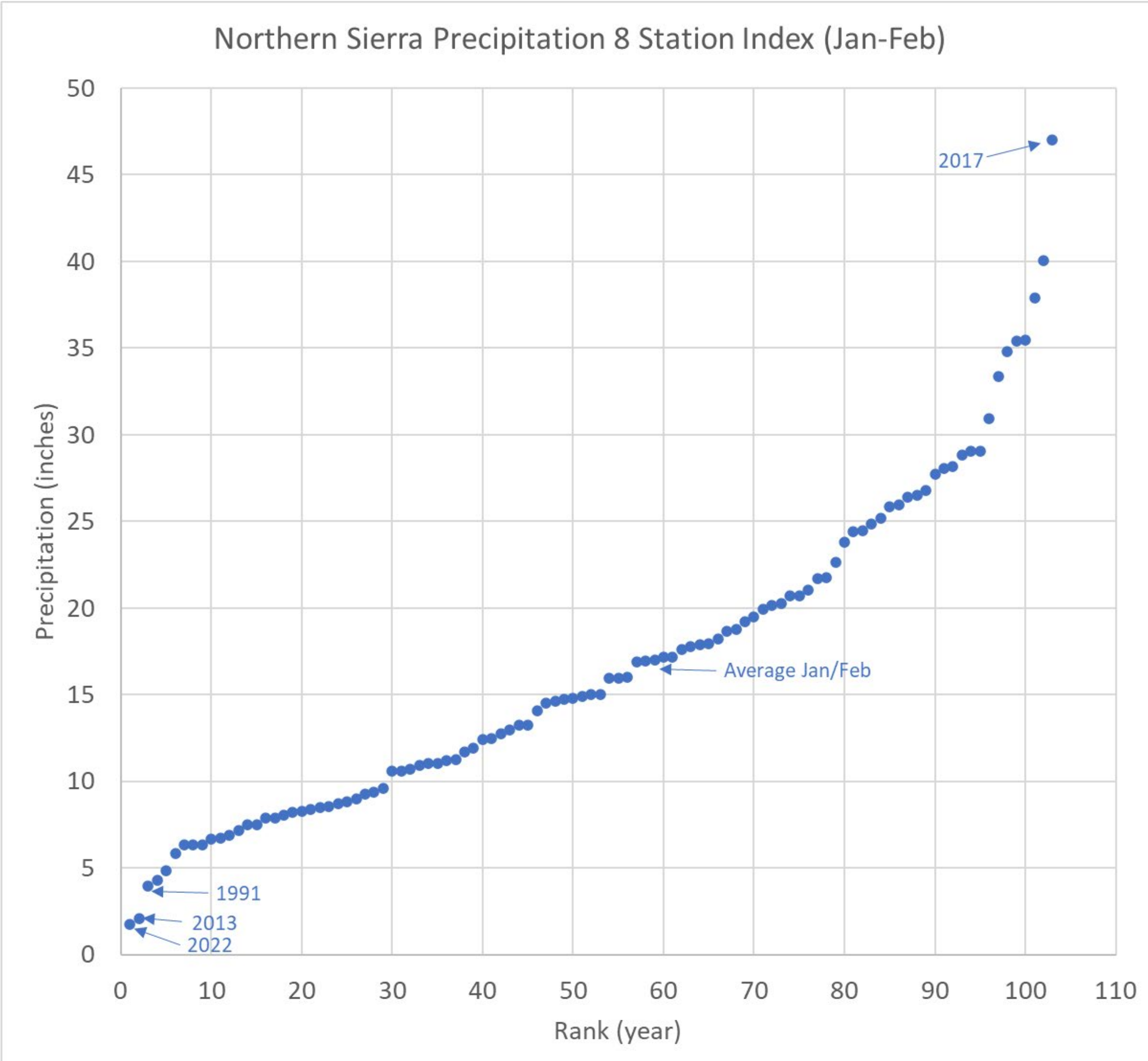
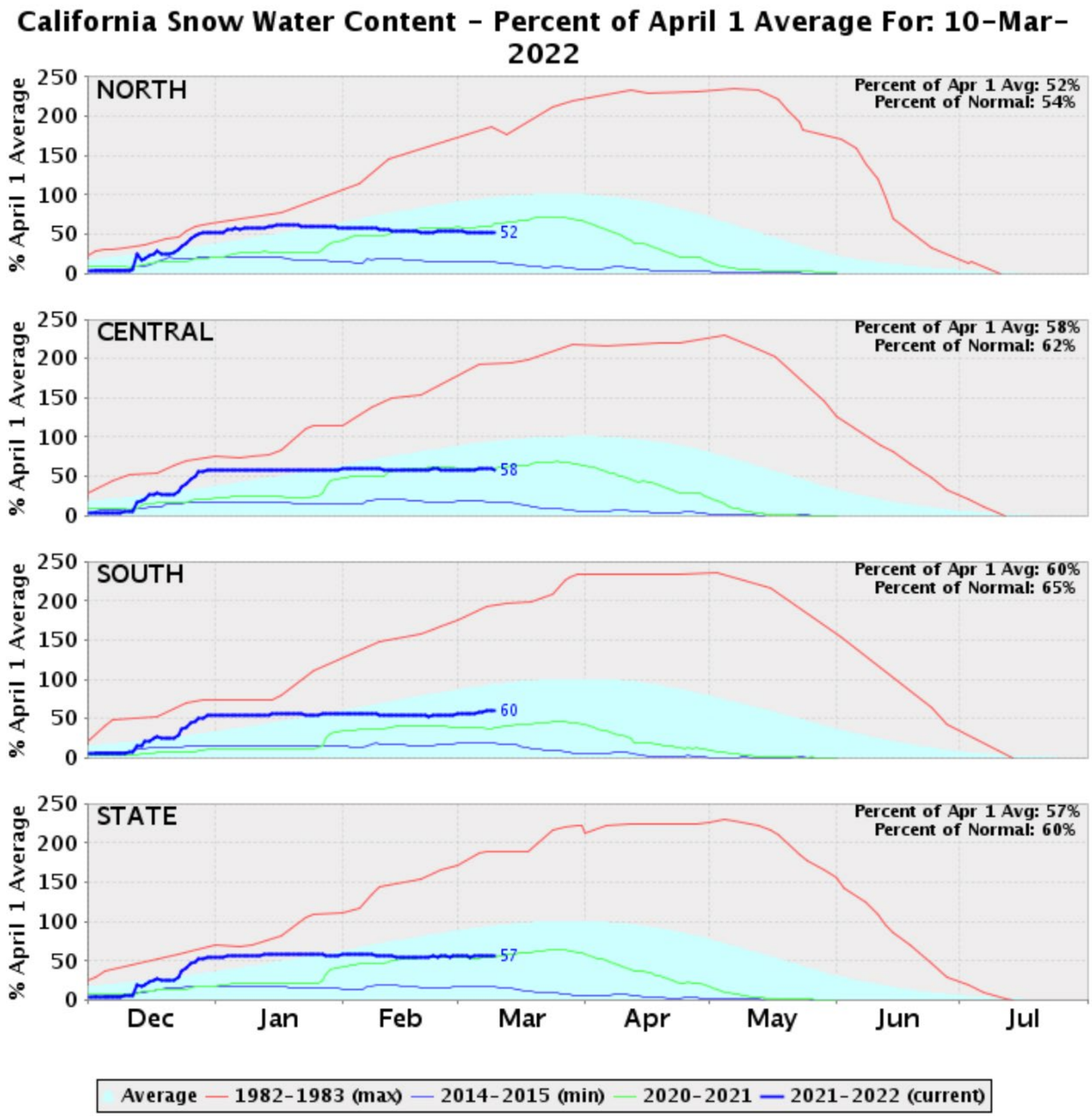


Figure 3. Progression of Snow Water Content

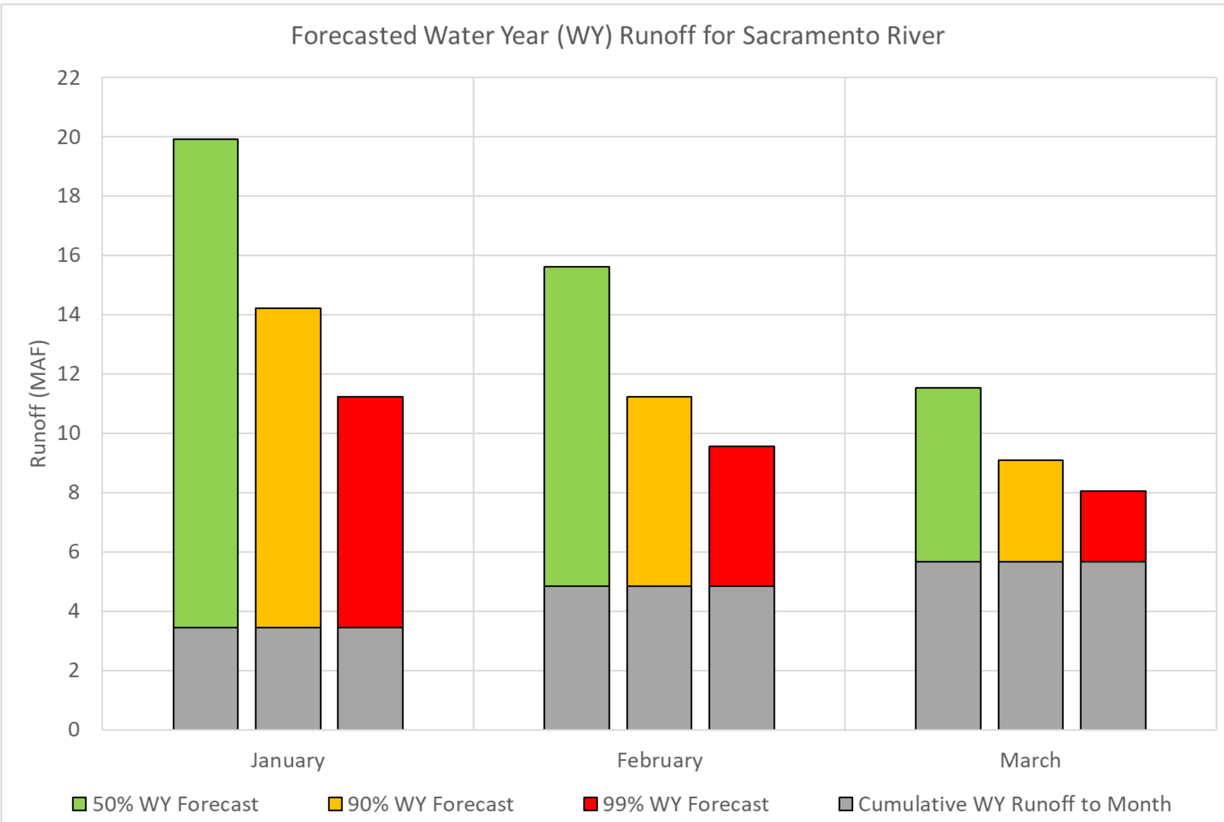


Projected Water Supply for Beneficial Use

Planned operations of the CVP and SWP utilize conservative assumptions where actual precipitation and runoff conditions are combined with forecasted hydrology. These conservative assumptions are used to estimate operations needed to meet regulatory and contractual obligations, determine if additional supplies are available, and estimate the amount of discretionary deliveries. In order to be conservative, CVP and SWP planned operations use forecasted hydrology representing drier future conditions.

Figure 4 shows a sample of forecasted water conditions from January, February, and March of 2022 for the Sacramento River Runoff in million acre-ft (MAF). This shows the total estimated WY runoff for the Sacramento River, which is a summation of runoff at Sacramento River at Bend Bridge, Feather River at Oroville, Yuba River near Smartville, and American River at Folsom. In the figure, the grey bars show the runoff that has occurred up to the month (e.g., grey bar in “January” is the total runoff October through December) and the green, orange, and red bars show the forecasted future runoff (e.g., red bar in “January”, showing 99%, is the total forecast runoff January through September). A 99% exceedance hydrology forecast indicates that there is only a 1% chance that conditions will be drier than the forecast.

Figure 4. Progression of Estimated Runoff Forecast from the Sacramento River



Forecasted CVP and SWP operations in early January used conditions associated with the January 99% forecast shown in **Figure 4**. Those early estimates indicated that Oroville and Folsom would be able to meet Delta regulatory requirements while remaining within facility constraints and reservoir health and safety storage levels. After a small amount of precipitation in early January 2022, the 8-station Index experienced no precipitation between January 8 and February 15, 2022; zero precipitation during this period is below a 99% exceedance for this time of the year.

The first Bulletin 120 forecast in February 2022 incorporates better estimates of the snowpack and water content of the snowpack. These estimates come from manual measurements at key locations within the Sierra Nevada Mountains. With this first snow-based water supply estimate, projected hydrology decreased from January 2022 estimates in large part due to the dry January conditions, but also because measured snowpack was included. **Figure 4** shows an increase in the February 2022 cumulative runoff due to antecedent runoff associated with December 2021 storms while the forecast of the water year total decreased for the 50%, 90%, and 99% exceedance hydrology.

Projection of CVP/SWP Storage Conditions

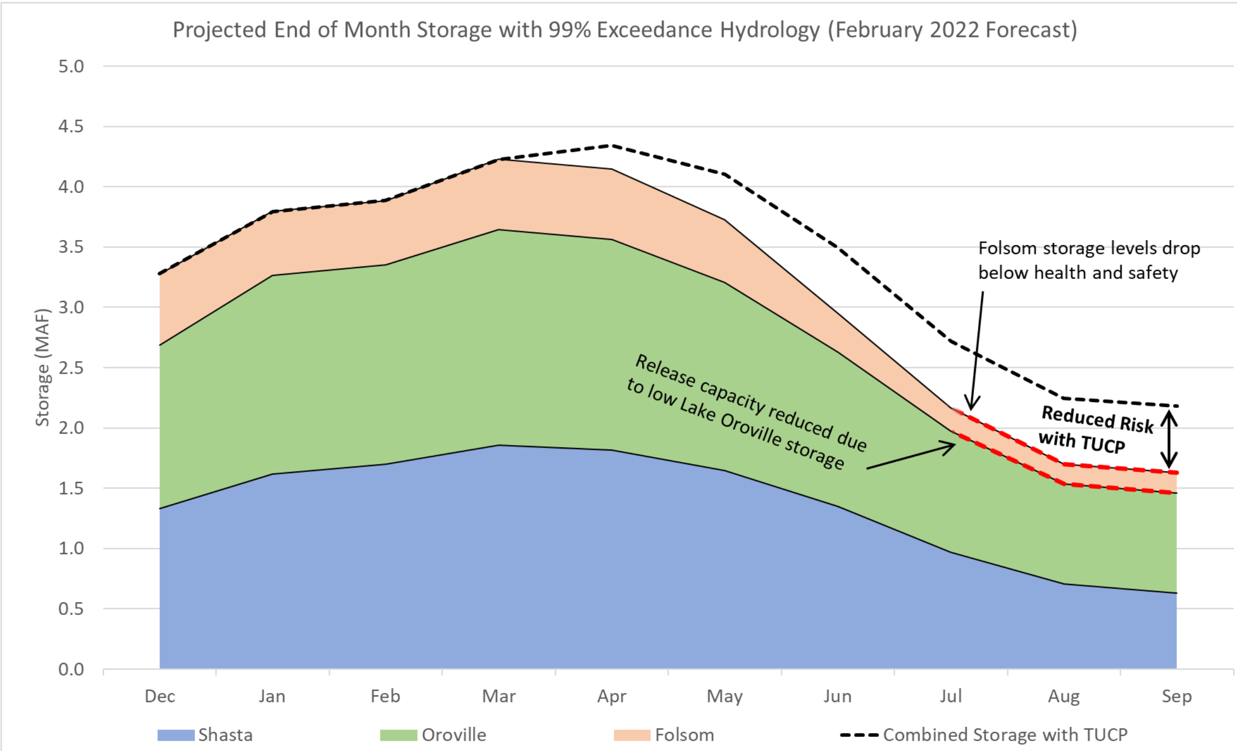
Operational forecasts using the 99% exceedance hydrology forecast in February 2022 indicated some concerns with respect to the risk of reservoir storage level depletion. Water not released due to these modified objectives reduces the risk that reservoir storage levels would drop below where releases for health and safety, and fish and wildlife priorities could not occur. As dry conditions persisted through February 2022, it became evident that the March 2022 forecast would also decrease. Operational studies utilized a February 99% projection of hydrology and, with the record low January through February 2022 precipitation, the March 2022 forecasted runoff decreased further from the February 2022 forecast (see **Figure 4**), which demonstrates the need for this TUCP.

Figure 5 shows the monthly progression of CVP and SWP storage with a 99% exceedance hydrology as estimated by the February 2022 forecast. Under this extreme dry forecast, Shasta operations would primarily focus on managing temperature requirements and senior water rights and riparian demands along the upper Sacramento River. Whereas Oroville and Folsom, in addition to managing to instream requirements, would be operated to meet Delta flow and water quality requirements.

This TUCP is requesting modification of outflow requirements to 4,000 cfs for the April 1 through June 30, 2022 period if the 90% Sacramento River Runoff forecast is greater than 8.1 MAF. With the February 2022 forecast (see **Figure 4**), the 99% forecast indicated that the Sacramento River runoff would be greater than 8.1 MAF and that a higher outflow (~7,100 cfs) would be required in May and June 2022. Under this 99% exceedance hydrology, April 2022 outflow would have 9 days of X2 at Chipps, with the remainder at Collinsville. This would suggest an average required outflow of about 8,400 cfs. Under these projections of available water supply and required outflow, Oroville releases in July would be limited due to low lake elevations and limit the ability to make releases for Delta standards in late summer. This would put more pressure on Folsom to release which would reduce storage below levels needed to protect public health and safety levels by mid-summer. Modification of Delta requirements would help conserve storage primarily in Oroville and Folsom and would reduce the risk of dropping storage to levels where either health and safety storages are at risk or release capacity is reduced. **Figure 5** shows the potential reduced risk of drawing storage below critical storage levels with the proposed modifications under the February 99% forecasted hydrology.

It should be noted that these are projected conditions based on the February 99% forecast, and a recent March 2022 updated forecast is incrementally drier (see **Figure 4**). The March 2022 forecast indicates a potential for the Sacramento River runoff forecast to drop below 8.1 MAF which would automatically reduce the May and June outflow to 4,000 cfs, however this condition is determined based on the May 90% forecast. However, the March forecast is also indicating lower reservoir inflows and indicating a greater need for modification of requirements.

Figure 5. Projected Storage Conditions based on February 99% exceedance hydrology



On February 17, 2022, the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center released their long-range outlook for March 2022 through May 2022 indicating an equal chance of below or above normal precipitation and an increased probability of leaning-above normal temperatures. The precipitation outlook for March 2022 through May 2022 indicates an increased probability of below normal precipitation and a tendency for the drought to persist for that period.[5] Based on the above-described projection, in addition to antecedent conditions from 2021, there is a significant risk of continued low reservoir levels extending into the summer of 2022 (see **Figure 6** NOAA Seasonal Precipitation Outlook March through May 2022 and **Figure 7** NOAA Seasonal Temperature Outlook).

[5] https://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.png

Attachment 1. Supplement to April - June 2022 Temporary Urgency Change

Figure 6. NOAA Seasonal Precipitation Outlook March through May 2022

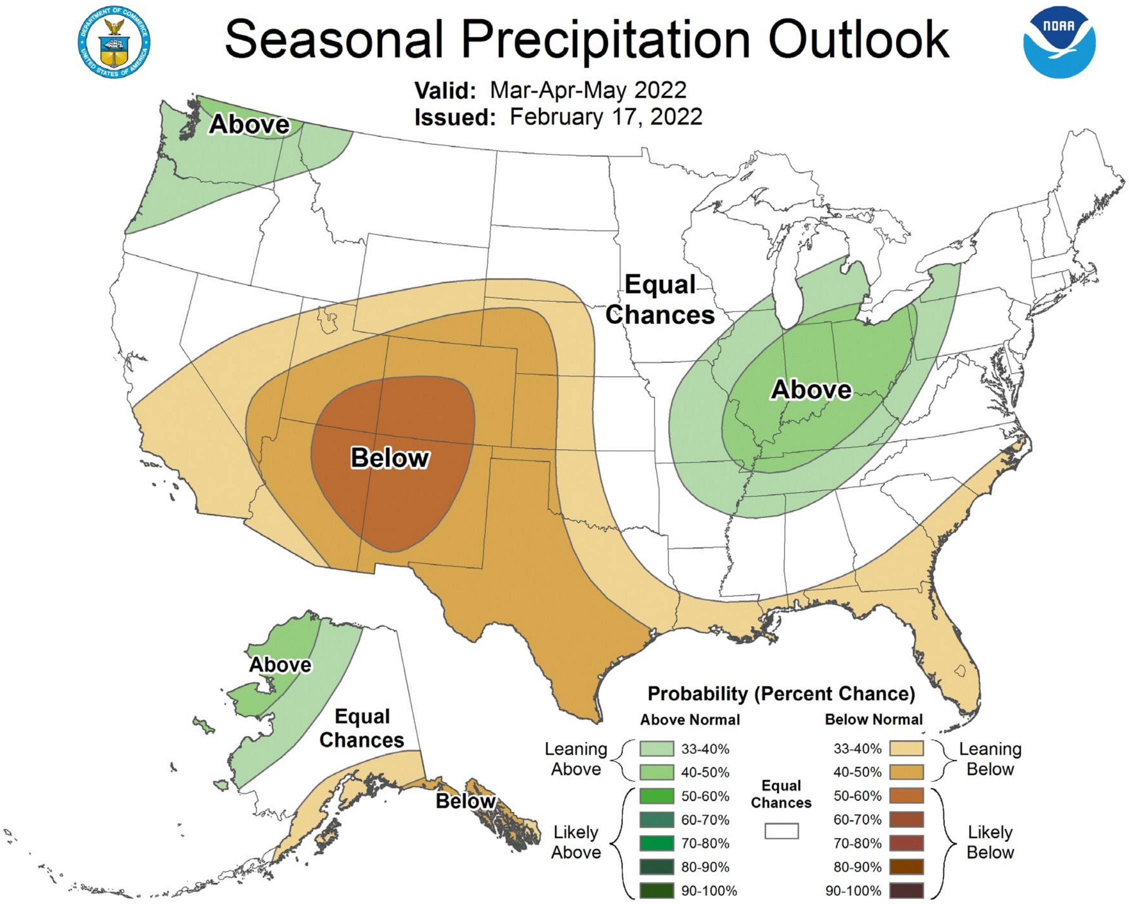
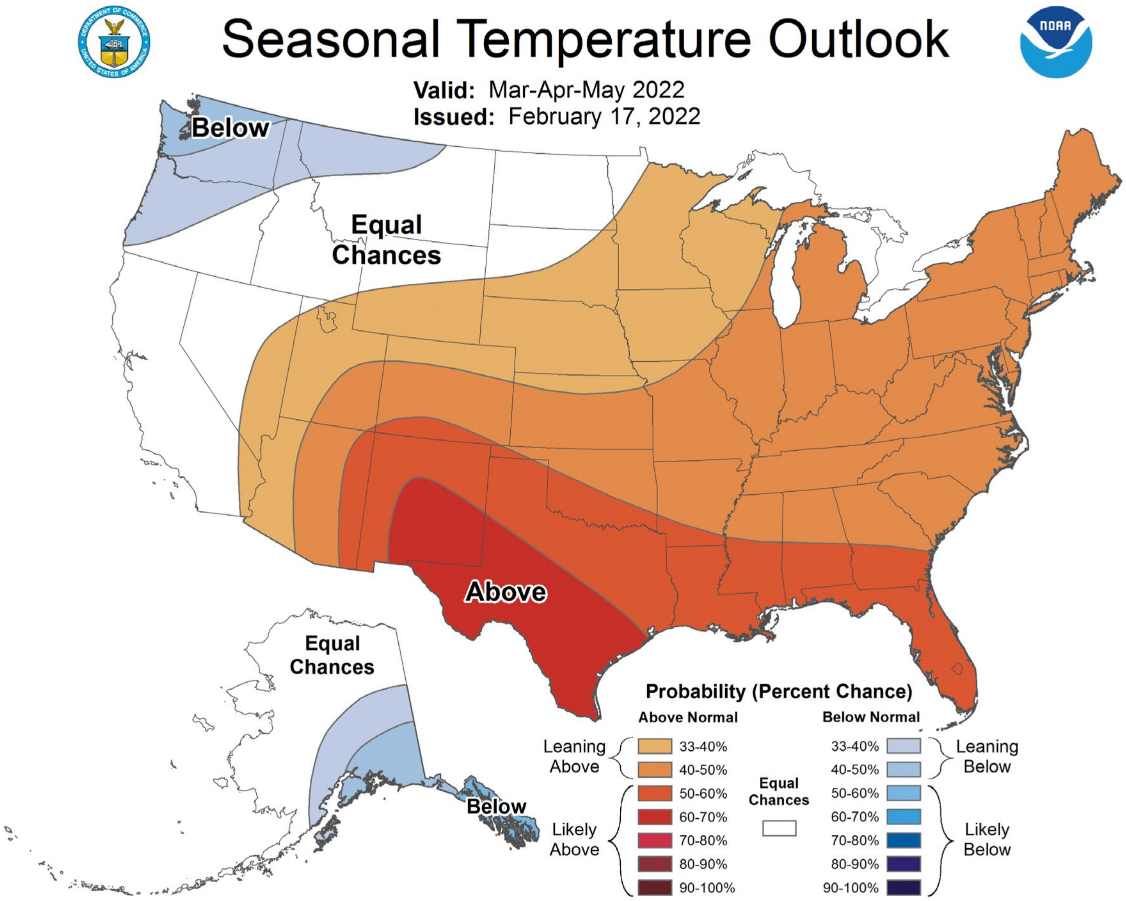


Figure 7. NOAA Seasonal Temperature Outlook



Therefore, DWR and Reclamation are preparing to take actions early in WY 2022 to protect against potential continued drought impacts in WY 2022, including the following:

- Upstream Reservoirs and Temperature Management. The Projects' upstream reservoirs will be operated through the spring 2022 to preserve and build storage. As indicated above, upstream storages in spring 2022 are anticipated to be well below average. Reclamation and DWR will be striving to increase cold water resources in spring for Project reservoirs where temperature management is needed later in the year. Temperature management at Shasta and Folsom reservoirs is dependent on the maximum storage reached in May which dictates to what extent warmer water can be released in the cooler months of May and June to save cold water for releases later in the summer. Lower storages limit access to the warmer water and result in needing to release colder water in the early summer before it's needed to meet temperature targets which leaves less cold water available in the warmer summer months.

- Water Supply. The Projects will be operated to maintain minimum combined exports at a level to meet health and safety demands, wildlife refuge deliveries and a portion of senior water right deliveries and lessen critical economic losses to agricultural, municipal and industrial uses due to water shortages through south of Delta transfers and exchanges to the extent possible, while balancing the needs of upstream storage, fishery and wildlife resource protection, and operational flexibility. A key to minimizing water supply shortages will be to utilize opportunities to increase exports when unregulated water is available due to specific hydrological events (e.g., increased Delta inflow due to precipitation) in the winter and spring. The increased water will primarily either be delivered to meet minimum health and safety and wildlife refuge needs or be stored in San Luis Reservoir for later delivery when the ability to export unregulated water has passed (e.g., summer).

- Emergency Drought Salinity Barrier. Excessive salinity increases in the Delta could render the water undrinkable for 27 million Californians and unusable by farms reliant upon this source, as well as harm many other Delta beneficial uses. A temporary rock (rip-rap) emergency drought salinity barrier (EDB) was installed at West False River in June 2021 to mitigate salinity intrusion and maintain Delta water quality. In preparation of a dry WY 2022 the EDB at West False River remained in-place and was notched in January 2022. The notch is planned to be backfilled in early April 2022, and the EDB is expected to remain in place throughout the requested TUCP period and into the fall.

I. C. The Need for a Change Petition in 2022 and Requested Change

While the exact hydrologic conditions of April 1 through June 30, 2022 cannot be known in advance, available forecasts suggest an elevated risk for continued drought conditions in April 1 through June 30, 2022. Reclamation and DWR are therefore requesting the State Water Board to temporarily modify specific standards defined by D-1641 from April 1 through June 30, 2022, as described below (**Table 1**).

Table 1. DWR and Reclamation D-1641 Modification Request Summary for the 2022 Spring/Summer TUCP

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
April 1 – April 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	4,000 cubic feet per second (cfs) based on a 14-day average	Max exports 1,500 cfs when not meeting D-1641	The 4,000 cfs outflow modification was assessed in the biological review submitted in the December 2021 TUCP submittal. (14-day average is smaller averaging period than previous proposed to address Temporary Urgency Change Order (TUCO) issuance during the month of April).

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
May 1 - June 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	If the May 1 90% Sacramento River Index is not less than 8.1 million acre-feet (MAF): 14-day running average of 4,000 cfs outflow as described in D-1641 Table 3, footnote 10.	Max exports 1,500 cfs when not meeting D-1641	May 2021, the 90% Sacramento River Index was below 8.1 MAF, therefore there was no TUCP requested as we triggered the natural offramp of spring X2 and operated to a 14-day average NDOI of 4,000 cfs. In June 2021, requested a change from 4,000 cfs to 3,000 cfs on a 14-day average.
April 1 - June 30	San Joaquin River at Airport Way Bridge, Vernalis	Stanislaus will be operated to the Stepped Release Plan, which includes a spring pulse flow. Stanislaus releases will be increased, if necessary, to meet Vernalis base flow of 710 cfs.	Not applicable	Modification was assessed in the biological review submitted in the December,1 2021 TUCP submittal.
April 1- June 30	Western Delta Agriculture Compliance point - Emmaton	Relocate Western Delta Agriculture compliance point from Emmaton to Threemile Slough.	Max exports 1,500 cfs when not meeting D-1641.	The relocation of the Emmaton Western Ag compliance point started June 1, 2021; and was assessed as part of the June 2021 TUCP biological review.

These modifications are necessary because of the extraordinarily dry conditions of WY 2020, WY 2021, and historically dry January through March 2022, in combination with the potential of limited future precipitation and low reservoir storage in April 1 through June in WY 2022, and the competing demands on a limited water supply for fish and wildlife protection, Delta salinity control, and critical water supply needs.

Modification of NDOI Requirement (April 1 through June 30, 2022)

D-1641 requires a minimum Net Delta Outflow Index (NDOI) of 7,100 cfs calculated as a 3-day running average,[6] and depending on hydrologic conditions in the previous month, may require outflow as high as 29,200 cfs for a period of time. These flow requirements can also be met with daily or 14-day average electrical conductivity (EC) standard at Collinsville, Chipps, and Port Chicago. Under extreme dry conditions, D-1641 reduces the requirement in May and June to 14-day average flow of 4,000 cfs when the Sacramento River Index (SRI) for the water year is forecasted to be less than

[6] D-1641 Table 3 Footnote 10

8.1 MAF at the 90% exceedance level. However, because of higher runoff in the early part of the water year (October through December), meeting less than 8.1 MAF condition may not occur, even considering the historical dry January through March conditions. Reclamation and DWR petition the State Water Board to temporarily modify the Delta outflow standard during the month of April to allow an NDOI no less than 4,000 cfs on a 14-day average. In addition, if the SRI forecast in May is 8.1 MAF or greater, modify months of May and June to allow an NDOI no less than 4,000 cfs based on a 14-day average, which is more consistent with the potential persistent dry conditions facing California than contained within D-1641 Table 3 and footnotes.

Export Limits (April 1 through June 30, 2022)

April 1 through June 30, the maximum combined SWP and CVP exports will be limited to 1,500 cfs when D-1641 Delta outflow or water quality standards are not being met. SWP and CVP exports may exceed 1,500 cfs when the petitioned modifications meet D-1641.

The maximum combined export of 1,500 cfs, as referenced in Table Action1, is consistent with other regulatory requirements. The combined 1,500 cfs export rate represents a sustainable rate and provides the CVP and SWP real-time operational flexibility in the Delta to meet salinity and water quality standards (as modified by the TUCP), as Delta conditions can rapidly change due to weather and tidal cycles. Absent this flexibility, additional sustained upstream releases would be required to manage the real-time changes in Delta conditions. In addition, the 1,500 cfs rate combined export allows the CVP the ability to maintain a one-unit operation and minimize the need to start and stop a unit in a 24-hour period (i.e., cycling) which could result in catastrophic damage. This rate also allows the SWP to meet Byron Bethany Irrigation District diversions, which occur from Clifton Court Forebay, and also provides for municipal and industrial water supply delivery to the SWP South Bay Public Water Agencies who are not directly connected to San Luis Reservoir and who rely on direct diversions from the Delta to meet their municipal and industrial demands.

Modify Vernalis Flow Requirement (April 1 through June 30, 2022)

D-1641 requires a San Joaquin River at Airport Way Bridge, Vernalis minimum monthly average flow in critically dry years of 710 cfs. Reclamation and DWR petition the State Water Board to approve a San Joaquin River at Vernalis river flow requirement for April 1 through June 30, 2022 consistent with the lower critical year flow objective, but no requirement for the higher flow objective (see D-1641 Table 3, footnote 13). The modified flow objective is necessary because of the extraordinarily dry conditions of the past several years in combination with the potential limited future precipitation, extremely low reservoir storage, and the competing demands on water supply of fish and wildlife protection, Delta salinity control, and critical water supply needs.

Modification of the Western Delta Salinity Compliance Point (April 1 through June 30, 2022)

In a critical year, D-1641 requires the Agricultural Western Delta Salinity Standard at Emmaton have a 14-day running average of 2.78 millimhos per centimeter from April 1 to June 30, 2022. Reclamation and DWR are petitioning the State Water Board to modify this requirement by moving the compliance location from Emmaton to Threemile Slough on the Sacramento River from April 1 through June 30, 2022.

I. D. Agency Coordination

DWR and Reclamation have been consistently coordinating with NMFS, USFWS, CDFW, and the State Water Board to discuss various TUCP Biological Review approaches and analyses methodologies since preparation of the 2021 TUCP. On October 21 and October 22, 2021, Reclamation and DWR met with the NMFS, USFWS, CDFW, and the State Water Board, to receive input and discussion on a proposed 2022 TUCP that was developed and submitted, but ultimately retracted in January of 2022. DWR and Reclamation utilized this previous coordination in addition to a dedicated agency staff discussion meeting on March 14, 2022 to develop this TUCP Biological Review (see **Attachment 2**).

In addition, from April 1 through June 30, 2022, DWR and Reclamation will meet and confer weekly with the State Water Board to coordinate Project operations and water management. DWR and Reclamation will use the Water Operations Management Team (WOMT) and the Long-term Operation Agency Coordination Team, comprised of staff from Reclamation, DWR, NMFS, USFWS, CDFW, and the State Water Board, for this coordination effort. The WOMT meets weekly to provide hydrology and operations updates, coordinate Project operations and will discuss TUCP actions and other drought actions, as appropriate.

During the TUCP period, D-1641 requirements are typically met through natural and unregulated flow; if these conditions occur during the April 1 through June 30, 2022 TUCP period, the TUCP may not be required. Further, if sufficient precipitation were to occur prior to and/or during the 2022 TUCP period to recover upstream storage, then Reclamation and DWR would re-evaluate the basis for the TUCP and amend the TUCP and/or resume operating to the D-1641 objectives in coordination with the Long-term Operation Agency Coordination Team.

Information on coordination with the WOMT and other technical teams is provided below and in Attachment 2 "Biological Review for the April 1 through June 30, 2022 Temporary Urgency Change Petition." In addition, as part of this petition, DWR and Reclamation will continue to coordinate with Long-term Operation Agency working groups to continue the robust monitoring programs in the 2022 Drought Contingency Plan. DWR shall also provide the State Water Board an updated harmful algal blooms (HABs) report in March 2023.

II. Basis to Authorize Modification of Water Rights

The California Water Code, Section 1435, authorizes the State Water Board to grant a temporary change order for any permittee or licensee who has an urgent need to change a permit or license, where the State Water Board finds: 1) the permittee has an urgent need for the proposed change, 2) the proposed change may be made without injury to any other lawful user of water, 3) the proposed change can be made without unreasonably affecting fish, wildlife, or other instream beneficial uses, 4) the proposed change is in the public interest. The law also requires consultation with representatives of CDFW.

DWR and Reclamation provide the information below to support the findings necessary under California Water Code section 1435. The modifications requested, along with additional actions, are intended to decrease the risk that DWR and Reclamation will be unable to provide future protection of beneficial uses that rely upon storage from the Projects. Therefore, the modifications requested are urgent and critical and can be implemented in a manner satisfying requirements of section 1435, as described below.

1) DWR and Reclamation Have an Urgent Need for the Proposed Change

WY 2020 and WY 2021 was the second driest two-year period on record for the Northern Sierra basin (after 1976 and 1977) and January through March 2022 may be one of the driest January through March on record The Emergency Proclamation signed by the Governor in May 2021 is still in effect due to drought conditions for the Bay-Delta and other watersheds and the continuation of extremely dry conditions in the Delta watershed. Although WY 2022 started with strong precipitation in northern California, the months of January, February, and March 2022 have been the driest on record and have further exacerbated the drought condition effects from the previous years. Additionally, and as stated above, the NOAA Climate Prediction Center released their long-range outlook for March 2022 through May 2022, indicating there is an increased probability of below normal precipitation for that period.

The continuation of extremely dry conditions in the Bay-Delta watershed will pose great challenges to water resources management, and DWR and Reclamation believe that there is great risk that water supplies will not be adequate to meet both the obligations under D-1641 and temperature requirements on the Sacramento River. As a result, significant risks to minimum health and safety supplies, temperature control, minimum in-stream flow requirements, and an inability to control salinity intrusion in the Delta could result later this season. Under the current circumstances, Reclamation and DWR believe the most prudent course of action is to conserve storage in upstream reservoirs until significant improvement of that storage is realized.

If the requested April 1 through June 30, 2022 modifications to D-1641 Table 3 are not granted, the Projects may have to supplement inflows, through reservoir releases, into the Delta in order to meet the outflow requirements specified in D-1641. Granting this petition will help delay the depletion of much-needed storage throughout the spring in order to provide for fish and wildlife habitat, Delta water quality, and exports for critical needs later in the year. Estimated reservoir storage impacts include the likelihood of substantial decreases in storage due to the extremely dry conditions as well as reduction in adequate cold-water reserves that would have been available to meet regulatory requirements protecting salmon and other cold-water fish species in the summer and fall of 2022. Further impacts could even result in a “loss of control” over salinity encroachment in the Delta in 2022 and into 2023 in a continued drought scenario. “Loss of control” describes a condition in which very low storages in the major Project reservoirs will not allow sufficient release capability to control intrusion of ocean water into the Delta, which would make the Delta water quality incompatible with in-Delta beneficial uses. This condition would persist until Northern California receives rainfall that produces sufficient runoff to flush the Delta of ocean water, which would once again allow for these in-Delta beneficial uses. Failure to sufficiently control Delta salinity would jeopardize the ability to provide for minimum health and safety supplies for communities both within the Delta and those who rely upon the Delta for water supply.

a. Authorization to Take Extraordinary Measures

On May 10, 2021, Governor Newsom issued a Proclamation of a State of Emergency (Emergency Proclamation) (see https://www.gov.ca.gov/wp-content/uploads/2021/05/5.10.2021-Drought-Proclamation.pdf). This Emergency Proclamation includes the following directives:

4. To ensure adequate, minimal water supplies for purposes of health, safety, and the environment, the State Water Board shall consider modifying requirements for reservoir releases or diversion limitations – including where existing requirements were established to implement a water quality control plan – to conserve water upstream later in the year in order to protect cold water pools for salmon and steelhead, improve water quality, protect carry over storage, or ensure minimum health and safety water supplies. The State Water Board shall require monitoring and evaluation of any such changes to inform future action. For actions taken in the Sacramento-San Joaquin Delta Watershed Counties pursuant to this paragraph, Water Code Section 13247 is suspended.

5. To ensure adequate, minimal water supplies for purposes of health, safety, and the environment in the Klamath River and Sacramento-San Joaquin Delta Watershed Counties, the State Water Board shall consider emergency regulations to curtail water diversions when water is not available at water right holders' priority of right or to protect releases of stored water. DWR shall provide technical assistance to the State Water Board that may be needed to develop appropriate water accounting for these purposes in the Sacramento-San Joaquin Delta Watershed.

11. For purposes of carrying out or approving any actions contemplated by the directives in operative paragraphs 3, 4, 5, 6, 8, and 9, the environmental review by state agencies required by the California Environmental Quality Act in Public Resources Code, Division 13 (commencing with Section 21000) and regulations adopted pursuant to that Division are hereby suspended to the extent necessary to address the impacts of the drought in the Klamath River, Sacramento San Joaquin Delta and Tulare Lake Watershed Counties.

b. Coordination with Water Operations and Watershed Monitoring Technical Teams

Consistent with the Record of Decision for the Long-Term Operation of the CVP/SWP (Reclamation 2020), DWR and Reclamation propose utilizing the team of managers already part of the WOMT to discuss TUCP actions and other drought actions as appropriate. These managers are already authorized to meet weekly and act in order to coordinate management of water supplies and protection of natural resources during the course of the declared drought emergency. The WOMT managers include representatives from the State Water Board, DWR, Reclamation, CDFW, NMFS and USFWS.

Additionally, as stated above, DWR and Reclamation will continue to coordinate with the Fisheries Technical Teams. Each of the Teams are responsible for real-time synthesis of fisheries monitoring information. The Fisheries Teams include technical representatives from federal and State fishery agencies along with stakeholders and will provide information to Reclamation and DWR on species abundance, species distribution, life stage transitions, and other relevant physical parameters.

Reclamation and DWR propose continued discussions, as described in the subsection (c) “Proposed Reporting” below, in order to evaluate continued use of this TUCP to best balance the protection of all beneficial uses.

c. Proposed Reporting

As stated in the Emergency Proclamation, the dry conditions and water supply levels are of a magnitude that they present peril to the safety of persons and property. In order to facilitate Directives 4 and 5 of the Emergency Proclamation, DWR and Reclamation propose that the operations and regulatory changes requested in this petition include monitoring using existing stations and programs to ensure that the objectives of this proposal and the requirements of Water Code Section 1435 are met under any changed conditions.

2) The Proposed Change Will Not Result in Injury to Any Other Lawful Users of Water

Modification of certain terms of the Projects’ water rights permit from April 1 through June 30, 2022 will allow Reclamation and DWR to operate the Projects to provide for minimum health and safety supplies and control saltwater intrusion into the Delta. Saltwater intrusion into the Delta could render Delta water unusable for municipal and industrial and agricultural needs, reduce habitat value for aquatic species, and affect over 25 million Californians who rely on the export of this water for personal use. The requested changes would result in a reduction of stored water releases, not a change in natural flow. The requested changes would broadly benefit water users, not result in injury to other legal users of water.

3) The Proposed Change Will Not Result in Unreasonable Impacts to Fish, Wildlife, and Other Instream Uses

Extreme drought conditions stress the aquatic resources of the Delta estuary and its watershed. Continued dry conditions during the spring of 2022 would be expected to adversely affect juvenile outmigration/rearing and adult spawning for Chinook salmon and steelhead, and egg and larval/early juvenile periods conditions for delta smelt and longfin smelt. Continued dry conditions without modifications to D-1641 could lead to extensive impacts to fishery resources later in the year. For example, extremely low reservoir storage and associated cold water pool could lead to reduced ability to maintain cold water later in the year for winter-run Chinook salmon egg survival and steelhead life stages. The petitioned modifications are intended to reduce the risk of excessive reservoir storage depletions and allow for some level of salinity and temperature control later in season. Analyses provided in Attachment 2, *Biological Review for the 2022 April through June Temporary Urgency Change Petition*, indicate that there would not be an unreasonable impact to fish, wildlife, or other instream resources in the Delta as a result of the 2022 April through June TUCP when considering the current and projected impacts related to the ongoing drought. Most of the anticipated negative effects associated with this petition would occur primarily as a result of the overall drought. The Biological Review analysis indicates that effects attributable to the TUCP are limited due to it including a south Delta exports cap. Furthermore, existing species management actions to minimize entrainment under the 2019 NMFS and USFWS Biological Opinions for the Re-initiation of Consultation on the Long-Term Operation (LTO) of the CVP and SWP and the 2020 Incidental Take Permit (ITP) from CDFW for Long-Term Operation of the SWP would continue.[7] Conversely, without the operational changes proposed in this petition in place, there is a greater potential for impacts related to the depletion of the cold water pool, as described below.

The TUCP is unlikely to appreciably increase entrainment of species of management concern during April through June 2022 at the south Delta export facilities because of restricted exports under the TUCP and restrictions being implemented or that would be implemented under the NMFS (2019) LTO Biological Opinion, USFWS (2019) LTO Biological Opinion, and CDFW (2020) SWP ITP to limit entrainment risk.

Through-Delta survival of juvenile Chinook salmon and steelhead migrating from the Sacramento River basin during April through June under the TUCP could be appreciably less than without the operational changes proposed under this TUCP because of less Delta inflow affecting north Delta hydrodynamics, including greater entry into the interior Delta through Georgiana Slough. These impacts are trade-offs when one considers that the TUCP modifications reduce the risk of excessive reservoir storage depletions, which would diminish continued releases for some level of temperature control later in season (which occur outside the geographic scope of the Delta). Through-Delta survival for juveniles emigrating from the San Joaquin River basin would be expected to be very low with or without the TUCP because of the drought conditions.

Migration conditions for adult Chinook salmon and steelhead in the Sacramento River basin generally would be similar under the base case and TUCP. However, less river flow under the TUCP could result in greater straying potential for returning adult Chinook salmon and steelhead returning to the San Joaquin River basin, should similar mechanisms exist as observed for fall-run Chinook salmon in the fall in the San Joaquin River.

---

7 On March 11, 2022, the Eastern District of California ordered implementation of an Interim Operations Plan (IOP) in litigation on the 2019 Biological Opinions that will remain in effect through Water Year 2022 (Order Re Motions to Remand Without Vacatur; Stay; and Impose Interim Injunctive Relief, Eastern District Case Nos. 1:20-cv-00431-DAD-EPG and 1:20-cv-00426-DAD-EPG). The IOP incorporates preexisting CDFW ITP requirements for Delta operations and therefore does not affect the analysis in the biological review for this TUCP.

The TUCP's modifications relative to the base case should not substantially reduce riverine or through-Delta survival of juvenile green sturgeon, although there is some uncertainty in the conclusion given the general lack of information on the species. It is expected that little to no salvage of green sturgeon at the south Delta export facilities would continue, consistent with recent years with greater levels of exports than the TUCP proposed operations.

The TUCP has the potential to result in negative changes to delta smelt and their habitat relative to the base case. This includes less zooplankton prey in the low salinity zone and higher salinity leading to a reduction in habitat quality in portions of the range such as the lower Sacramento River as well as lower extent of low salinity habitat in the west and north Delta. Preliminary analyses discussed in the 2015 biological review and more recent peer-reviewed analyses suggest the potential for negative effects to delta smelt recruitment and post-larval survival resulting from less Delta outflow under the TUCP.

Lower Delta outflow could have limited negative effects on longfin smelt prey. The reduction in outflow due to the TUCP may have some negative impact on longfin smelt abundance based on observed correlations between abundance indices and Delta outflow, though this effect likely would be difficult to quantify given the generally poor environmental conditions due to the drought and statistical analysis suggesting that the probability of a lower abundance index under the TUCP relative to the base case is not greatly different than 0.5 (i.e., 50% chance).

In addition, the reduction in outflow due to the TUCP may have negative and/or positive impacts on other native and nonnative species, including the migratory, pelagic, and littoral species described above. Species with positive correlations with Delta outflow such as striped bass and American shad may be negatively affected, whereas species with negative correlations such as Mississippi silversides may be positively affected.

TUCP impacts are considered in light of the reduced risk associated with excessive reservoir storage depletions and allow for some level of salinity and temperature control later in season. As indicated above, operational requirements that would be implemented under the NMFS (2019) LTO Biological Opinion, USFWS (2019) LTO Biological Opinion, and CDFW (2020) SWP ITP will continue to be in effect to protect listed species. Based on these factors, there would not be an unreasonable impact of the TUCP on public trust resources such as fish and wildlife or other instream resources.

4) The Proposed Change is in the Public Interest

The public interest is best served by maintaining, for as long into the year as possible, storage to support minimum exports and water quality necessary for the protection of critical water supplies and species protections. The requested changes are in the public interest by preserving water supplies to meet minimum health and safety supplies, by increasing the duration and likelihood of maintaining minimal Delta salinity control, and by reducing the risk of cold water pool depletions which would further impact sensitive aquatic species. In addition, modifying the Delta outflow as proposed in this petition will increase the probability that the Projects will be able to minimize the likelihood of uncontrolled salinity intrusion into the Delta. If by meeting unmodified D-1641 outflow objectives earlier in the year the Projects have insufficient storage to control seawater intrusion, problematic water quality would persist in the Delta until Northern California receives a rainy season with sufficient runoff to flush the Delta of ocean water to once again allow for in-Delta beneficial uses.

III. Due Diligence has been Exercised

DWR and Reclamation rely upon sound science and methods to forecast and project hydrology and water supply needs. This scientific approach to water management is the most prudent course of action in such a complex and variable system. Based upon this approach, DWR and Reclamation revisit the forecasts and projections frequently and adjust the Projects' operations accordingly. These may include updated hydrodynamic and water quality modeling simulations.

Reclamation and DWR have exercised due diligence to avoid the circumstance necessitating this request. As stated above, Reclamation and DWR previously submitted a TUCP for the February through April 2022 period based on the extremely low storages in CVP and SWP reservoirs at the end of WY 2021 and, based on hydrologic conditions in December 2021, Reclamation and DWR subsequently withdrew the TUCP request in mid-January. Unfortunately, the conditions seen in January and February 2022 were the driest on record throughout Northern California. Based upon conservative hydrologic forecasts, the Projects are likely to experience challenges in meeting in-basin uses, temperature requirements or human health and safety, whether it be from capacity constraints or inadequate storage at CVP/SWP reservoirs. Reclamation and DWR will re-evaluate the observed and forecasted precipitation and inflow in early May 2022 to determine if a subsequent TUCP for the summer months is warranted. This approach allows for the conservation of critical spring storage, which is beneficial for temperature management, and avoiding relaxation if improved conditions can support D-1641.

In addition, the Projects exercised due diligence by both initially issuing very low allocations to its water supply contractors and then later further reducing allocations, when the worsening severe dry pattern began to emerge. Further, comprehensive monitoring is continuing to be conducted to understand the effects of the ongoing drought, and EDB.

Prior to this petition, DWR and Reclamation provided weekly hydrology and condition updates through WOMT. DWR and Reclamation have met with the State Water Board staff and with representatives of CDFW, NMFS and USFWS, to discuss the elements of this TUCP, and will continue to provide updates and to seek their input on how best to manage multiple needs for water supply. In addition, as stated above, DWR and Reclamation will continue to coordinate with Long-term Operation Agency working groups to continue the robust monitoring programs in the 2022 Drought Contingency Plan. DWR shall also provide the State Water Board an updated HABs report in March 2023.

IV. References

California Department of Fish and Wildlife (CDFW). 2020. *California Endangered Species Act Incidental Take Permit No. 2081-2019-066-00. Long-Term Operation of the State Water Project in the Sacramento San Joaquin Delta*. Sacramento, CA: California Department of Fish and Game, Ecosystem Conservation Division.

National Marine Fisheries Service. 2019. *Biological Opinion on the Long-term Operation of the Central Valley Project and State Water Project*. October 21. National Marine Fisheries Service, West Coast Region.

U.S. Bureau of Reclamation (Reclamation). 2019. *Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Central Valley Project*. California Mid-Pacific Region Final Biological Assessment.

U.S. Fish and Wildlife Service. 2019. *Biological Opinion for the Reinitiation of Consultation on the Long Term Operation of the Central Valley Project and State Water Project*. USFWS Pacific Southwest Region. Sacramento, CA.

ATTACHMENT 2: BIOLOGICAL REVIEW FOR THE 2022 APRIL 1 THROUGH JUNE 30, 2022 TEMPORARY URGENCY CHANGE PETITION

I. Purpose and Background

Based on extraordinarily dry conditions throughout California and the projections for continued dry conditions, the California Department of Water Resources (DWR) for the State Water Project (SWP) and the U.S. Bureau of Reclamation (Reclamation) for the Central Valley Project (CVP) (collectively, Projects) are requesting through a Temporary Urgency Change Petition (TUCP) that the State Water Resources Control Board (State Water Board) modify the terms of the CVP and SWP water rights permits from what is currently provided in Water Rights Decision 1641 (D-1641) for the period from April 1 through June 30, 2022, as summarized in Table Action1 and outlined below.

Table Action1: DWR and Reclamation D-1641 Modification Request Summary for the 2022 Spring/Summer TUCP

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
April 1 – April 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	4,000 cubic feet per second (cfs) based on a 14-day average	Max exports 1,500 cfs when not meeting D-1641.	The 4,000 cfs outflow modification was assessed in the biological review submitted in the December 2021 TUCP submittal. (14-day average is smaller averaging period than previous proposed to address Temporary Urgency Change Order (TUCO) issuance during the month of April).

Month	D-1641	Proposed Modification	Exports (CVP/SWP)	2021 Comparison
May 1 - June 30	7,100 cfs to 29,200 cfs - Habitat Protection Outflow (X2), dependent on previous months Eight River Index Flow Volume	If the May 1 90% Sacramento River Index is not less than 8.1 million acre-feet MAF: 14-day running average of 4,000 cfs outflow as described in D-1641 Table 3, footnote 10.	Max exports 1,500 cfs when not meeting D-1641	May 2021, the 90% Sacramento River Index was below 8.1 MAF, therefore there was no TUCP requested as we triggered the natural offramp of spring X2 and operated to a 14-day average NDOI of 4,000 cfs. In June 2021, requested a change from 4,000 cfs to 3,000 cfs on a 14-day average.
April 1 - June 30	San Joaquin River at Airport Way Bridge, Vernalis	Stanislaus will be operated to the Stepped Release Plan, which includes a spring pulse flow. Stanislaus releases will be increased, if necessary, to meet Vernalis base flow of 710 cfs.	Not applicable.	Modification was assessed in the biological review submitted in the December,1 2021 TUCP submittal.
April 1- June 30	Western Delta Agriculture Compliance point - Emmaton	Relocate Western Delta Agriculture compliance point from Emmaton to Threemile Slough.	Max exports 1,500 cfs when not meeting D-1641.	The relocation of the Emmaton Western Ag compliance point started June 1, 2021; and was assessed as part of the June 2021 TUCP biological review.

Modification of NDOI Requirement (April 1 through June 30, 2022)

D-1641 requires a minimum Net Delta Outflow Index (NDOI) of 7,100 cfs calculated as a 3-day running average,[1] and depending on hydrologic conditions in the previous month, may require outflow as high as 29,200 cfs for a period of time. These flow requirements can also be met with daily or 14-day average electrical conductivity (EC) standard at Collinsville, Chipps, and Port Chicago. Under extreme dry conditions, D-1641 reduces the requirement in May and June to 14-day average flow of 4,000 cfs when the Sacramento River Index (SRI) for the water year is forecasted to be less than 8.1 MAF at the 90% exceedance level. However, because of higher runoff in the early part of the water year (October through December), meeting less than 8.1 MAF condition may not occur, even considering the historical dry January through March conditions. Reclamation and DWR petition the State Water Board to temporarily modify

1 D-1641 Table 3 Footnote 10

the Delta outflow standard during the month of April to allow an NDOI no less than 4,000 cfs on a 14-day average. In addition, if the SRI forecast in May is 8.1 MAF or greater, modify months of May and June to allow an NDOI no less than 4,000 cfs based on a 14-day average, which is more consistent with the potential persistent dry conditions facing California than t contained within D-1641 Table 3 and footnotes.

Export Limits (April 1 through June 30, 2022)

April 1 through June 30, the maximum combined SWP and CVP exports will be limited to 1,500 cfs when D-1641 Delta outflow or water quality standards are not being met. SWP and CVP exports may exceed 1,500 cfs when the petitioned modifications meet D-1641.

The maximum combined export of 1,500 cfs, as referenced in Table Action1, is consistent with other regulatory requirements. The combined 1,500 cfs export rate represents a sustainable rate and provides the CVP and SWP real-time operational flexibility in the Delta to meet salinity and water quality standards (as modified by the TUCP), as Delta conditions can rapidly change due to weather and tidal cycles. Absent this flexibility, additional sustained upstream releases would be required to manage the real-time changes in Delta conditions. In addition, the 1,500 cfs rate combined export allows the CVP the ability to maintain a one-unit operation, and minimize the need to start and stop a unit in a 24-hour period (i.e., cycling) which could result in catastrophic damage. This rate also allows the SWP to meet Byron Bethany Irrigation District diversions, which occur from Clifton Court Forebay, and also provides for municipal and industrial water supply delivery to the SWP South Bay Public Water Agencies who are not directly connected to San Luis Reservoir and who rely on direct diversions from the Delta to meet their municipal and industrial demands.

Modify Vernalis Flow Requirement (April 1 through June 30, 2022)

D-1641 requires a San Joaquin River at Airport Way Bridge, Vernalis minimum monthly average flow in critically dry years of 710 cfs. Reclamation and DWR petition the State Water Board to approve a San Joaquin River at Vernalis river flow requirement for April 1 through June 30, 2022 consistent with the lower critical year flow objective, but no requirement for the higher flow objective (see D-1641 Table 3, footnote 13). The modified flow objective is necessary because of the extraordinarily dry conditions of the past several years in combination with the potential limited future precipitation, extremely low reservoir storage, and the competing demands on water supply of fish and wildlife protection, Delta salinity control, and critical water supply needs.

Modification of the Western Delta Salinity Compliance Point (April 1 through June 30, 2022)

In a critical year, D-1641 requires the Agricultural Western Delta Salinity Standard at Emmaton have a 14-day running average of 2.78 millimhos per centimeter from April 1 to June 30, 2022. Reclamation and DWR are petitioning the State Water Board to modify this requirement by moving the compliance location from Emmaton to Threemile Slough on the Sacramento River from April 1 through June 30, 2022.

Agency Coordination

DWR and Reclamation have been consistently coordinating with NMFS, USFWS, CDFW, and the State Water Board to discuss various TUCP Biological Review approaches and analyses methodologies since preparation of the 2021 June through August TUCP. On October 21 and October 22, 2021, Reclamation and DWR met with the NMFS, USFWS, CDFW, and the State Water Board, to receive input and discussion on a proposed 2022 TUCP that was developed and submitted, but ultimately retracted in January of 2022. DWR and Reclamation utilized this previous coordination in addition to a dedicated agency staff discussion meeting on March 14, 2022 to develop this TUCP Biological Review.

In addition, from April 1 through June 30, 2022, DWR and Reclamation will meet and confer weekly with the State Water Board to coordinate Project operations and water management. DWR and Reclamation will use the Water Operations Management Team (WOMT) and the Long-term Operation Agency Coordination Team, comprised of staff from Reclamation, DWR, NMFS, USFWS, CDFW, and the State Water Board, for this coordination effort. The WOMT meets weekly to provide hydrology and operations updates, coordinate Project operations and will discuss TUCP actions and other drought actions, as appropriate.

During the TUCP period, D-1641 requirements are typically met through natural and unregulated flow; if these conditions occur during the April 1 through June 30, 2022 TUCP period, the TUCP may not be required. Further, if sufficient precipitation were to occur prior to and/or during the 2022 TUCP period to recover upstream storage, then Reclamation and DWR would re-evaluate the basis for the TUCP and amend the TUCP and/or resume operating to the D-1641 objectives in coordination with the Long-term Operation Agency Coordination Team.

In addition, as part of this petition, DWR and Reclamation will continue to coordinate with each of the Upper Sacramento, Clear Creek, American, Delta, and Stanislaus watersheds (Watershed Monitoring Workgroups) to continue the robust monitoring programs for long-term Project operations through completion of the 2022 Drought Contingency Plan, with updates to the Long-term Operation Agency Coordination Team. DWR shall also provide the State Water Board an updated harmful algal blooms (HABs) report in March 2023.

II. Purpose of Biological Review

As described in this April through June 2022 TUCP, legal users of water will not be injured by the requested changes. In support of the April through June 2022 TUCP, Reclamation and DWR have prepared this Biological Review of these proposed changes for compliance with the Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code), which establishes California’s statutory authority for the protection of water quality. Under the Porter-Cologne Water Quality Control Act, the State must adopt water quality policies, plans, and objectives that protect the State’s waters. The Porter-Cologne Water Quality Control Act sets forth the obligations of the State Water Board and Regional Water Quality Control Boards pertaining to the adoption of Basin Plans and establishment of: (1) beneficial uses to be protected; (2) water quality objectives for the reasonable protection of beneficial uses; and (3) a program of implementation for achieving the water quality objectives. The beneficial uses protected in Basin Plans include fish and wildlife, rare, threatened, or endangered species, and their habitats. Additional information is also provided in the Biological Review to inform the State Water Board with respect to potential effects to other public trust resources, such as fish and wildlife. The Biological Review included technical assistance from CDFW, NMFS, USFWS, and the State Water Board staff.

Scope of Analysis

The area of analysis for the Biological Review is limited to the Delta region because the proposed modification to D-1641 standards associated with the April through June 2022 TUCP addresses Delta conditions. The 2020 ROD implementing the Proposed Action consulted upon in the NMFS 2019 Biological Opinion addresses federal Endangered Species Act (ESA)-listed species on the Sacramento River, Clear Creek, Stanislaus River, and American River, and the Delta, and their flow and temperature management requirements, and the NMFS 2016 Biological Opinion addresses Feather River flow management requirements.

TUCP impacts are considered with respect to the risk of excessive reservoir storage level depletion. Water not released due to these modified objectives reduces the risk that reservoir storage levels would drop below where releases for health and safety, and fish and wildlife priorities could not occur. As indicated above, operational requirements that would be implemented under the NMFS (2019) LTO Biological Opinion, USFWS (2019) LTO Biological Opinion, and CDFW (2020) SWP ITP will continue to be in effect to protect listed species. Based on these factors, and the analysis presented below, there would not be an unreasonable impact of the TUCP on public trust resources such as fish and wildlife or other instream resources.

The Biological Review assesses the potential for biological impacts that could result from the April through June 2022 TUCP, specifically, those actions identified in Table Action1 above. DWR is also operating an emergency drought salinity barrier (EDB) in West False River as a separate drought contingency measure. While the EDB is being implemented as a separate action (separate from the April through June 2022 TUCP), its operation is included in the Delta Simulation Model II (DSM2) hydrodynamic modeling study to support the this TUCP analysis and conclusions in this Biological Review. A description of the DWR DSM2 hydrodynamic study is provided below.

III. Methods and Modeling

The potential impacts of the proposed April through June 2022 operational actions as part of the TUCP are considered in the context of conceptual models, current regulatory documents and court order, and peer-reviewed literature. For example, the delta smelt (*Hypomesus transpacificus*) conceptual model (Interagency Ecological Program Management, Analysis, and Synthesis Team 2015); the NMFS and USFWS CVP/SWP Biological Opinions (NMFS 2019 and USFWS 2019); the CDFW ITP (CDFW 2020); the Interim Operations Plan (IOP) for Water Year 2022 as ordered by the Eastern District of

California in the litigation regarding the 2019 Biological Opinions;[2] conceptual models for winter-run Chinook salmon (*Oncorhynchus tshawytscha*) (Windell et al. 2017), and green sturgeon (*Acipenser medirostris*) (Heublein et al. 2017a,b); and other information as cited below are materials considered in developing this Biological Review.

DSM2 Modeling

DSM2 simulations were performed and evaluated for two operational management scenarios: a TUCP case (generally referred to as 'TUCP' or 'With TUCP') and a base case ('Base' or 'Without TUCP') representing operations that would occur without the TUCP. These simulations were designed to evaluate potential impacts of the TUCP on Delta flows, salinity, and other factors described below, in order to infer potential impacts to fish and aquatic resources as part of this biological review.

To model the Delta flows, water levels and salinity, Delta models such as DSM2 need boundary inflows, exports and diversions, stages, and salinity data. Data to run the model for this analysis were developed from two sources:

- Up to the point where the forecast begins, observed historical data (through February 22, 2022) were used.
- From the end of available historical data through the end of the forecast, data from DWR's Delta Coordinated Operations (DCO) model was used. Information that is fed into the DCO includes hydrology data, contractor delivery requests, and legal restrictions on exports. The DCO forecast that was used for this analysis utilized the 99% exceedance hydrology, as forecasted in the February Bulletin 120. This represents a forecast for a very dry year. Based on historical data, a 99% exceedance hydrology assumes that only 1% of years would be drier than this forecast.[3]

Table Model1 provides a summary of the primary modeling assumptions. Additional summaries of Delta flows and other variables are provided in the *Analysis of the Impacts of TUCP* below.

Non-hydrologic modeling assumptions are listed below; these assumptions are common to the base case and TUCP:

- Suisun Marsh Salinity Control gates are in tidal operation through the end of May, then open until September 1, 2022, when tidal operation begins again.

2 The court ordered implementation of the IOP on March 11, 2022 (Order Re Motions to Remand Without Vacatur; Stay; and Impose Interim Injunctive Relief, Eastern District Case Nos. 1:20-cv-00431-DAD-EPG and 1:20-cv-00426-DAD-EPG). The IOP incorporates preexisting CDFW ITP requirements for Delta operations and therefore does not affect the analysis in this biological review.
3 Note that the subsequent March forecast's 90% exceedance, issued following the completion of quantitative analyses in this review, is lower than the February 99% exceedance.

- The False River temporary barrier was notched for fish passage and boating access, but not fully removed, on January 7, 2022, and will be closed again on April 10, 2022.

- The Delta Cross Channel Gates are closed in all of March through May. Open partially in June. The gates open fully in July and August and open partially in September.

- The Middle River will be hydraulically closed by May 15, 2022. The Old River at Tracy barriers and Grant Line Canal Barrier will be hydraulically closed by May 27, 2022.

- Temporal period March-September 2022 was modeled and presented to allow for species effects to be estimated that may occur over a larger time frame than the petitioned April 1 through June 30, 2022 time period.

CVP and SWP operations planning scenarios were developed to evaluate the system capability using conservative forecasted conditions for the remainder of 2022. Because of the extreme dry trend, hydrology based on the 99% exceedance hydrology forecast from February was used. Initial projections, as represented by the “Base (No TUCP)” scenario indicated a high risk of storages in Oroville and Folsom dropping below levels where release capacity would be reduced at Oroville and the ability to provide health and safety throughout the fall would be lost at Folsom. In the “Base (No TUCP)” scenario, Shasta is operated primarily for temperature management and senior water rights and riparian demands along the Sacramento River, where-as Oroville and Folsom are operated to maintain Delta outflow, other In-Basin Use, and temperature management. Outflow requirements for X2 (April to June) in this scenario are met by limiting exports as much as possible and releasing stored water.

A second CVP and SWP operations planning scenario “TUCP” was developed to evaluate the potential reduced risk to storage with modifications to the outflow requirements. In this scenario, Shasta is operated the same as in the “Base (No TUCP)” scenario, but Oroville and Folsom are able to reduce releases while meeting the modified standards. Both Oroville and Folsom under this scenario are projected to stay above critical levels reached in the “Base (No TUCP)” scenario. Exports in the “TUCP” scenario are able to increase incrementally due to additional un-stored water made available with the modified standards under the TUCP.

Shasta operations for temperature management and downstream deliveries are currently under discussion and may be adjusted significantly to protect upstream storage; however, releases that contribute to meeting delta objectives are expected to stay consistent to what was analyzed and will be consistent in both Base and TUCP scenarios presented in Table Model1.

Table Model1. Summary of Primary Operational Modeling Assumptions by Case for March through September 2022.

Month	Base (No TUCP) Sacramento River at Freeport (cfs)	Base (No TUCP) San Joaquin River at Vernalis (cfs)	Base (No TUCP) Computed Delta Outflow (cfs)	Base (No TUCP) Combined Exports (cfs)	TUCP Sacramento River at Freeport (cfs)	TUCP San Joaquin River at Vernalis (cfs)	TUCP Computed Delta Outflow (cfs)	TUCP Combined Exports (cfs)
March	8,300	850	8,350	1,050	8,300	850	8,350	1,050
April	9,450	1,000	8,400	1,050	6,150	700	4,350	1,500
May	9,100	950	7,100	1,050	6,150	950	4,000	1,200
June	10,850	700	7,100	1,000	7,950	700	4,000	1,200
July	8,600	500	4,000	1,000	8,600	500	4,000	1,000
August	7,550	550	3,400	1,100	7,550	550	3,400	1,100
September	6,250	650	3,000	1,600	6,250	650	3,000	1,600

Note: Values are rounded to nearest 50 cfs. Months subsequent to TUCP period (April–June) are included for analyses considering longer time periods with lagged effects.

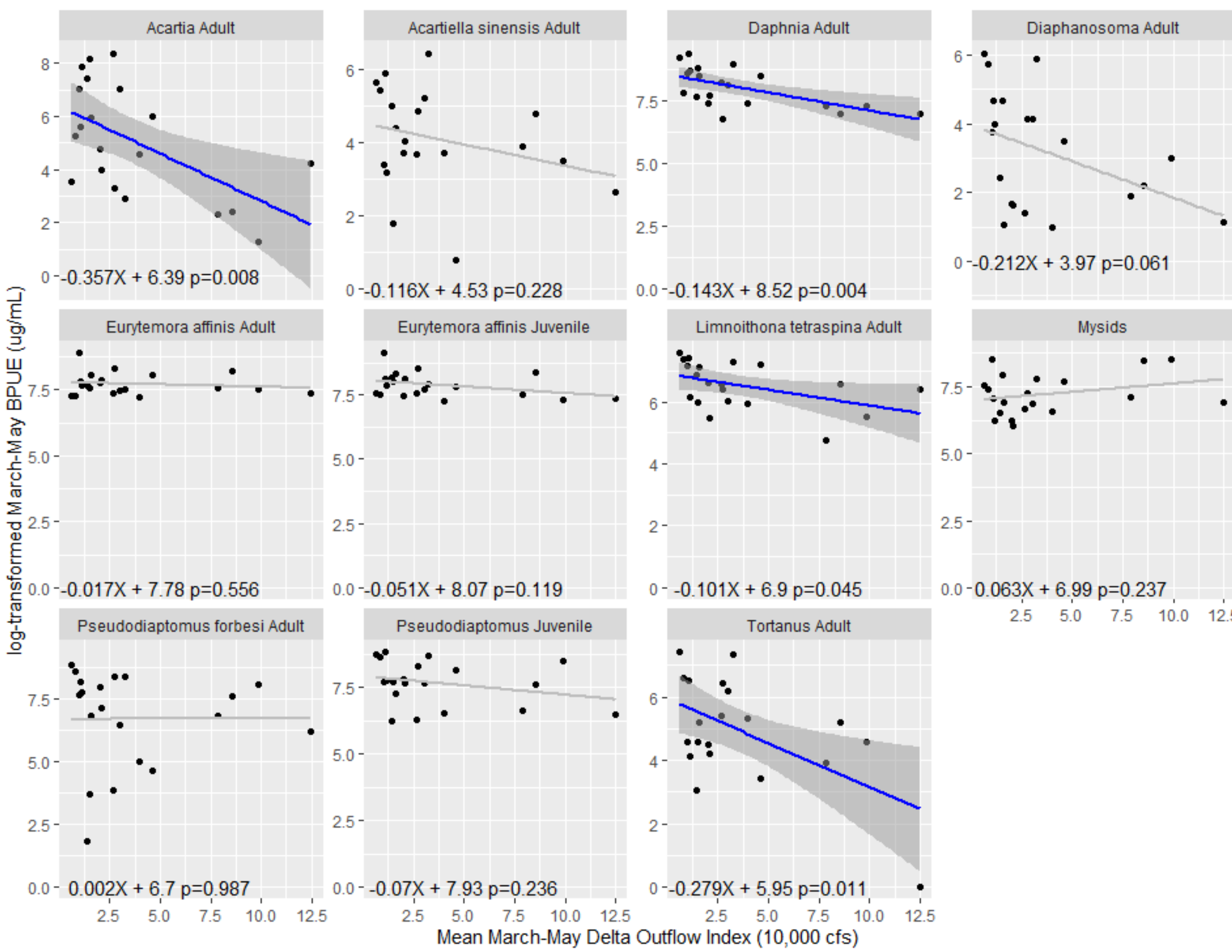
IV. Analysis of the Impacts of TUCP

Ecosystem Impacts

Impacts of the April through June 2022 TUCP on focal species and their habitat are discussed in the species-specific sections below. Impacts to species and their habitat reflect ecosystem-level impacts of drought conditions, key among them being factors such as potential impacts on food webs.

Phytoplankton and zooplankton abundance are correlated with flow, though the direction of the correlation varies with region of the Delta. Phytoplankton blooms frequently occurring during lower flows in the past (Glibert et al. 2014). At the overall scale sampled by existing monitoring programs in the Delta and Suisun Bay/Marsh, there are more statistically significant negative relationships between common zooplankton taxa biomass and spring Delta outflow than positive relationships (Figure ZOOP1).

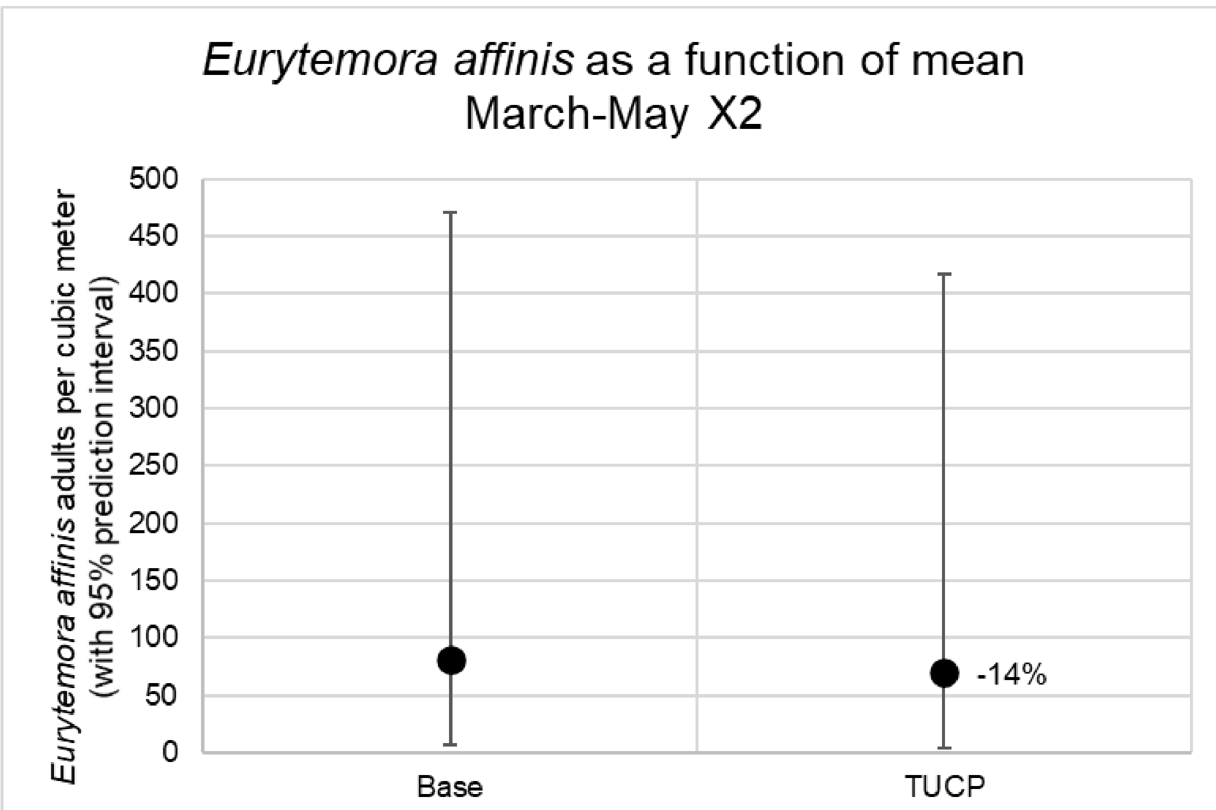
Figure ZOOP1. Regression Relationships of Various Zooplankton Taxa and Mean March through May Delta Outflow from Environmental Monitoring Program and 20-mm Survey Stations, 2000 through 2021.



Note: Blue lines and confidence intervals are included only for regressions statistically significant at p<0.05. Mysids include *Neomysis mercedis*, *Neomysis kadiakensis*, and *Hyperacanthomysis longirostris*.

One of the most important taxa for larval smelt early in the spring is the calanoid copepod *Eurytemora affinis* (*E. affinis)* (Slater and Baxter 2014; Jungbluth et al. 2021). While the graph shown in Figure ZOOP1 did not show a relationship between Delta outflow and *E. affinis* biomass at the scale of the entire estuary, March through May Delta outflow is positively correlated with the density of *E. affinis,*[4] in the low salinity zone (Kimmerer 2002; Greenwood 2018), a key habitat area for delta smelt. Drought conditions generally would be expected to reduce the low salinity zone's density of *E. affinis* relative to higher levels of outflow, but there is uncertainty in the extent to which this would be affected by the TUCP on top of baseline drought conditions. Application of the statistical relationship developed by Greenwood (2018) shows differences between mean estimates of the base case and the TUCP scenario of 14%, with relatively broad prediction intervals (Figure ECO1).

Figure ECO1. *Eurytemora affinis* Adult Density in the Low Salinity Zone as a Function of Mean March through May X2, Based on Statistical Relationship from Greenwood (2018).



Note: Circles represent mean estimate, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 95% prediction interval.

4 *Eurytemora affinis* has since been reclassified as *E. carolleeae* (Jungbluth et al. 2021) but for this biological review is referred to herein as *E. affinis* for consistency with previous works referenced herein.

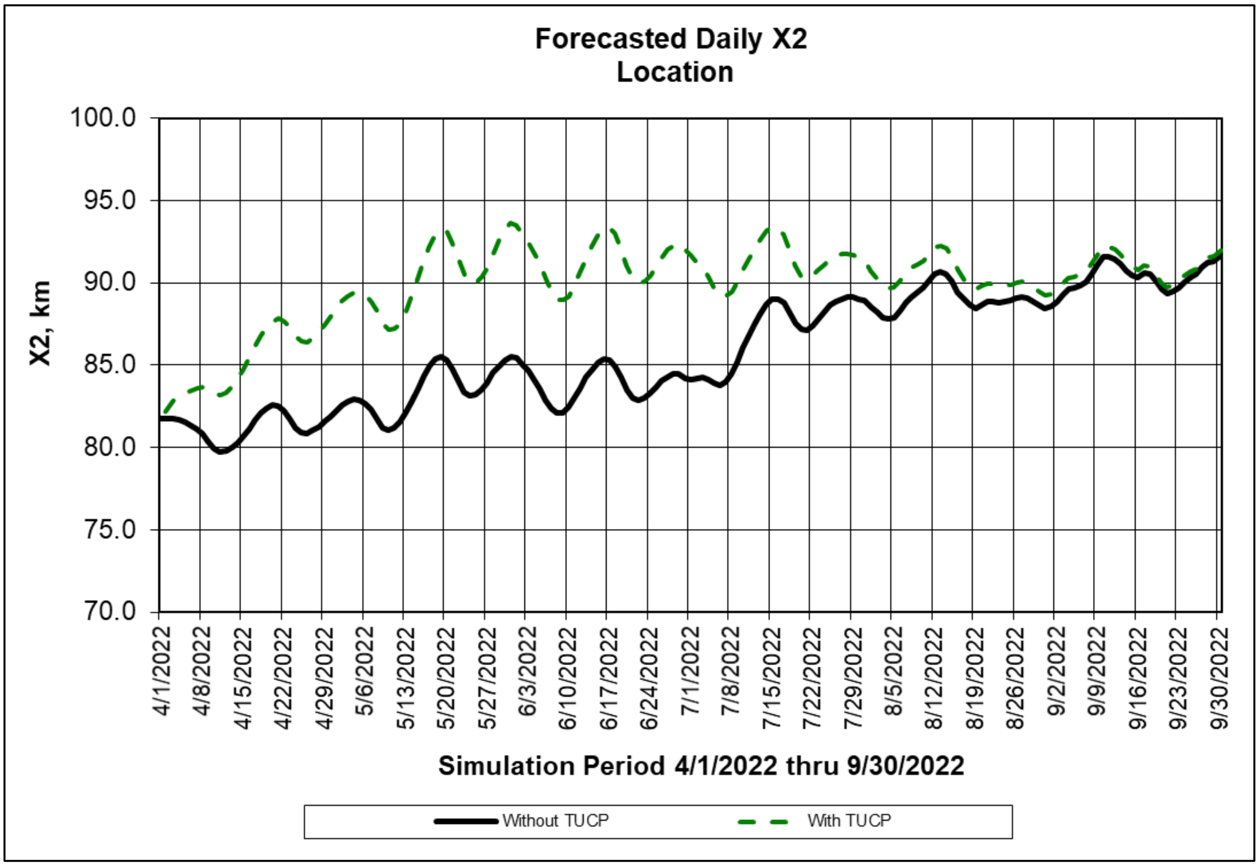
The density of the mysid shrimp *Neomysis mercedis*, prey for species such as longfin smelt (Feyrer et al. 2003; Jungbluth et al. 2021; Baxter et al. 2010) in the low salinity zone has also been correlated with Delta outflow during March through May, although with a relatively modest proportion of variation in density explained by outflow ($r^2 = 0.32$; Hennessy and Burris 2017). *Neomysis mercedis* (*N. mercedis*) abundance indices declined considerably in the late 1990s and by far the most abundant mysids now are *Hyperacanthomysis longirostris* and *Neomysis kadiakensis* (Barros 2021). Neither *H. longirostris* nor *N. kadiakensis* has statistically significant correlations with Delta outflow, as reflected in the lack of significant correlations with Delta outflow for these three mysid taxa combined (Figure ECO1). This indicates that the TUCP's changes to spring outflow would have very limited effects on mysids in March–May as a whole, although with some potential negative effects to *N. mercedis* based on the correlation observed by Hennessy and Burris (2017). The density of *N. mercedis* in the low salinity zone during May–October has also been correlated with X2, although Kimmerer (2002) observed a change in the relationship from negative to positive following 1987, indicating that less Delta outflow (greater X2) under the 2022 TUCP during April–June would not be expected to negatively affect *N. mercedis* density.

July through September Delta outflow is positively correlated with the density of the zooplankton *Pseudodiaptomus forbesi* (an important prey item for species including delta smelt and longfin smelt) in the low salinity zone as a result of spatial subsidy from the freshwater Delta (Kimmerer et al. 2018). Drought conditions would be expected to reduce the density of *P. forbesi* but July–September Delta outflow would not differ between the base case and the April–June TUCP, therefore the TUCP would not affect *P. forbesi*.

Abundance indices of Mississippi silversides (*Menidia audens*), predators of larval delta smelt (Schreier et al. 2016), are negatively related to spring (March through May) south Delta exports and summer (June through September) Delta inflow (Mahardja et al. 2016). Silverside abundance could increase as a result of the drought's reduction in Delta inflow and minimal south Delta exports. Note that the lowest level of March–May exports (~2,500 cfs) assessed by Mahardja et al. (2016) was greater than the ~1,050-cfs exports level that would occur under the base and the ~1,050–1,500-cfs exports level that would occur under the TUCP (Table Model1). Similarly, June through September Delta inflow under the base (~9,300 cfs) and April–June TUCP (~8,500 cfs) would be appreciably lower than the lowest level (~13,000 cfs) of Delta inflow assessed by Mahardja et al. (2016). The relatively small differences in south Delta exports (~200 cfs) and Delta inflow (~800 cfs) between the base and TUCP would be unlikely to result in appreciably different silverside abundance given the overall very low south Delta exports and Delta inflow because of the drought conditions.

Less Delta outflow under the TUCP relative to the base would move the salinity field upstream (as illustrated by modeled X2; Figure ECO2), potentially allowing the invasive clam *Potamocorbula amurensis* to move further upstream and thereby expand its range and overall grazing effect if salinity remains high enough for several months (Kimmerer et al. 2019). Given that generally dry conditions have been persisting in the system since 2020, *P. amurensis* may have already moved upstream in response to drought conditions and therefore, the extent to which the 2022 TUCP and continuing drought would add to this is uncertain.

Figure ECO2. Daily X2 from DSM2 Modeling.



Note: Base case = Without TUCP.

Reduced Delta inflow and increased residence time may contribute to a general drought-related increase in intensity of *Microcystis* and other cyanobacterial harmful algal bloom (cyanoHAB) species (Lehman et al. 2018); however, the extent to which the TUCP's changed operations from baseline conditions would affect harmful *Microcystis* cyanoHABs is uncertain, but likely small, given that water temperature is the main driver of bloom intensity (Lehman et al. 2013; Berg and Sutula 2015). Increased occurrences of *Microcystis* cyanoHABs have been linked with increases in water temperatures which enables the growth rate of *Microcystis* to become competitive relative to other members of the phytoplankton community (Berg and Sutula 2015). A temperature threshold of 19 degrees Celsius (°C) has been identified as necessary to trigger growth of *Microcystis* in the Delta (Lehman et al. 2013), whereas temperatures of 25°C and above have been hypothesized to play a role in explaining its interannual variability (Lehman et al. 2018). Whereas water temperature appears to be a trigger for growth, other factors such as nutrient availability and high irradiance are necessary to sustain its growth and lead to the development of a bloom. In other words, once growth of *Microcystis* has been triggered, it cannot attain high enough growth rates to accumulate biomass and become dominant unless it can 1) maintain itself at the surface of the water column where irradiance is high and 2) there is an ample supply of nutrients available in the water column at the start of the bloom (Visser et al. 2005). At any time during a bloom, if the nutrient supply is depleted or the water mixing rate increases such that the time

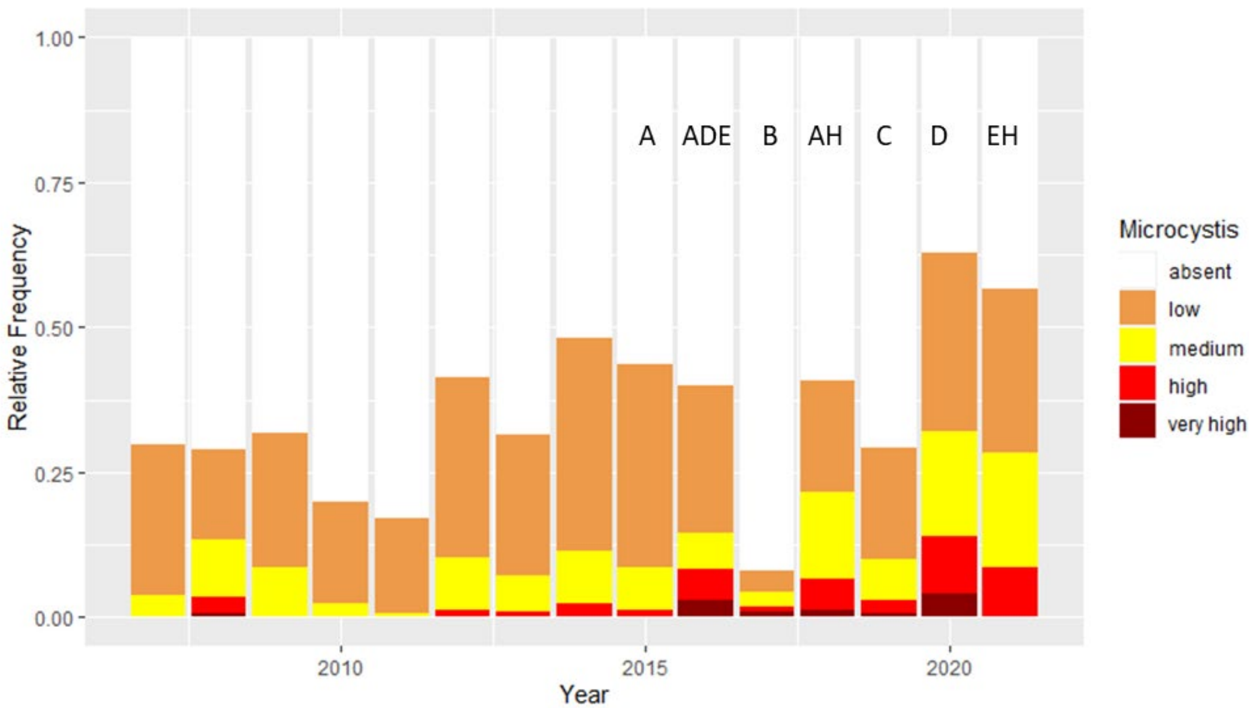
Microcystis can spend at the surface becomes limited, cells may become stressed and growth may slow down. An additional factor that will retard growth of *Microcystis* is exposure to saline water. This is evident when water containing *Microcystis* colonies is advected from the San Joaquin River into the lower Sacramento River or Suisun Bay; salinities in those regions are not conducive to growth resulting in the colonies breaking apart and blooms dissipating (Lehman et al. 2008). When *Microcystis* cells become sufficiently stressed, due to any environmental factor (e.g., light, nutrients, temperature, salinity), the colonies will settle out of the water column and the bloom will terminate (Visser et al. 1995).

Predicting whether cyanoHAB occurrences will either develop, or increase in frequency, severity, and/or duration, relative to a baseline, in a given location due to incremental changes in environmental factors is difficult. At a minimum, it requires knowledge of the factors discussed above for triggering (water temperature) and sustaining (high irradiance and high nutrient availability) growth and blooms in any particular location, together with data on how these factors are predicted to change. It is important to keep in mind that all three factors have to occur simultaneously for cyanoHABs to develop. Change in one factor alone will most likely not lead to a change in bloom status. For example, increase in nutrient concentration in a location with a well-mixed water column may not lead to a bloom as continued mixing of *Microcystis* to the bottom will prevent it from increasing its growth rate sufficiently to become dominant.

Analysis of the impact of the 2021 TUCP on cyanoHABs did not find evidence for a Delta-wide increase in *Microcystis* attributable to the TUCP, since *Microcystis* was seen as frequently in 2020 (no TUCP) as in 2021 (Hartman et al 2021; Figure ECO3). However, Delta outflow is a significant predictor of *Microcystis* occurrence, and a large bloom that occurred in Franks Tract in 2021 may have been exacerbated by the emergency drought barrier (Hartman et al. 2021).

Discussion of other relevant ecosystem impacts is provided in the species-specific analyses below.

Figure ECO3. Frequency of visual *Microcystis* observations in the Delta and Suisun from long-term monitoring programs, June-October, 2007–2021.



NOTE: Letters indicate groups of years that were not significantly different at the p = 0.05). The ordinal regression was only run on 2014–2021, but earlier years are shown for comparison.

Winter-Run Chinook Salmon

<u>Presence and Life Stages of Winter-Run Chinook Salmon</u>

The Juvenile Production Estimate for natural-origin winter-run Chinook salmon entering the Delta in water year 2022 is 125,038 fish (NMFS 2022). The Salmon Monitoring Team, which meets weekly, estimated at the 33/1/2022 meeting that 7.5% of winter-run juveniles were yet to enter the Delta, the majority (85%) were in the Delta, and 7.5% had exited the Delta (Figure WR1). Juvenile winter-run Chinook salmon migrating to the Delta have been observed to potentially rear for the entire winter in the Delta (del Rosario et al. 2012) and historically exit during March and April. This winter-long rearing period is consistent with historical timing suggested in summaries by NMFS (2019: Tables WR1 and WR2) and the SacPAS database of Central Valley monitoring efforts (Figures WR2, WR3, WR4, and WR5). Adult winter-run also migrate through the Delta in highest abundance in February through April and in lower abundance until June (Table WR2).

Figure WR1. Salmon Monitoring Team Estimates of the Percentage of Juvenile Winter-Run Chinook Salmon Yet to the Enter the Delta, In Delta, and Exited Delta.

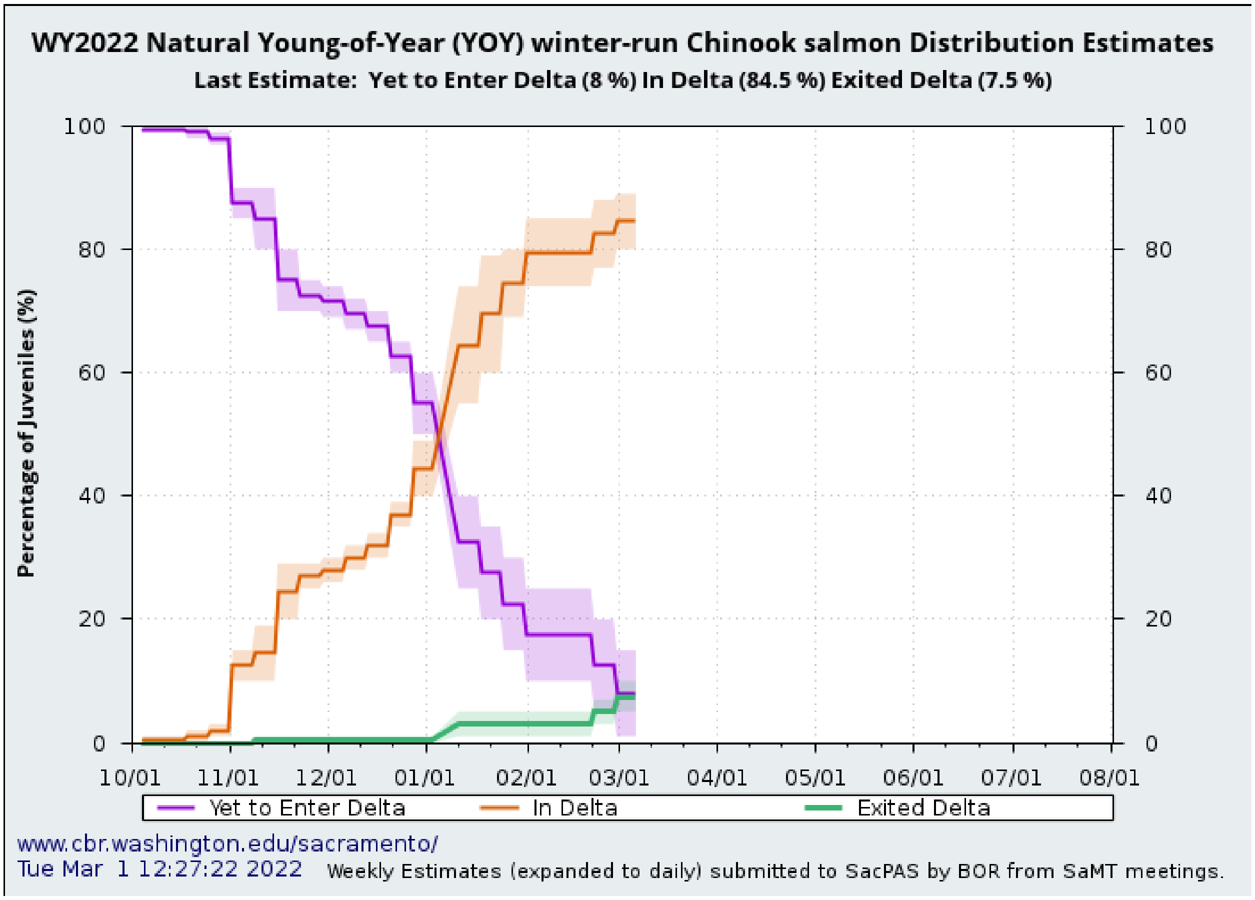


Table WR1. Temporal Occurrence of Sacramento River Winter-Run Chinook Salmon by Life Stage in the Sacramento River

Relative Abundance	High (▼)			Medium (☒)			Low (#)			None (-)		
Adults Freshwater	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin [a,b]	☒	☒	☒	☒	☒	☒	☒	-	-	-	☒	☒
Upper Sacramento River spawning [c]	-	-	-	-	#	▼	▼	☒	-	-	-	-
Juvenile Emigration	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff [d]	#	#	#	-	-	-	#	☒	☒	☒	☒	☒
Sacramento River at Knights Landing [e]	▼	☒	#	-	-	-	-	-	-	#	☒	▼
Sacramento trawl at Sherwood Harbor [f]	☒	▼	▼	#	-	-	-	-	-	-	☒	▼
Midwater trawl at Chipps Island [f]	☒	☒	▼	▼	#	-	-	-	-	-	-	#

Sources: [a] Yoshiyama et al. (1998), Moyle (2002) ; [b] Myers et al. (1998); [c] Williams (2006); [d] Martin et al. (2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2019); [f] Delta Juvenile Fish Monitoring Program, USFWS (1995-2019), del Rosario et al. (2013).

Source: National Marine Fisheries Service 2019:67.

Table WR2. Temporal Occurrence of Sacramento River Winter-Run Chinook Salmon by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)		Low (#)			None (-)		
Life-Stage	Month										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	▼	▼	▼	⊠	⊠	-	-	-	-	⊠	⊠
Juvenile [2]	#	⊠	▼	⊠	-	-	-	-	-	#	#	⊠
Salvaged [3]	⊠	▼	▼	#	#	#	-	-	-	-	-	#

[1] *Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).*
[2] *Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.*
[3] *Months in which salvage of wild juvenile winter-run at State and Federal pumping plants occurred (National Marine Fisheries Service 2016c).*

Source: National Marine Fisheries Service 2019:68.

Figure WR2. Catch Index Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon in Sacramento Beach Seines, Brood Years 1996 through 2020.

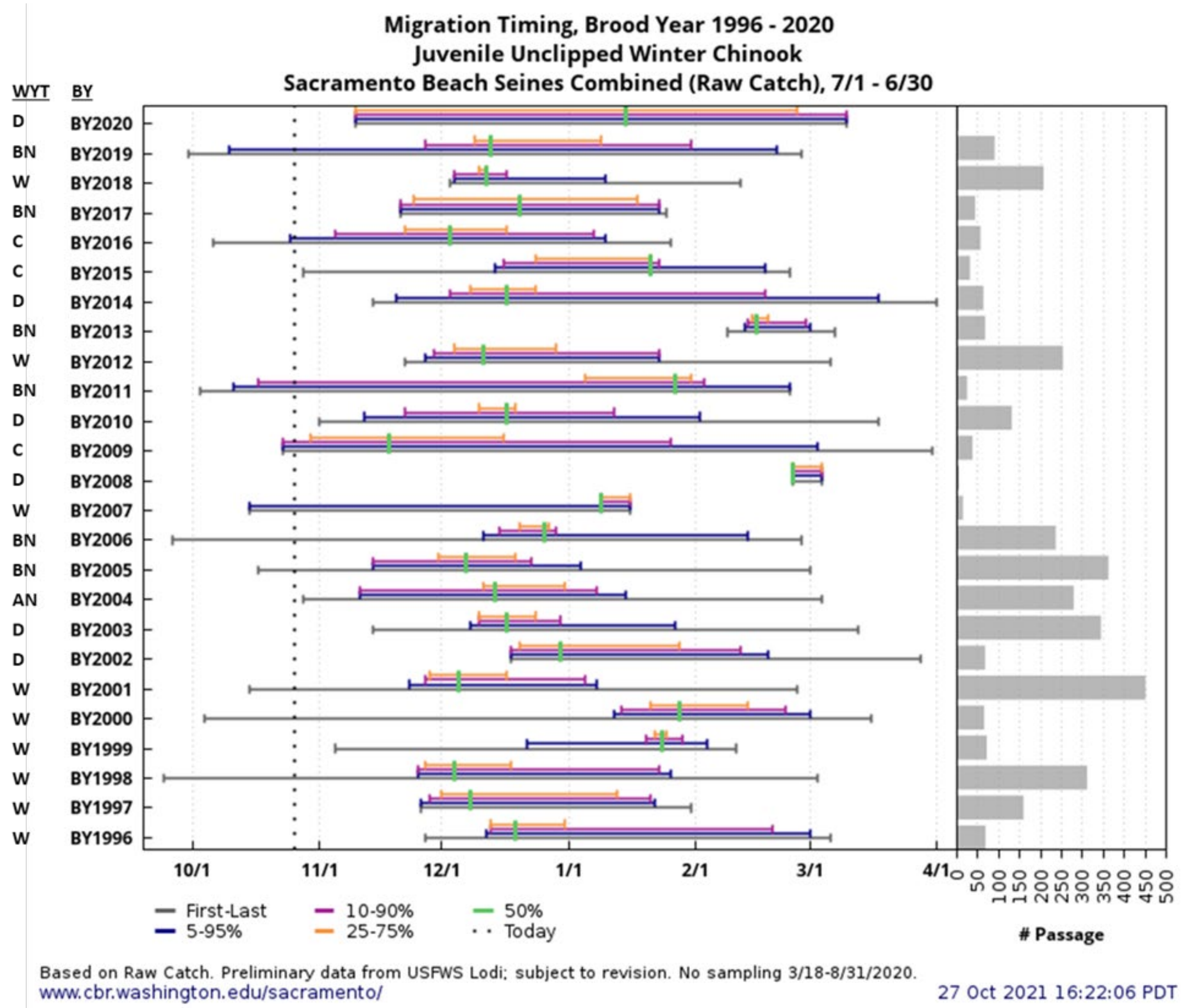


Figure WR3. Catch Index Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon in Sacramento Trawls at Sherwood Harbor, Brood Years 1996 through 2020.

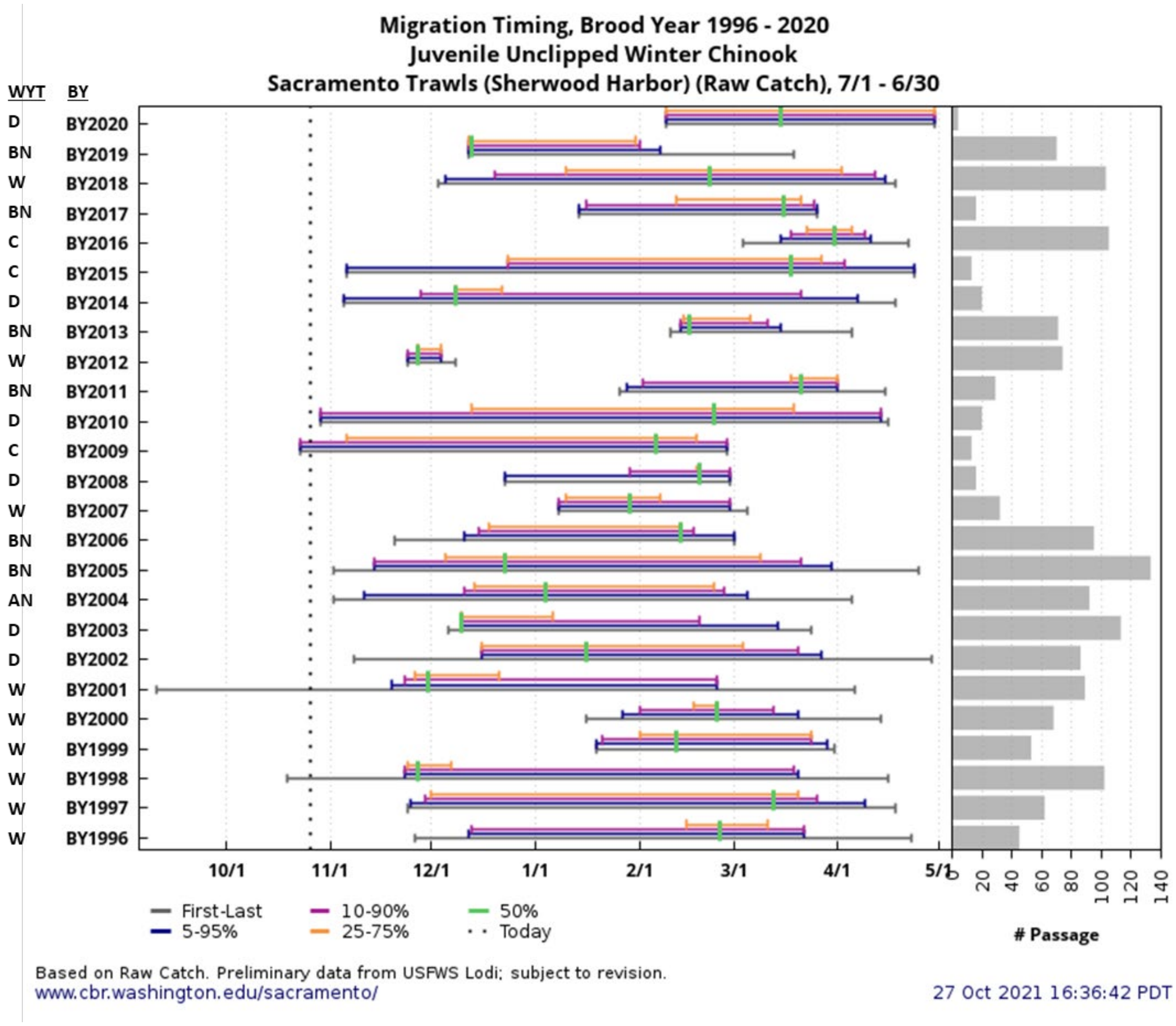


Figure WR4. Catch Index Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon in Chipps Island Trawls, Brood Years 1996 through 2020.

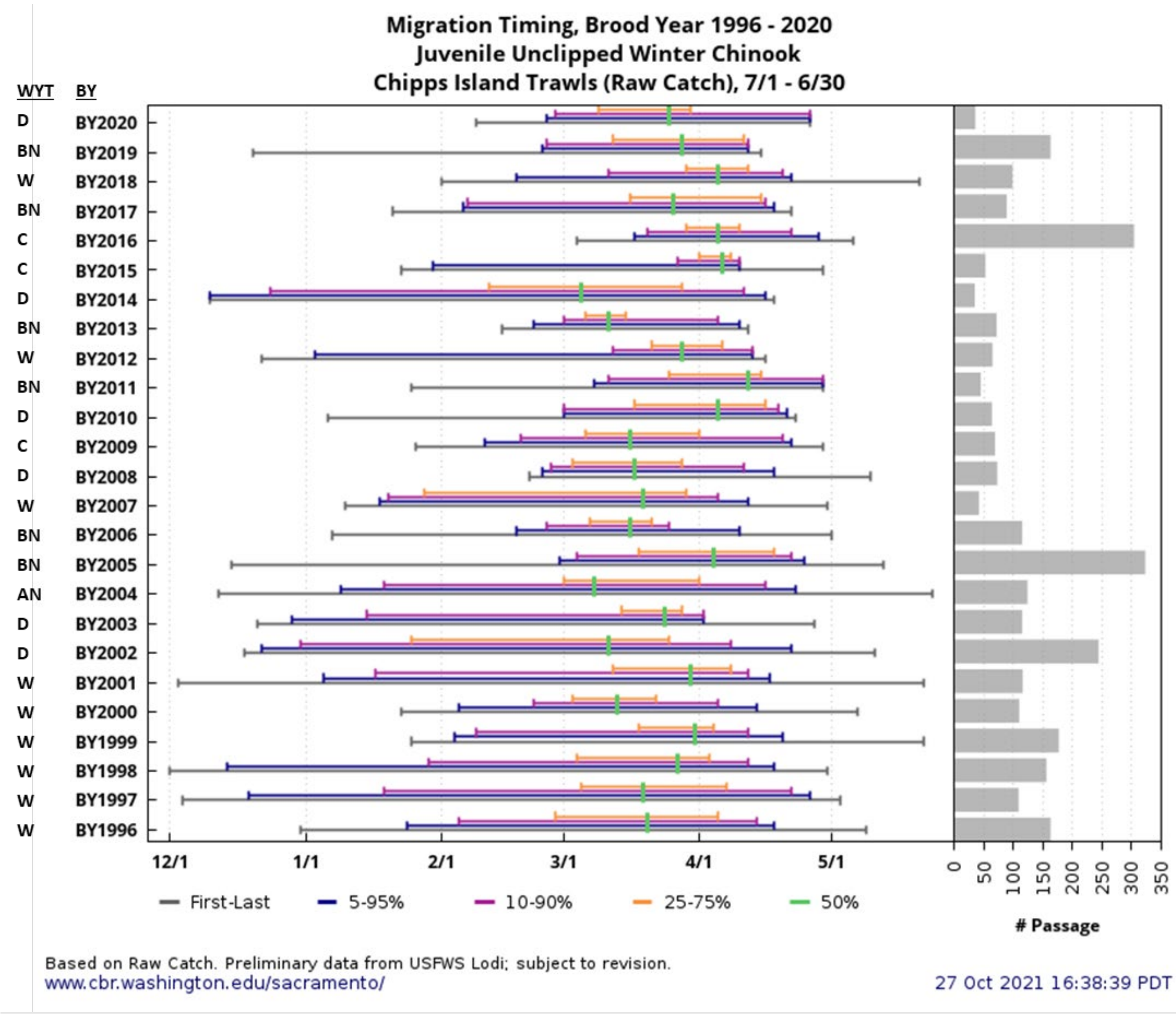
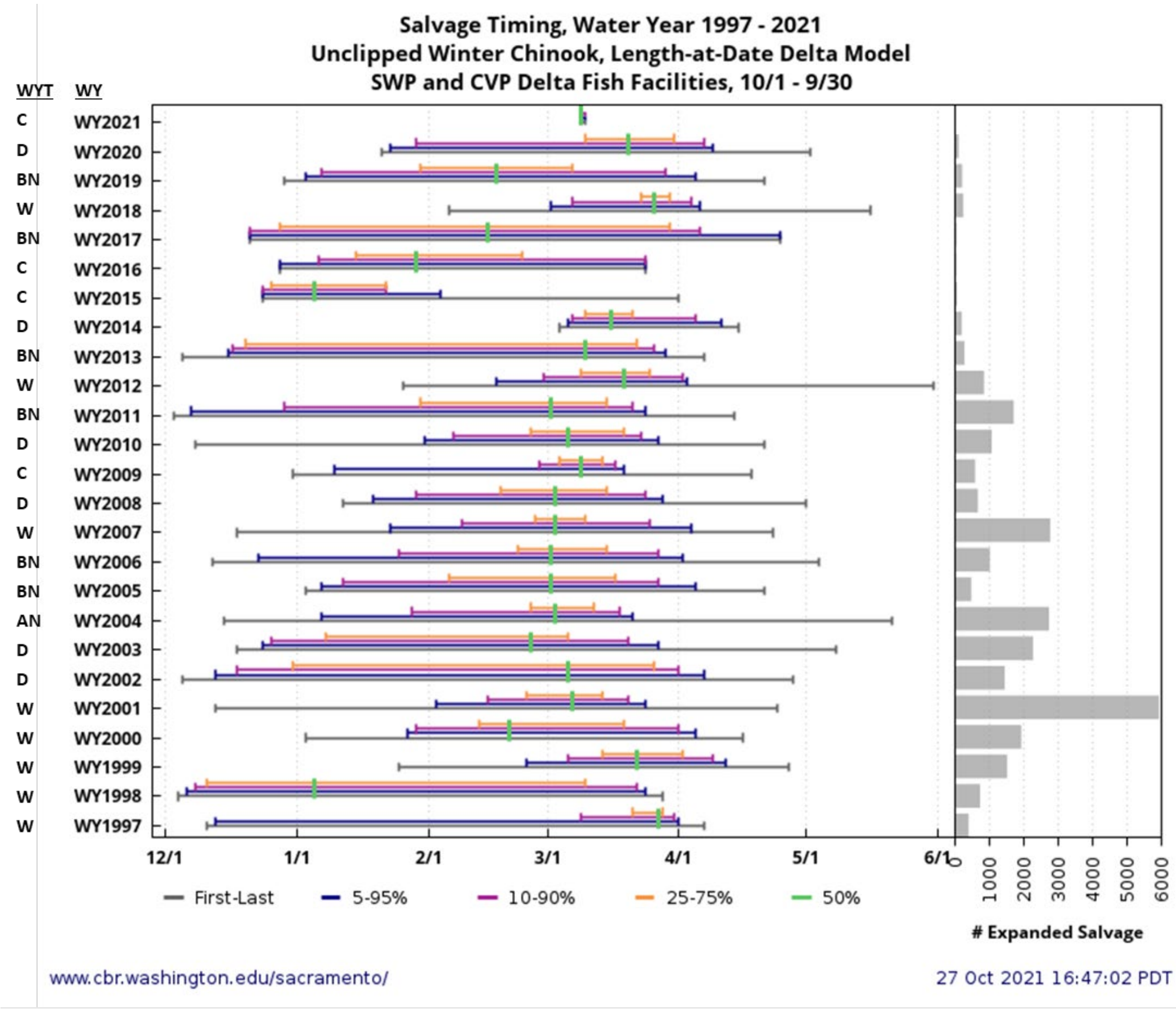


Figure WR5. Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon (Race Determined from Length at Date, LAD) at the SWP and CVP South Delta Fish Salvage Facilities, Water Years 1997 through 2021.



Impacts of TUCP on Winter-Run Chinook Salmon

Per the presence summary above, some BY 2021 winter-run Chinook salmon juveniles will be in or entering the Delta between early April and June when there would be changes in flows relative to the base case due to the TUCP. Individuals migrating during this time could experience reduced through-Delta survival due to factors like increased reverse flows and slower mean flow velocity, both of which have been shown to result in longer travel times (Romine et al. 2013; Perry et al. 2018), which may increase predation risk under the TUCP relative to the base case. Through-Delta survival was estimated based on the model of Perry et al. (2018)[5] Estimates of through-Delta survival from this model are estimated using flow conditions and Delta Cross Channel gate status (open / closed), including channel flow and proportion of flow entering distributaries such as Georgiana Slough. Note that this model does not include south Delta exports as an input variable. Subsequent research to update this model has not found south Delta exports to be a predictor of survival for fish in the Sacramento River nor for entry into Georgiana slough, although south Delta exports were correlated with survival for the portion of fish entering the south Delta region. This unreleased version of the model was not available for consideration in this analysis, but the focus on north Delta effects is appropriate given the changes to Delta inflow from the Sacramento River as the main driver in the model. Modeling results indicated that the differences in Freeport flow may result in lower through-Delta survival probability of juvenile Chinook salmon for the TUCP than the base case (0.03–0.04 [i.e., a decrease of 3–4% absolute difference], or a decrease of 9–10% relative difference; Table WR3[6]). These results reflect flow-survival relationships and the probability of entry into low-survival pathways. With respect to the latter, the Perry et al. (2018) model estimated juvenile Chinook salmon entry into the low-survival interior Delta through Georgiana Slough and the Delta Cross Channel from the Sacramento River would be greater (0.02–0.03 [i.e., an increase of 2-3% absolute difference], or an increase of 7–8% relative difference) under the TUCP relative to base (Table WR4); these patterns are part of the through-Delta survival estimates.

5 The North Delta Routing Management Tool is a spreadsheet-based tool that was provided by Perry (pers. comm.) and reproduces the mean response of the STARS (Survival, Travel time, And Routing Simulation) model (Perry et al. 2019). Note that the North Delta Routing Management Tool gives calculations for Freeport flow as low as 5,000 cfs (which is less than the assumptions for TUCP cases), although flows below 6,800 cfs are extrapolations given the range of data available for modeling (Perry et al. 2019: 5). Also note that the statistical relationships in the model were based on large hatchery-origin late fall Chinook salmon smolts that migrated through the Delta during December–March, so survival of other runs could have a different response to operations (Perry et al. 2019: 14).

6 The absolute estimates are generally of similar magnitude to those estimated for April–June in critically dry water years in the analysis conducted for the NMFS ROC LTO biological opinion (see Perry et al. 2019, Appendix 1: figures for critically dry water years 1924, 1929, 1931, 1933, 1934, 1976, 1977, 1988, 1990, 1992, and 1994).

Table WR3. Mean Monthly Probability of Through-Delta Survival of Juvenile Winter-run Chinook Salmon Based on Freeport Flow and Delta Cross Channel Position from the Model of Perry et al. (2018).

Month	Base	TUCP
April	0.38	0.34 (-10%)
May	0.37	0.34 (-9%)
June	0.38	0.35 (-9%)

Note: Percentage difference in parentheses represents TUCP minus base.

Table WR4. Mean Monthly Probability of Juvenile Winter-run Chinook Salmon Entering the Interior Delta Through Georgiana Slough and the Delta Cross Channel Based on Freeport Flow and Delta Cross Channel Position from the Model of Perry et al. (2018).

Month	Base	TUCP
April	0.27	0.30 (8%)
May	0.28	0.30 (7%)
June	0.28	0.30 (7%)

Note: Percentage difference in parentheses represents TUCP minus base.

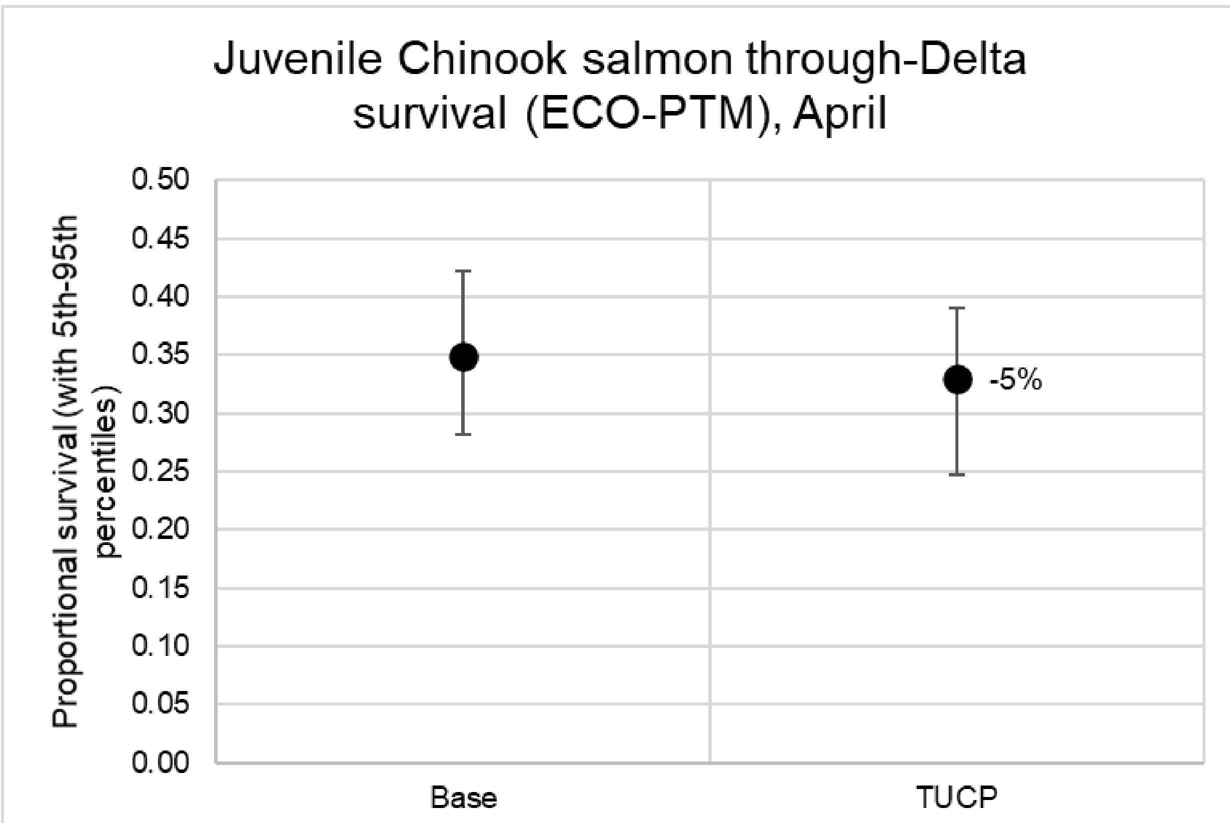
The ECO-PTM model (Wang 2019) was used as an additional line of evidence for potential TUCP through-Delta survival effects.[7] Particles with juvenile salmon-like behaviors were used in the model in association with 15-minute DSM2 modeling outputs representing hydrodynamic conditions in the Delta.[8] Particles were released in between April and June 2022 in the Sacramento River at Freeport. Particles that reach Chipps Island represent fish that survived through the Delta in the modeled period. The results from the ECO-PTM model generally were similar to the results from the spreadsheet model version of Perry et al. (2018; Table WR3): differences in through-Delta survival in April and May from ECO-PTM were less than Perry et al. (2018) and differences in through-Delta survival in June from ECO-PTM were greater than Perry et al. (2018) (Figures WR6, WR7, and WR8). These differences may reflect more detailed Delta hydrodynamics in the ECO-PTM model than the spreadsheet model based on Perry et al. (2018), for which the through-Delta migration survival probability is based on the flows on Delta entry. The greater temporal overlap of particles released in June migrating through the Delta with subsequent partial opening of the Delta Cross Channel in June contributes to the estimated differences between through-Delta survival in the TUCP and the base case (Figure WR8). Note that most winter-run

7 The ECO-PTM model does not include consideration of south Delta entrainment (Wang 2019).
8 100 particles were inserted near Freeport at DSM2 channel 412 (at distance 0) every 15 minutes (i.e., starting at 00:00 and ending at 23:45 each day, for a total of 9,600 particles per day) and tracked for 90 days. Particles were inserted for 91 days (4/1/2022–6/30/2022). Results presented herein show the mean and range of through-Delta survival for particles released in a given month.

juveniles would have migrated through the Delta before May/June per the summary above in *Presence and Life Stages of Winter-Run Chinook Salmon*.

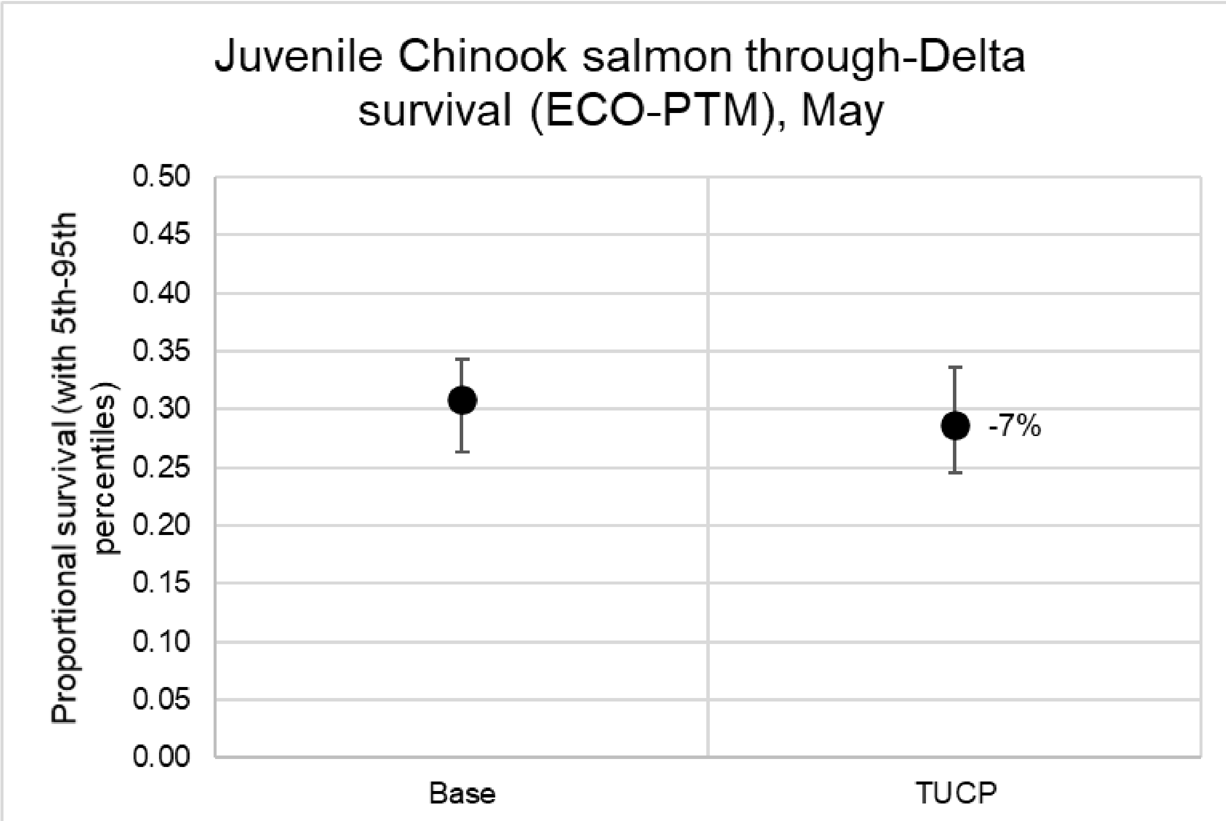
At low outflow (i.e., decreased outflow as a result of decreased riverine inflow), channel margin habitat becomes exposed and is unavailable for juvenile salmonids that are present. This lack of cover in habitat may reduce juvenile survival. Lower outflows may intensify the density of littoral predators into a smaller, shallower area and/or decrease the quantity of cover available to outmigrating salmonids to avoid predators, but noted that there is a high level of uncertainty in this conclusion. Note that such effects may be represented to some unknown extent by the flow-dependent survival relationships in the through-Delta survival model results described above.

Figure WR6. April – Juvenile Winter-run Chinook Salmon Through-Delta Survival, Based on the ECO-PTM Model.



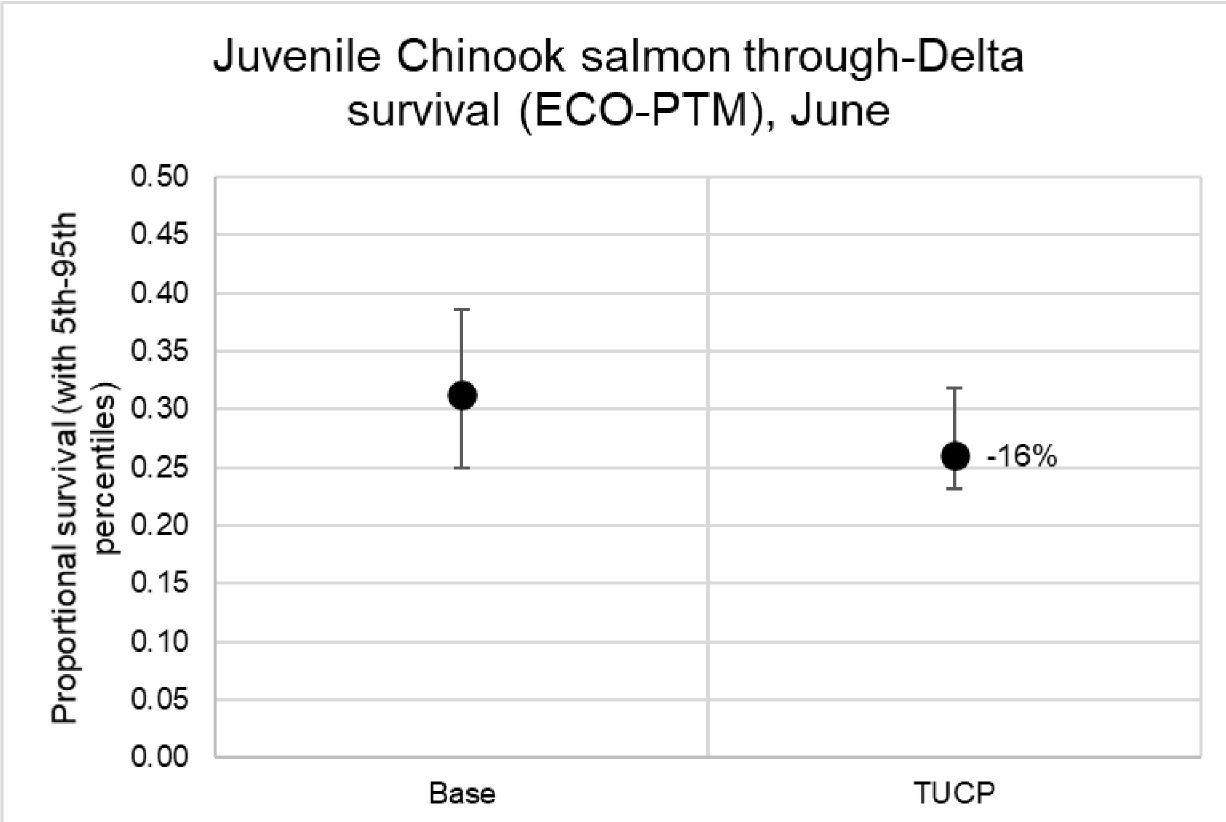
Note: Circles represent mean estimate, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 5th–95th percentiles of daily estimates. The summary is for particles released in April; migration may extend later than April depending on the simulated movement patterns.

Figure WR7. May – Juvenile Winter-run Chinook Salmon Through-Delta Survival, Based on the ECO-PTM Model.



Note: Circles represent mean estimate, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 5th–95th percentiles of daily estimates. The summary is for particles released in May; migration may extend later than May depending the simulated movement patterns.

Figure WR8. June – Juvenile Winter-run Chinook Salmon Through-Delta Survival, Based on the ECO-PTM Model.



Note: Circles represent mean estimate, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 5th–95th percentiles of daily estimates. The summary is for particles released in June; migration may extend later than June depending on the simulated movement patterns.

The base case and TUCP would have low levels of south Delta exports in April through June (~1,000 cfs under the base; ~1,200 cfs –1,500 cfs under the TUCP; Table Model1). Therefore, Old and Middle River flows (Table WR5) would be expected to limit juvenile (and adult) winter-run Chinook salmon entrainment at the south Delta export facilities to low levels given that the Old and Middle River flows are greater (less negative) than the Old and Middle River flow restrictions associated with loss thresholds (NMFS 2019: 478–479; CDFW 2020: 87–90). Exports and Old and Middle River flows would be at levels that generally would result in low levels of entrainment considering Old and Middle River flow restrictions associated with salvage loss thresholds. In addition, in order to minimize entrainment loss of juvenile winter-run Chinook salmon, real-time monitoring and the development of a weekly risk assessment is required by the CDFW (2020) SWP ITP in order to determine the effects of south Delta operational adjustments. This would continue under the base case and the TUCP, limiting entrainment to low levels. By the time the TUCP would take e effect (April), most juvenile winter-run Chinook salmon would be expected to have exited the Delta and most salvage would have occurred (Figures WR4 and WR5).

Table WR5. April through June 2022 Old and Middle River Flows (cfs).

Month	Base	TUCP
April	-1,438	-1,873
May	-1,551	-1,704
June	-1,508	-1,686

Based on timing information in Table WR2 above, the TUCP period would coincide with part of the highest relative abundance of adult winter-run Chinook salmon migrating through the Delta (highest abundance is from February to April, lower abundance in May to June). Delta Cross Channel operations would not differ between the base case and the TUCP, thus there would not be any difference in potential delay of adult winter-run Chinook salmon that may move upstream via the Mokelumne River when the Delta Cross Channel is open. There is little information from which to infer the potential for adult winter-run Chinook salmon migratory delay because of reductions in Delta inflow (e.g., reduced upstream migration cues). However available information for coded-wire-tagged (CWT) hatchery-origin fall-run Chinook salmon released north of the Delta indicates straying rates of fish returning to the Sacramento River are relatively low compared to straying into the San Joaquin River (Marston et al. 2012). Further, within the Sacramento River basin, Williamson and May (2005) found that off-site release of hatchery-reared fall-run Chinook salmon juveniles was the primary factor associated with adult straying rates of fall-run populations. This suggests relatively little influence of flows and therefore no likely difference between the TUCP and the base case for winter-run Chinook salmon adults returning during the TUCP period.

Conclusions for Winter Run Chinook Salmon

In the Delta, a portion of BY 2021 juvenile winter-run Chinook salmon may be in or migrating through the Delta during the early portion of the April–June 2022 TUCP. These juvenile winter-run Chinook salmon in the Delta at the time of the TUCP would not experience risk of high levels of entrainment at the south Delta export facilities from April to June 2022, because of low exports under the TUCP resulting in Old and Middle River flows generally greater than (less negative than) the Old and Middle River flow restrictions associated with loss thresholds, and continued implementation of entrainment risk assessment and operations adjustments. Through-Delta survival of juveniles migrating under the TUCP (primarily in April, with less potential in May and June) could be appreciably less than the base case because of less Delta inflow resulting in negative changes to north Delta hydrodynamics, including greater entry into the interior Delta through Georgiana Slough. Migration conditions for adult winter-run Chinook salmon adults generally would be similar under the base case and TUCP.

Spring-Run Chinook Salmon

Presence and Life Stages of Spring-Run Chinook Salmon

The Salmon Monitoring Team, which meets weekly, estimated at the start of March 2022 during the March 8, 2022 meeting, 27.5% of young-of-the-year (YOY) spring-run Chinook salmon were yet to enter the Delta, 72.5% were in the Delta, and 0% had exited the Delta (Figure SR1). Historical migration timing data also suggest that the greatest period of abundance for young-of-the-year in the Delta is April and May (Tables SR1 and SR2; Figures SR2, SR3, and SR4). The footnote for Table SR1 indicates that yearling downstream emigration generally occurs in fall and winter, resulting in considerably less potential overlap with the TUCP period than for young-of-the-year juveniles. Adult presence in the Delta is also relatively high in April, extending into June (Table SR2).

Figure SR1. Salmon Monitoring Team Estimates of the Percentage of Juvenile Spring-Run Chinook Salmon Yet to the Enter the Delta, In Delta, and Exited Delta.

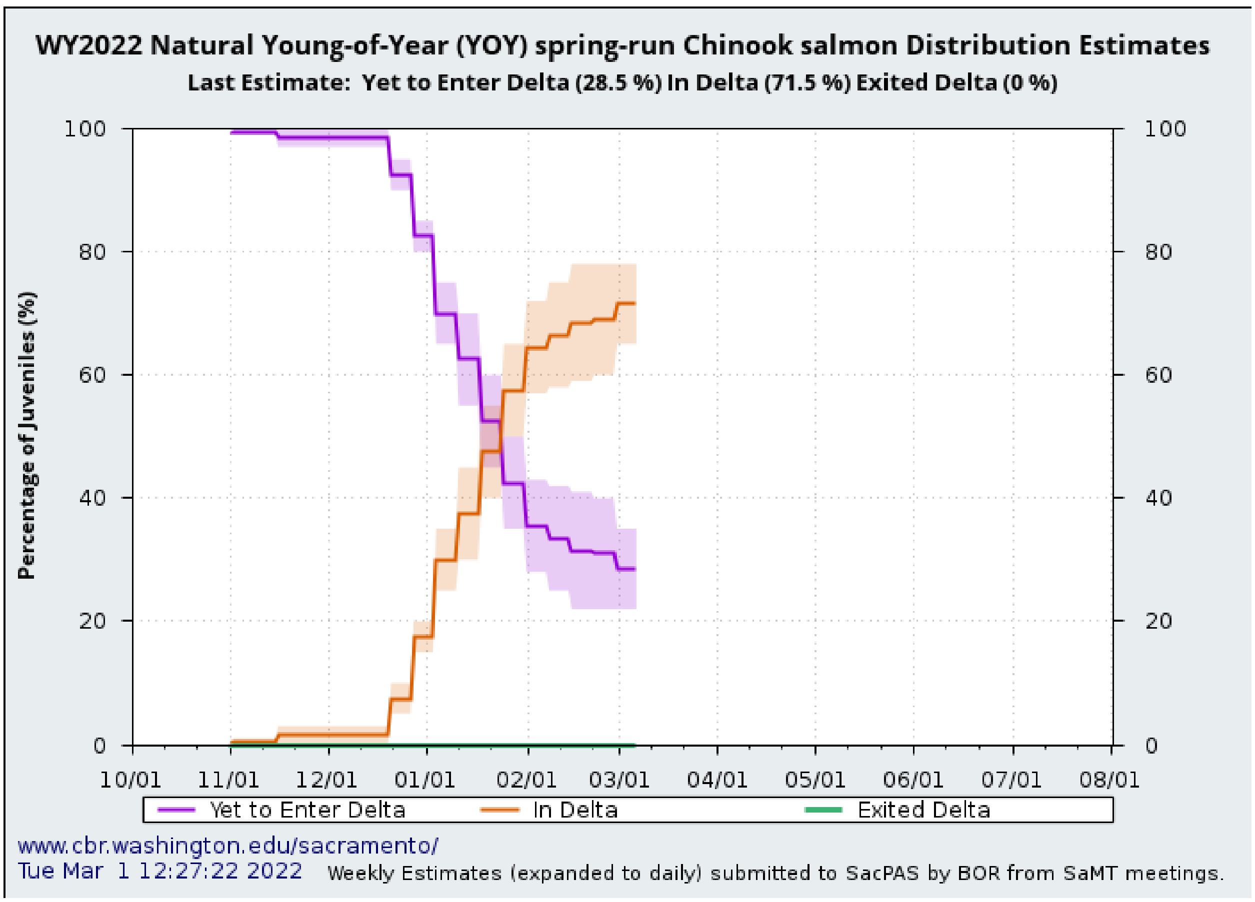


Table SR1. Temporal Occurrence of Central Valley Spring-Run Chinook Salmon by Life Stage in the Sacramento River

Relative Abundance	High (▼)								Medium (⊠)							Low (#)						None (-)		
(a) Adult Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River Basin [a,b]	-	-	-	-	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠	⊠	#	-	-	-	-	-
Sac. River Mainstem [b,c]	-	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	-	-	-	-	-	-	-	-
Adult Holding [a,b]	-	-	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-
Adult Spawning [a,b,c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	#	⊠	▼	▼	⊠	#	-	-	-	-
(b) Juvenile Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River at Red Bluff Diversion Dam [c]	▼	▼	#	#	#	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	▼	▼	▼	▼
Sac. River at Knights Landing[h]	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	-	-	-	-	-	-	-	-	-	-	⊠	⊠	▼	▼

Sources: [a] *Yoshiyama et al. (1998);* [b] *Moyle (2002);* [c] *Myers et al. (1998);* [d] *Lindley et al. (2004);* [e] *California Department of Fish and Game (1998);* [f] *McReynolds et al. (2007);* [g] *Ward et al. (2003);* [h] *Snider and Titus (2000b)*

Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

Source: National Marine Fisheries Service 2019:83.

Table SR2. Temporal Occurrence of Central Valley Spring-Run Chinook Salmon by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)		Low (#)			None (-)		
Life Stage	Month										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	▼	▼	▼	⊠	⊠	-	-	-	-	-	-
Juvenile [2]	#	#	#	▼	⊠	-	-	-	-	-	-	#
Salvaged [3]	#	#	⊠	▼	⊠	-	-	-	-	-	-	-

[1]*Adults enter the Bay late January to early February* (California Department of Fish and Game 1998) *and enter the Sacramento River in March* (Yoshiyama et al. 1998). *Adults travel to tributaries as late as July* (Lindley et al. 2004). *Spawning occurs September to October* (Moyle 2002).
[2]*Juvenile presence in the Delta based on Delta Juvenile Fish Monitoring Program data.*
[3]*Juvenile presence in the Delta based on salvage data* (National Marine Fisheries Service 2016a).

Source: National Marine Fisheries Service 2019:84.

Figure SR2. Catch Index Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon in Sacramento Beach Seines, Brood Years 1996 through 2020.

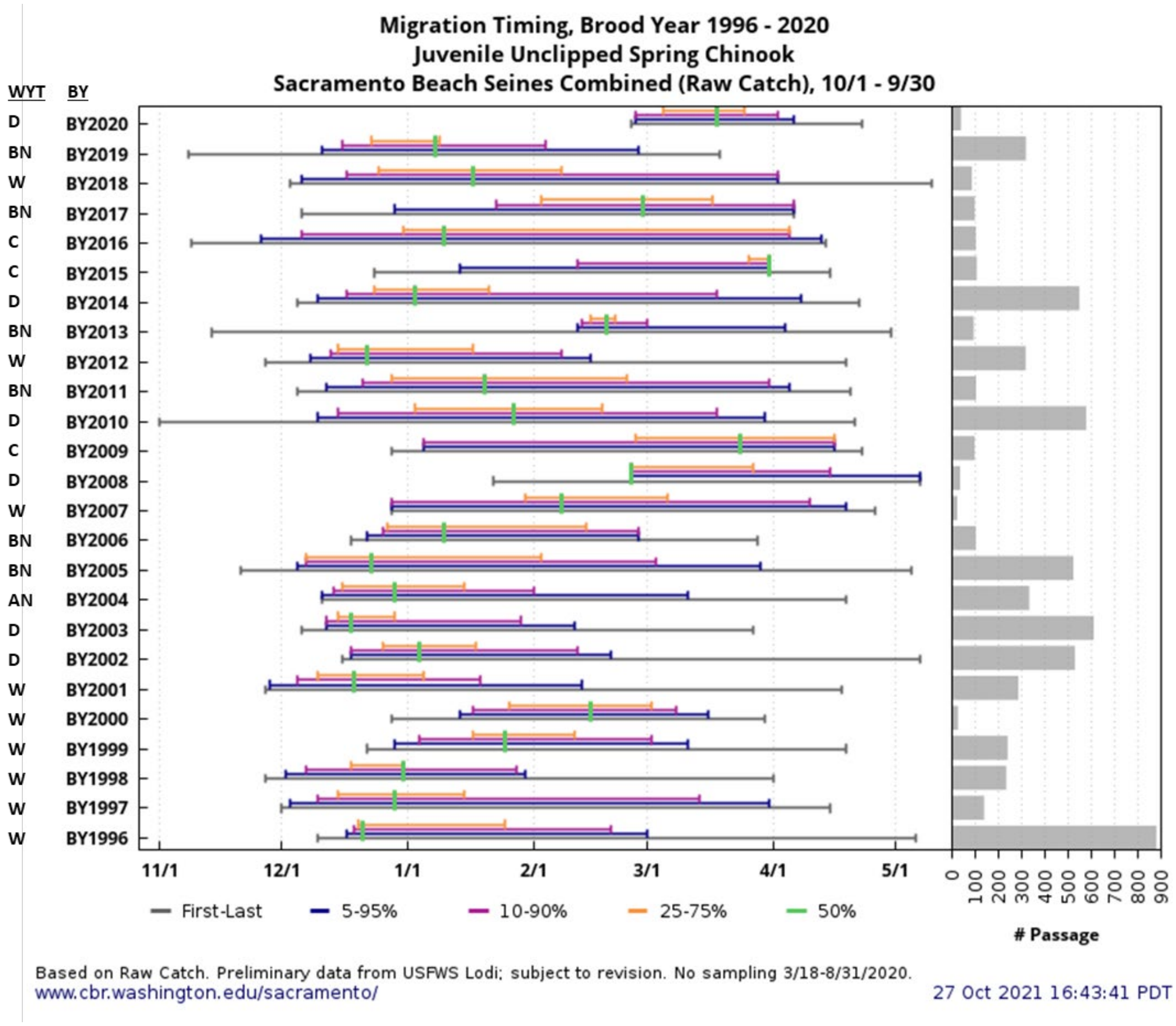


Figure SR3. Catch Index Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon in Sacramento Trawls at Sherwood Harbor, Brood Years 1996 through 2020.

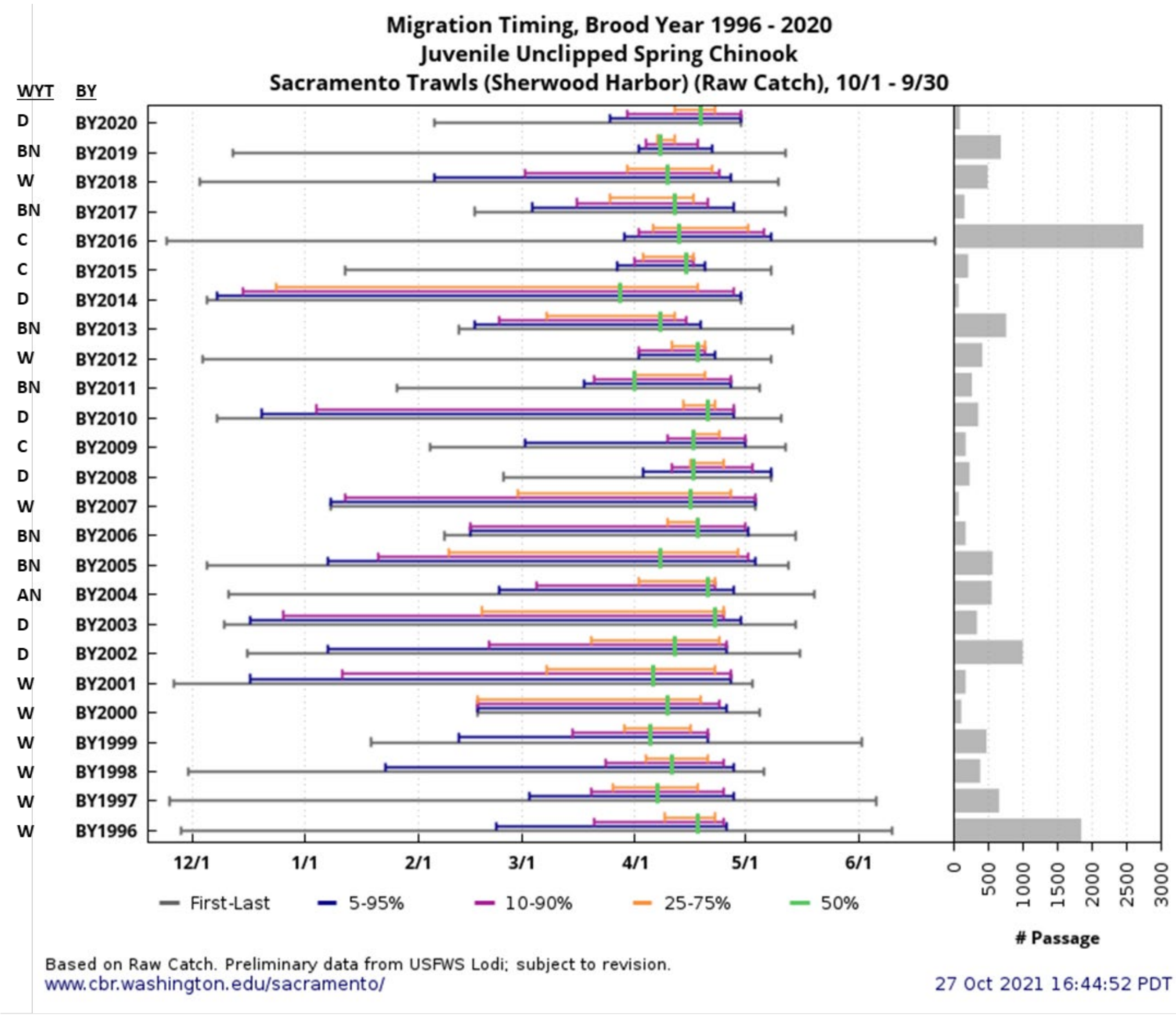


Figure SR4. Catch Index Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon in Chipps Island Trawls, Brood Years 1996 through 2020.

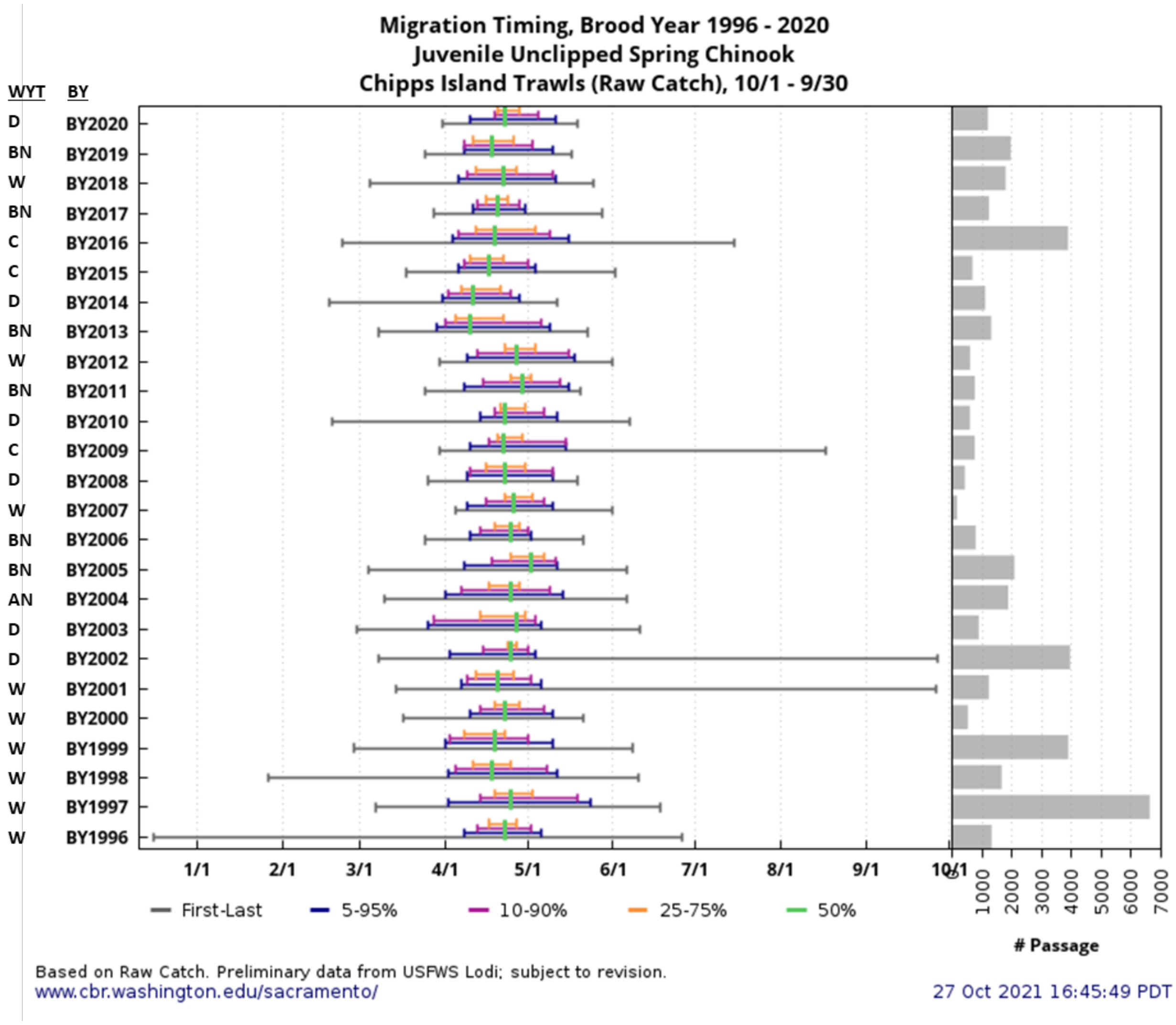
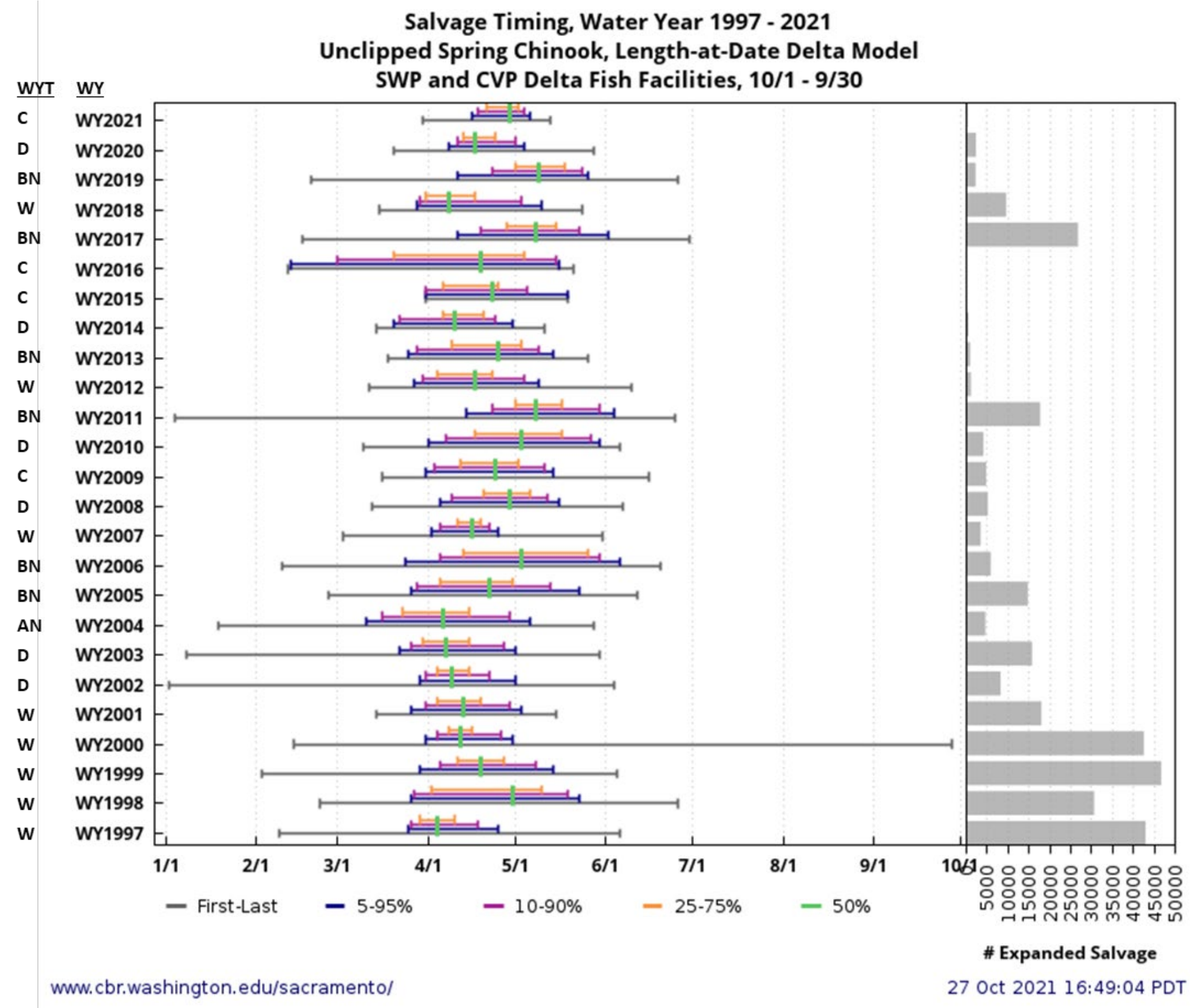


Figure SR5. Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon (Race Determined from Length at Date) at the State Water Project and Central Valley Project South Delta Fish Salvage Facilities, Water Years 1997 through 2021.



Impacts of TUCP on Spring-run Chinook Salmon

Within the Delta, there is potential for similar types of impacts to young-of-the-year juvenile spring-run Chinook salmon and habitat as discussed previously for winter-run Chinook salmon. As noted above in *Presence and Life Stages of Spring-Run Chinook Salmon*, the onset of the TUCP in April 2022 would be after the period of yearling spring-run Chinook salmon in the Delta.

The peak of young-of-year spring-run Chinook salmon abundance in the Delta occurs in April, coinciding with the start of the TUCP (Table SR2). Entrainment of any migrating young-of-year spring-run Chinook salmon at the south Delta export facilities during the TUCP period would be low because of the TUCP limits on south Delta exports as well as continued entrainment risk management (see discussion for winter-run Chinook salmon). As with winter-run Chinook salmon, through-Delta survival modeling suggests young-of-the-year Sacramento River basin juvenile spring-run Chinook salmon through-Delta survival will be reduced as a result of the TUCP (Table WR3 and Figures WR6–WR8), reflecting factors such as increased entry into lower survival pathways in the interior Delta (Table WR4). As noted for winter-run Chinook salmon, the available through-Delta survival modeling tools do not account for south Delta entrainment, although as noted above, south Delta entrainment would be low because of limits on south Delta exports.

Small numbers of juvenile spring-run Chinook salmon may also be emigrating from the San Joaquin River basin. Recent drought-year results from acoustic telemetry studies (Buchanan et al. 2018) suggest that through-Delta survival of juvenile spring-run Chinook salmon from the San Joaquin River basin would be low regardless of the TUCP. Slightly greater south Delta exports (200–400 cfs more negative; Table Model1) at the CVP during April and May under the TUCP could give marginally greater through-Delta survival based on observed statistical positive relationship between survival and CVP exports (see California Department of Water Resources 2020, Appendix E, Section E.4.6 *Structured Decision Model (Chinook Salmon Routing Application)*). However, lower San Joaquin River flows at Vernalis in April under the TUCP (Table Model1) could give lower through-Delta survival than the base case, although there is overall uncertainty in the effects of river flow differences and the export differences discussed above given the drought conditions and the presence of the emergency drought barrier, which give conditions outside of those considered in the historical modeling of through-Delta survival. Overall, however, any differences between TUCP and the base case would be minimal relative to the very low survival that is expected based on the drought hydrology and acoustically tagged fish survival during similar conditions.

Based on timing information in Table SR2 above, a medium–high relative abundance of adult spring-run Chinook salmon would be migrating through the Delta during the April through June TUCP period. As discussed for winter-run Chinook salmon, Delta Cross Channel operations would not differ between the base case and the TUCP, thus there would not be any difference between these cases in delay of adult spring-run Chinook salmon that may move upstream via the Mokelumne River when the Delta Cross Channel is open. There is little information from which to infer the potential for adult spring-run Chinook salmon migratory delay because of reductions in Delta inflow (e.g., reduced upstream migration cues). However, available information for hatchery-origin fall-run Chinook salmon released north of the Delta indicates stray rates of fish returning to the Sacramento River (compared to straying into the San Joaquin River) are relatively low (Marston et al. 2012). Further, within the Sacramento River basin, Williamson and May (2005) found that off-site release of hatchery-reared juveniles was the primary factor associated with adult straying rates of fall-run populations. This suggests relatively little influence of flows and therefore no likely difference between the TUCP and the base case for spring-run Chinook salmon adults returning during the TUCP period. Straying of adult spring-run Chinook salmon returning to the San Joaquin River basin has not been studied in relation to flows in the same way it has been for fall-run adults, so it is uncertain what effect the reductions in San Joaquin River flow of ~300 cfs in April[9] under the TUCP relative to the base case may be given the overall drought hydrology. However, if similar mechanisms apply as for spring-run Chinook salmon they do for fall-run Chinook salmon (Marston et al. 2012), there may be greater potential for straying for spring-run Chinook salmon under the TUCP.

Conclusions for Spring-run Chinook Salmon

In the Delta, an appreciable portion of BY 2021 young-of-the-year spring-run Chinook salmon may be in the Delta during the early portions of the April through June 2022 TUCP. Juvenile spring-run Chinook salmon in the Delta would not experience risk of high levels of south Delta entrainment in spring 2022 because of very low exports under the TUCP and continued implementation of entrainment risk assessment and operations adjustments from the NMFS (2019) Biological Opinion and the CDFW (2020) ITP. Through-Delta survival of juveniles migrating from the Sacramento River basin during spring under the TUCP could be appreciably less than the base case because of less Delta inflow affecting north Delta hydrodynamics, including greater entry into the interior Delta through Georgiana Slough. Through-Delta survival for juveniles emigrating from the San Joaquin River basin would be low with or without the TUCP because of the drought conditions. Migration conditions for adult spring-run Chinook salmon adults generally would be similar under the base case and TUCP. Less San Joaquin River flow under the TUCP in April could result in greater straying potential for adult spring-run Chinook returning to the San Joaquin River basin, should similar mechanisms exist as observed for fall-run Chinook salmon in the fall.

Southern Distinct Population Segment (sDPS) Green Sturgeon

Presence and Life Stages of Green Sturgeon

There are relatively limited monitoring data available for sDPS green sturgeon. In the Delta, juveniles and adults may occur year-round (Tables GS1 and GS2), although the main adult upstream migration to spawning grounds primarily in the upper Sacramento River is late winter to early summer (Heublein et al. 2017a) and therefore overlaps the period of the TUCP.

9 In April, the base case would have Vernalis flow of ~1,000 cfs, whereas the TUCP would have Vernalis flow of ~700 cfs; there would be no difference in the other months (Table Model1).

Table GS1. Temporal Occurrence of Southern Distinct Population Segment Green Sturgeon by Life Stage

Relative Abundance	High (▼)						Medium (⊠)								Low (#)						None (-)			
Life-Stage: (a) Adult-sexually mature[1]	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (river mile 332.5-451)	#	#	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠
Sac River (<river mile 332.5)	#	#	#	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Sac-SJ-SF Estuary	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#
(b) Larva	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	#	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	-	-	-	-
(c) Juvenile (≤5 months old)	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	-	-	#	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠
(d) Juvenile (≤5 months old)	Month																							

Source: National Marine Fisheries Service 2019:113–114.

Table GS2. Temporal Occurrence of Southern Distinct Population Segment Green Sturgeon by Life Stage in the Delta

Relative Abundance	High (▼)	Medium (☒)	Low (#)	None (-)

Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Juvenile [2]	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Salvaged [3]	#	#	#	#	#	-	☒	▼	#	#	#	#

[1]Adult presence was determined to be year round according to information in (California Department of Fish and Game 2008; California Department of Fish and Game 2009; California Department of Fish and Game 2010a; California Department of Fish and Game 2011; California Department of Fish and Game 2012; California Department of Fish and Wildlife 2013a; California Department of Fish and Wildlife 2014a; Lindley et al. 2008; Moyle 2002).
[2]Juvenile presence in the Delta was determined to be year round by using information in (USFWS Delta Juvenile Fish Monitoring Program data), (Moyle et al. 1995; Radtke 1966).

Source: National Marine Fisheries Service 2019:115.

Impacts of TUCP on sDPS Green Sturgeon

Juvenile and sub-adult green sturgeon rearing in and utilizing the Delta are expected to be minimally affected by the TUCP's changes to Delta flows relative to the base case. In most of the Delta where juvenile green sturgeon are expected to be rearing, flows are tidally dominated and therefore changes in riverine inflow would have minimal to no effect. However, there is low certainty in understanding of the juvenile and sub-adult green sturgeon biological processes affected by flow in the Delta. South Delta exports would be at very low levels during the TUCP and recent years have seen minimal salvage of green sturgeon, indicating that very low or zero salvage would be expected under the TUCP.

The NMFS green sturgeon recovery plan suggested that green sturgeon larval abundance and distribution may be influenced by spring and summer outflow, and recruitment may be highest in wet years, making water flow an important habitat parameter (NMFS 2018: 12). As noted by NMFS (2018: 12), there are correlations between white sturgeon year-class strength and Delta outflow, which have previously been used to infer potential impacts on green sturgeon (ICF International 2016: 5-197 to 5-205). However, impacts on green sturgeon as a result of changes in flow under the TUCP may be limited primarily because the largest sturgeon recruitment occurs in wetter years (Fish 2010; Gingras et al. 2013); the continuation of drought conditions in 2022 makes it uncertain the extent to which the difference in drought-year-flows between the TUCP and the base case would result in differing impacts to green sturgeon compared to the potential impacts that may occur between much broader ranging hydrological conditions (i.e., different water year types). As discussed in more detail for white sturgeon below, application of statistical relationships between white sturgeon year-class strength and Delta outflow gives negative estimates of year-class strength (i.e., estimates below zero) under the base case and the TUCP, supporting the conclusion that very little recruitment may occur under either the TUCP or the base case.

Adult green sturgeon will be potentially present in the Delta throughout the TUCP period as they migrate into and out of the Sacramento River and possibly forage in the Delta during the summer. The reductions in outflow through multiple distributaries in the North Delta in the TUCP could reduce migration cues and increase straying and travel time of green sturgeon in this region during the TUCP, although this is uncertain. Additionally, most (90%) migratory adult sturgeon have migrated upstream by mid-April.

Conclusions for sDPS Green Sturgeon

Cumulatively, the TUCP's modifications relative to the base case should not appreciably reduce riverine or through-Delta survival of juvenile sDPS green sturgeon, although this conclusion is uncertain, given the general lack of information on the species. Little to no salvage of sDPS green sturgeon at the south Delta export facilities would be expected to continue, consistent with recent years with greater levels of exports than the TUCP.

Central Valley Steelhead

Presence and Life Stages of Central Valley Steelhead

Relative to Chinook salmon, effective monitoring for Central Valley steelhead (*O. mykiss*) is limited. Few steelhead have been collected in routine monitoring. Historical abundance in surveys shows juvenile peaks in the Delta during late winter/spring, including the April–May period (Tables SH1 and SH2). Salvage may continue into June in low numbers and some juveniles are present in low numbers in the Delta in summer. Adults occur in the Delta in most months with peak occurrence in May and September (Table SH2).

Table SH1. Temporal Occurrence of Central Valley Steelhead by Life Stage

Relative Abundance	High (▼)								Medium (⊠)								Low (#)						None (-)		
Migration Life Stage: (a) Adult	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1]Sacramento R. at Fremont Weir	#	#	#	#	#	-	-	-	-	-	-	#	#	#	#	⊠	▼	▼	▼	⊠	#	#	#	#
[2]Sacramento R. at Red Bluff Diversion Dam	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	⊠	⊠	▼	⊠	#	#	#	#
[3]San Joaquin River	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	▼	▼
Migration Life Stage: (b) Juvenile	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,2]Sacramento R. near Fremont Weir	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	⊠	⊠	⊠	⊠	#	#
[4]Sacramento R. at Knights Landing	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	#	#	#	#
[5]Chipps Island (clipped)	⊠	⊠	▼	▼	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	-	#	#
[5]Chipps Island (unclipped)	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	-	#	#	#
[6]San Joaquin R. at Mossdale	-	-	#	#	⊠	⊠	▼	▼	▼	▼	#	#							#	#	-	-	-	-

Sources: [1] Hallock et al. (1957); [2]McEwan (2001); [3]California Department of Fish and Game (2007); [4]NMFS analysis of 1998-2018 CDFW data; [5]NMFS analysis of 1998-2018 USFWS data; [6]NMFS analysis of 2003-2018 USFWS data.

Source: National Marine Fisheries Service 2019:100.

Table SH2. Temporal Occurrence of Central Valley Steelhead by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)			Low (#)			None (-)		
Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	⊠	⊠	⊠	▼	-	#	⊠	▼	⊠	⊠	⊠
Juvenile [2]	#	⊠	⊠	▼	▼	#	#	-	#	-	-	#
Salvaged [3]	⊠	▼	▼	⊠	#	#	-	-	-	-	#	#

1Adult presence was determined using information in Moyle (2002), Hallock et al. (1961), and California Department of Fish and Wildlife (2015b).
2Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.
3Months in which salvage of wild juvenile steelhead at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (He and Stuart 2016).

Source: National Marine Fisheries Service 2019:101.

Impacts of TUCP on Central Valley Steelhead

Given the species' timing in the Delta (Table SH2), juvenile steelhead migrating through the Delta from the Sacramento River basin in spring 2022 could experience similar types impacts of the TUCP as previously described for juvenile winter-run and spring-run Chinook salmon, with the highest relative abundance occurring in April and May. There is uncertainty in the extent of the negative effect given that factors such as through-Delta survival as a function of flow have not been examined in a similar manner as done for Chinook salmon, although as with juvenile Chinook salmon, low survival through the interior Delta relative to the Sacramento River has been observed (Singer et al. 2013). As with juvenile Chinook salmon, low south Delta exports and entrainment risk management under the NMFS (2019) Biological Opinion would limit entrainment risk for juvenile steelhead. For juvenile steelhead emigrating from the San Joaquin River basin, lower flow under the TUCP may give lower through-Delta survival than the base case. Buchanan et al. (2021) developed statistical models based on detections of steelhead fitted with acoustic tags and found San Joaquin River flow at Vernalis to be a significant predictor of survival from the Head of Old River to Chipps Island. Application of one of Buchanan et al.'s (2021) statistical models[10] gave mean estimates of the probability of through-Delta survival under the TUCP that were 0.06 (25%) less than the base case (Table SH3). There is uncertainty in the extent to which this modeling applies given the presence of the emergency drought barrier under both the base case and the TUCP.

10 The equation used for this assessment was based on 2016 results because that year included flows generally covering the range assumed for April–June 2022 in this review and also because results were available without the Head of Old River barrier being installed, as would be the case in 2022. The equation used was: Probability of survival = (EXP(-10.988+ 0.012*245+ln(Vernalis flow)))/(1+(EXP(-10.988+0.012*245+ln(Vernalis flow)))), where EXP = exponent, -10.988 is the intercept for 2016, and 245 the mean 245-mm fork length for juvenile steelhead when acoustically tagged; terms for the Head of Old River barrier (value = 0 when not installed) and the Vernalis flow coefficient (1.000) were omitted for clarity.

Table SH3. Mean Monthly Probability of Through-Delta Survival of Juvenile Steelhead Based on Buchanan et al. (2021).

Month	Base	TUCP
April	0.24	0.18 (-25%)
May	0.23	0.23 (0%)
June	0.18	0.18 (0%)

Note: Percentage difference in parentheses represents TUCP minus base.

As shown in Table SH2, adult steelhead may occur in the Delta during the period of the TUCP. As discussed further for adult winter-run and spring-run Chinook salmon, migration delay or straying of adult steelhead generally would not be expected to greatly differ for adult steelhead returning to the Sacramento River. Straying of adult steelhead returning to the San Joaquin River basin has not been studied, so it is uncertain what effect the reductions in San Joaquin River flow of ~300 cfs under the TUCP in April relative to the base case may have given the overall drought hydrology. As noted for spring-run Chinook salmon, if similar mechanisms apply as for fall-run Chinook salmon (Marston et al. 2012), there may be greater potential for straying under the TUCP.

Conclusions for Steelhead

The April–June 2022 TUCP period coincides with portions of the main period of juvenile and adult steelhead in the Delta. Juvenile steelhead in the Delta would not experience greater risk of south Delta entrainment in spring 2022, as a result of low exports under the TUCP and continued implementation of entrainment risk assessment and operations adjustments from the NMFS (2019) Biological Opinion and the CDFW (2020) ITP. Assuming similar mechanisms apply as to through-Delta survival of juvenile Chinook salmon migrating from the Sacramento River basin during spring 2022, survival under the TUCP could be appreciably less than the base case as a result of less Delta inflow affecting north Delta hydrodynamics, including greater entry into the interior Delta through Georgiana Slough. Through-Delta survival for juveniles emigrating from the San Joaquin River basin would likely be lower under the TUCP than the base case in April. Migration conditions for adult steelhead generally would be similar under the base case and TUCP. Less San Joaquin River flow under the TUCP could result in greater straying potential for adult steelhead returning to the San Joaquin River basin, should similar mechanisms exist as observed for fall-run Chinook salmon in the fall.

Delta Smelt

Presence and Life Stages of Delta Smelt

The 2021 CDFW Fall Midwater Trawl abundance index of delta smelt was zero for the fourth year in a row. Relatively few delta smelt are currently being collected in sampling: for the Spring Kodiak Trawl, none were collected in January 2022 and all five individuals collected in February 2022 were in Suisun Marsh;[11] one delta smelt was collected by Bay Study, 46 delta were captured in Enhanced Delta Smelt Monitoring and two delta

11 See https://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp

smelt were captured in Chipps Island trawling.[12] In sum, a total of 54 delta smelt have been collected during WY 2022, including one seen in salvage at the Tracy Fish Collection Facility (TFCF) in January 2022. Except for one wild Delta Smelt (confirmed genetically) caught by EDSM on January 5, 2022, all of the delta smelt collected in WY 2022 were marked as coming from experimental releases (see below). The TUCP period would overlap the spring portion of the adult spawning, and the presence of egg and larval/early juvenile delta smelt. Risk assessments[13] for delta smelt entrainment, undertaken as part of CDFW (2020) ITP implementation, concluded that based on distribution patterns over the past decade and detections in WY 2022, delta smelt were unlikely to be prevalent in the south Delta and that the risk of entrainment into the south Delta was low for delta smelt.

Experimental releases of captive-reared delta smelt occurred for the first time in December to February of WY 2022[14]: in the Sacramento River at Rio Vista (12,800 fish on 12/14/2021–12/15/2021; 12,800 fish on 1/11/2021–1/12/2021), in the Sacramento River Deep Water Ship Channel (6,400 fish on 2/3/2022; 10,933 on 2/16/2022–2/17/2022) and in Montezuma Slough at Belden's Landing (12,800 fish on 2/9/2022–2/10/2022). All released fish were marked by either adipose fin clip or visible implant elastomer tag. No Delta Smelt have been salvaged since the one fish observed in January. It is unlikely that, under the low export conditions in the TUCP, that these fish would be advected into the San Joaquin River and south Delta.

Impacts of TUCP on Delta Smelt

Risk of delta smelt entrainment during the TUCP period would be low because south Delta exports would be at minimal levels (≤1,500 cfs) under the base case and TUCP. These export levels result in more positive Old and Middle River flows (Table WR5) and a positive QWEST (which represents net flow in the lower San Joaquin River; Table DS1) which reduce south Delta entrainment risk. Weekly risk assessments from the Smelt Monitoring Team will continue and, as necessary, operational adjustments made as part of USFWS (2019) Biological Opinion and CDFW (2020) ITP implementation until delta smelt OMR management offramps are reached, typically in June. See also Appendix A for Particle Tracking Modeling Analysis (Delta Smelt Entrainment).

Table DS1. Mean Monthly QWEST (cfs) During April–June 2022.

Month	Base	TUCP
April	1,414	238
May	1,072	459
June	1,772	870

The biological review for the 2015 February through March TUCP noted that ongoing drought will subject the current year-class and future year-classes of delta smelt to continued poor habitat conditions. The discussion presented above related to

12 See http://www.cbr.washington.edu/sacramento/workgroups/delta_smelt.html

13 See, for example, https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=199083&inline

14 See http://www.cbr.washington.edu/sacramento/workgroups/delta_smelt.html

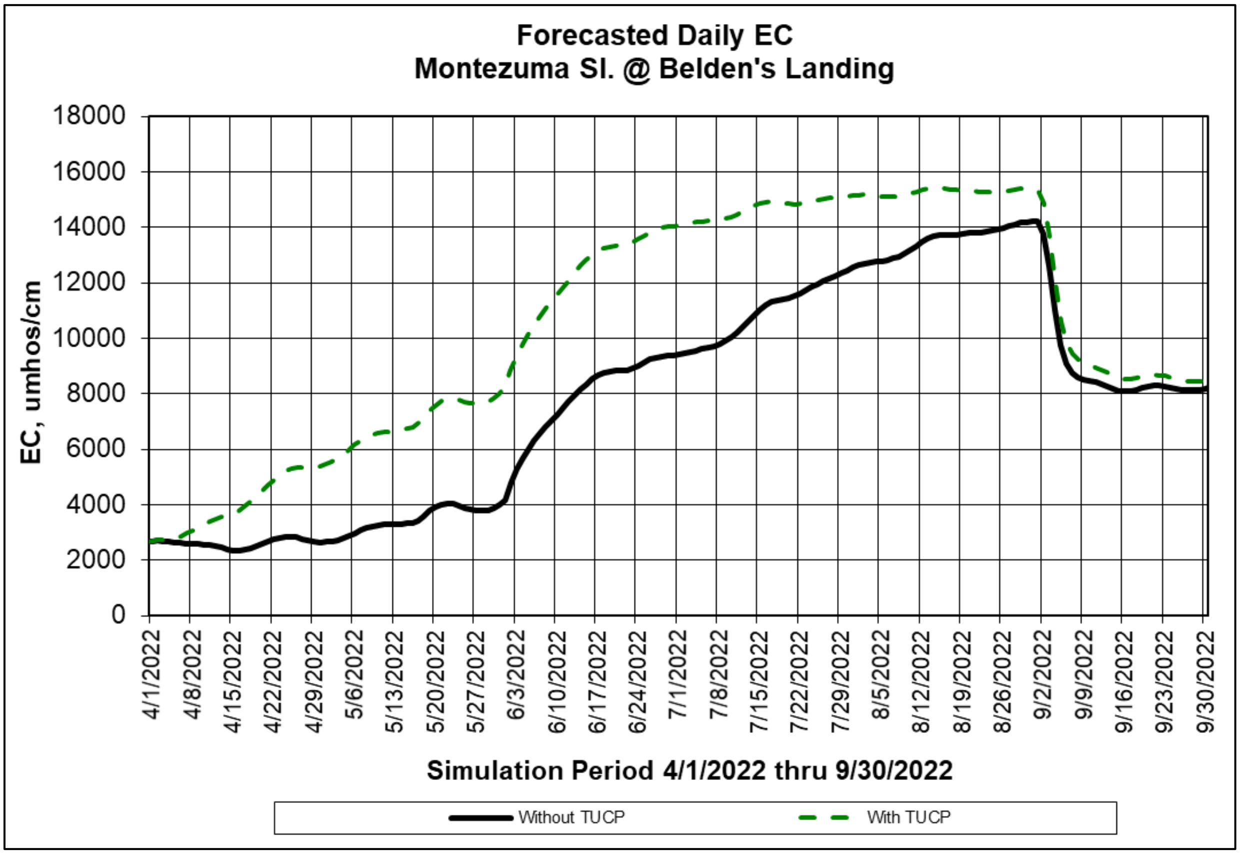
Ecosystem Impacts described how drought conditions generally would be associated with a reduction in the density of the delta smelt zooplankton prey, *E. affinis,* in the low salinity zone*,* with the TUCP giving mean estimates of 14% lower density than the base case (Figure ECO1), with relatively broad prediction intervals. Other prey items such *Pseudodiaptomus* and *Limnoithona* (Slater and Baxter 2016) do not have statistically significant relationships with Delta outflow (Figure ZOOP1). Miller et al. (2012) found that the minimum *Pseudodiaptomus* + *E. affinis* biomass density in April–June was one of the best predictors of delta smelt survival from fall to the subsequent summer and from fall to fall. In contrast, Polansky et al. (2021) did not find that prey represented by March–May total copepod nauplii + juvenile biomass per unit volume was strongly supported as a predictor of delta smelt recruitment. Polansky et al. (2021: Figure 1b) found that post-larval delta smelt survival was positively related with June–August Delta outflow, indicating a potential negative effect of the TUCP relative to baseline because of lower outflow in June under the TUCP (Table Model1), although with appreciable uncertainty based on the width of the credible intervals in their statistical relationship.

Lower Delta outflow under the TUCP generally would result in higher conductivity, which may reduce the probability of occurrence of delta smelt in areas they would otherwise occur in, particularly downstream of the confluence of the Sacramento and San Joaquin Rivers. Polansky et al. (2018) found that adult delta smelt had several regional hotspots of highest density from Spring Kodiak Trawl sampling, including the waterways surrounding Grizzly Island such as Montezuma Slough and the lower Sacramento River (Horseshoe Bend area down to Collinsville). These areas are relevant to consideration of potential TUCP effects because salinity could be affected and modeling information is available, whereas the other main hotspots in the Cache Slough Complex and Sacramento Deepwater Ship Channel are further upstream and therefore unlikely to have negative salinity effects.

DSM2 modeling suggests that conductivity in Montezuma Slough near Belden's Landing would be around 2,700 μmhos/cm at the start of the TUCP period in April 2022 (Figure DS1). Whereas under the base case conductivity would remain between ~2,000 and ~4,000 μmhos/cm during April and May, conductivity under the TUCP during this time period would increase to nearly 8,000 μmhos/cm (Figure DS1). Given the negative relationship between adult delta smelt density and conductivity observed by Polansky et al (2018), the TUCP may reduce the density of delta smelt in Montezuma Slough. Hamilton and Murphy's (2020) analysis examining habitat affinity as the difference between habitat availability and use found that for spawning adult delta smelt in March–April a conductivity range of 500–730 μmhos/cm is suitable; a range of 300–1,300 μmhos/cm is adequate; >1,630 μmhos/cm is unsuitable; and >5,900 is uninhabitable.[15] Based on this classification, the TUCP and the base case both provide unsuitable conditions for spawning delta smelt in Montezuma Slough at Belden's Landing during April (Figure DS1).

15 Hamilton and Murphy's (2020) affinity analysis classified ranges of environmental variables as suitable (habitat use minus availability is statistically significant positive), adequate (habitat use minus availability is positive, although not statistically significant), inadequate (habitat use minus availability is negative, although not statistically significant), unsuitable (habitat use minus availability is statistically significant negative), and uninhabitable (habitat use is always equal zero, i.e., delta smelt were never observed).

Figure DS1. Daily Electrical Conductivity in Montezuma Slough at Beldon's Landing from DSM2 Modeling.

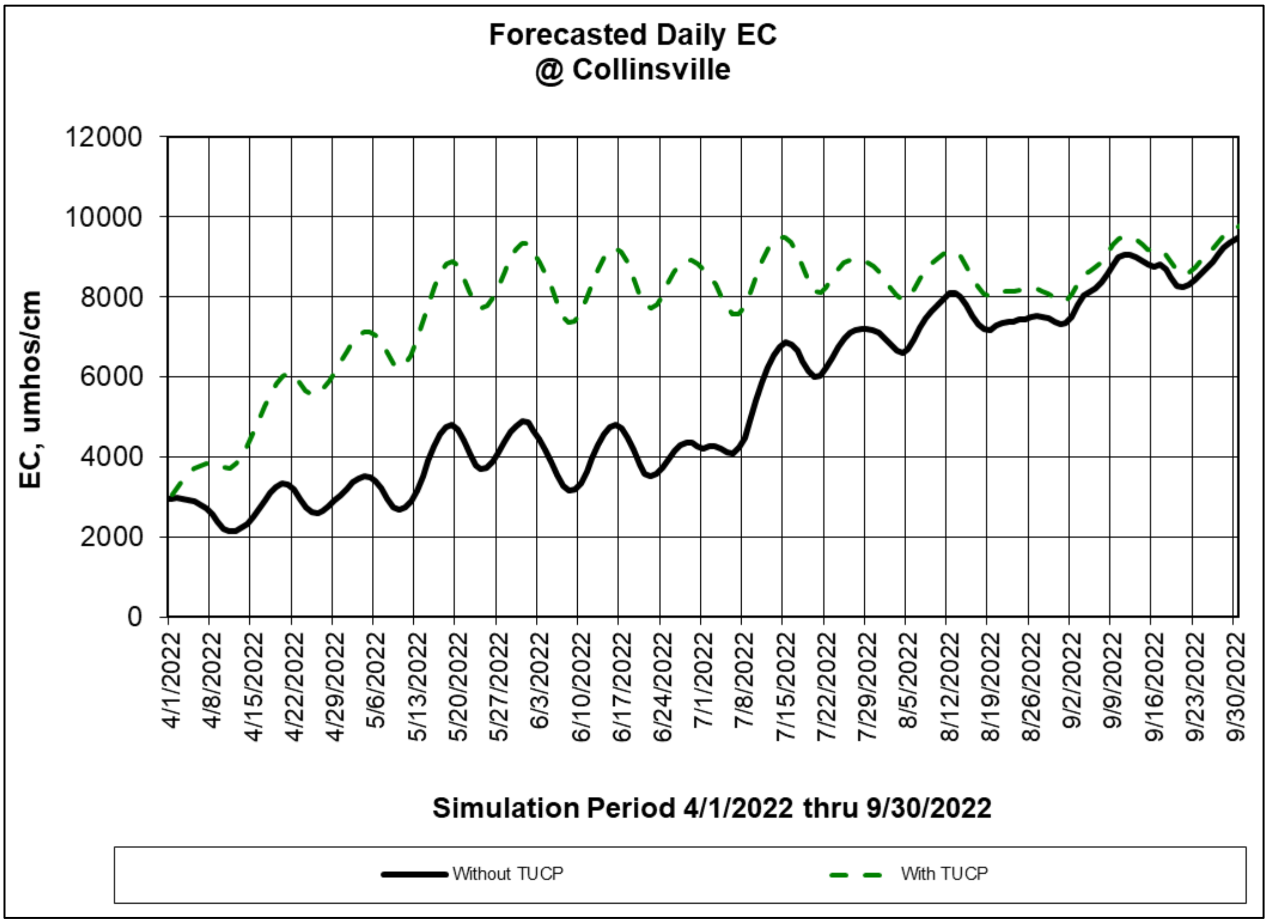


Note: Base case = Without TUCP.

Hamilton and Murphy (2020) also found that for subjuvenile delta smelt in May and June conductivity ≤2,450 µmhos/cm is adequate, conductivity >4,015 µmhos/cm is unsuitable, and conductivity >10,200 µmhos/cm is uninhabitable. Based on the DSM2 modeling, the TUCP may result in uninhabitable conductivity in Montezuma Slough at Belden's Landing for delta smelt subjuveniles from early June to the end of June, whereas the base case would have unsuitable (but not uninhabitable) conditions in June (Figure DS1). For juvenile delta smelt in June–July, Hamilton and Murphy (2020) found unsuitable conditions to be >7,800 µmhos/cm and uninhabitable conditions >18,750 µmhos/cm. Neither the TUCP nor the base case would have uninhabitable conditions for juvenile delta smelt based on these criteria, with the base case having conductivity below the unsuitable threshold for the first half of June and the TUCP case having unsuitable conductivity through June and July (Figure DS1). For juvenile delta smelt in July–August, Hamilton and Murphy (2020) found adequate conductivity to be up to 6,300 µmhos/cm, unsuitable conductivity to be >15,140 µmhos/cm, and uninhabitable conductivity to be >28,400 µmhos/cm. By these criteria, conductivity under the TUCP would be at or close to the unsuitable threshold, but not uninhabitable, whereas under the base case conductivity would be greater than the adequate threshold but below the unsuitable threshold (Figure DS1).

The patterns noted above at Belden's Landing are generally similar at Collinsville for spawning adults, i.e., conductivity between unsuitable and uninhabitable (per Hamilton and Murphy 2020) during April under both the TUCP and the base (Figure DS2). Conductivity for delta smelt subjuveniles at Collinsville in April–May would be unsuitable (>4,015 µmhos/cm) under the TUCP, whereas under the base case conductivity would be between adequate (≤2,450 µmhos/cm) and unsuitable per Hamilton and Murphy (2020) (Figure DS2). For juvenile delta smelt in June–July, per Hamilton and Murphy's (2020) criteria, the TUCP generally would have unsuitable conductivity at Collinsville (>7,800 µmhos/cm), whereas the base case would have adequate conductivity (≤5,300 µmhos/cm) in June and conductivity between adequate and unsuitable in July (Figure DS2). For juvenile delta smelt in July–August, both the TUCP and base case generally would have conductivity between adequate (up to 6,300 µmhos/cm) and unsuitable (>15,140 µmhos/cm) (Figure DS2).

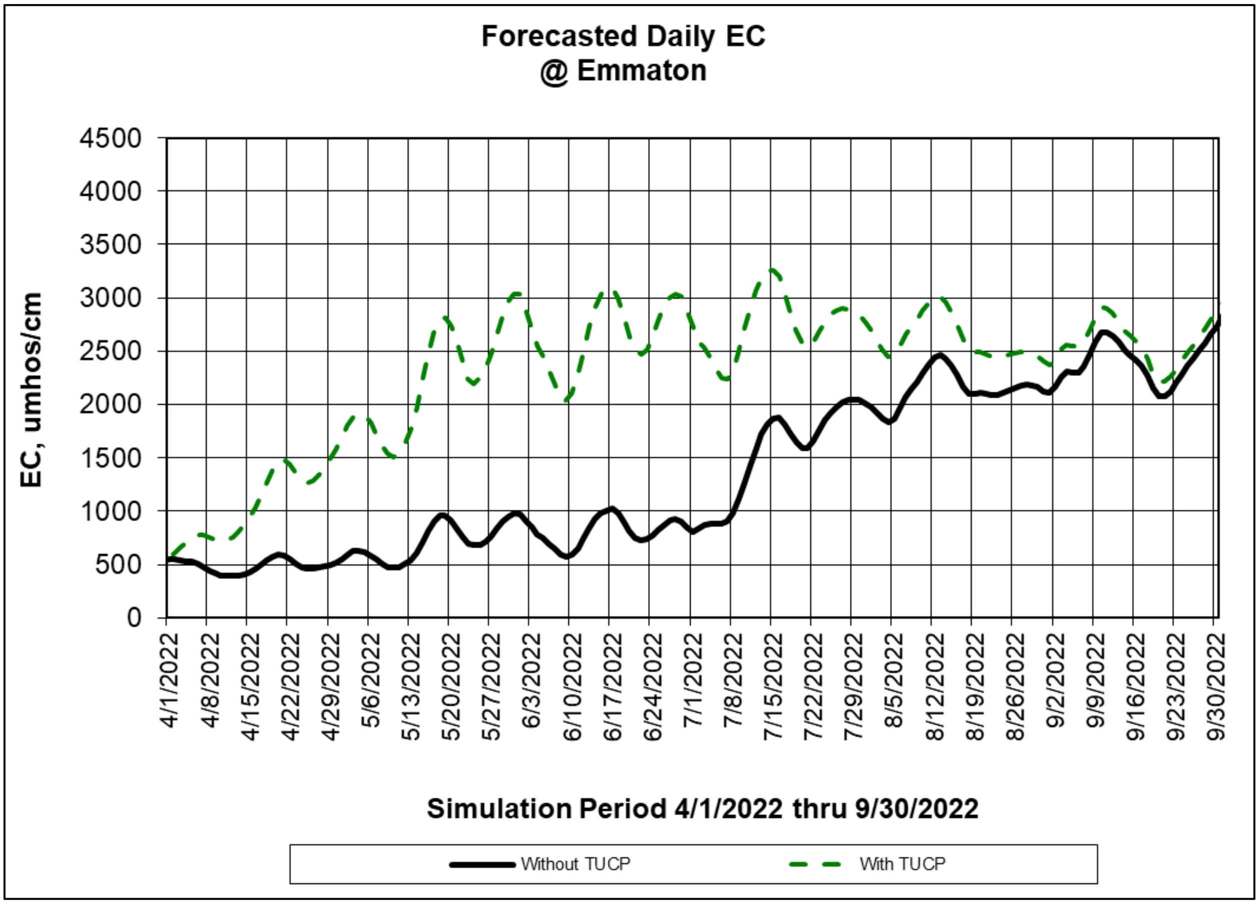
Figure DS2. Daily Electrical Conductivity at Collinsville from DSM2 Modeling.



Note: Base case = Without TUCP. With TUCP = April–August TUCP; With TUCP2 = April–June TUCP.

Based on the criteria of Hamilton and Murphy (2020), at Emmaton, conductivity for spawning adults in April generally would be suitable (i.e., 500–730 µmhos/cm) or adequate (i.e., 300–1,300 µmhos/cm) under the base case, whereas by mid-April conductivity would have been greater than the adequate range for the TUCP (Figure DS3). Conductivity for delta smelt subjuveniles at Emmaton in May–June would be suitable (≤1,380 µmhos/cm) under the base case at all times, whereas under the TUCP, whereas under the base case conductivity would be adequate (≤2,450 µmhos/cm) until mid-May and thereafter between adequate and unsuitable (>4,015 µmhos/cm) until the end of June (Figure DS3). For juvenile delta smelt in June–July and July–August, per Hamilton and Murphy's (2020) criteria, the TUCP and base case would have suitable conductivity (≤4,550–5,330 µmhos/cm; Figure DS3).

Figure DS3. Daily Electrical Conductivity at Emmaton from DSM2 Modeling.



Note: Base case = Without TUCP. With TUCP = April–August TUCP; With TUCP2 = April–June TUCP.

The USFWS (2019) Biological Opinion found that the position of X2 should be managed between Carquinez Strait and Threemile Slough on the Sacramento River for rearing habitat. Results from the DSM2 modeling illustrated that reduced outflow under the TUCP would shift the salinity field upstream (Figure ECO2). The mean shift would be 7.5 km (range: 6.7–8.1 km) in June, 4.2 km (range: 2.3–7.6 km) in July, and 1.4 km (range: 0.8–2.2 km) in August. In general, movement of the salinity field upstream reduces the area of low salinity zone habitat which a relatively large proportion of the delta smelt population inhabits as juveniles and subadults, although with low Delta outflow the area of habitat would be considerably reduced under both TUCP and baseline scenarios relative to wetter years (Feyrer et al. 2011). SCHISM modeling was undertaken for this biological review and indicated that the TUCP would result in up to 27% less habitat with low salinity (i.e., below 6 parts per thousand [ppt]) in the North Delta Arc habitat noted as important delta smelt habitat by Hobbs et al. (2017) (Table DS2).[16] As discussed in the biological review for the June through August 2021 TUCP (DWR and Reclamation 2021b), based on the drought years of 2014 and 2015, there was no evidence for less Delta outflow leading to greater water temperature or lower turbidity in delta smelt low salinity habitat.

Table DS2. Mean Area (Acres) within the North Delta Arc with Salinity Below 6 PPT During April–October 2022, from SCHISM Modeling.

Month	Base	TUCP
April	23,588	20,299 (-14%)
May	20,555	15,809 (-23%)
June	18,688	13,629 (-27%)
July	17,341	14,182 (-18%)
August	15,898	14,655 (-8%)
September	14,395	13,815 (-4%)
October	13,102	12,870 (-2%)

As described in the *Ecosystem Impacts* section of this biological review, there is correlative evidence of Mississippi silverside abundance being related to Delta outflow and south Delta exports (Mahardja et al. 2016). Miller et al. (2012) found some support for predation risk from predators including Mississippi silversides as a negative predictor of fall-to-fall survival of delta smelt, whereas the recent analysis by Polansky et al. (2020) did not find strong support for March–May inland silverside catch per seine as a predictor of delta smelt recruitment. As described in the *Ecosystem Impacts* section of this biological review, the relatively small differences in south Delta exports (~200 cfs) and Delta inflow (~300–800 cfs) between the base and TUCP would be unlikely to result in appreciably different silverside abundance given the overall very low south Delta exports and Delta inflow because of the drought conditions.

As also described in the *Ecosystem Impacts* section of this biological review, less Delta outflow under the TUCP relative to the base would move the salinity field upstream (as illustrated by modeled X2; Figure ECO2), potentially allowing the invasive clam *Potamocorbula amurensis* to move further upstream and thereby expand its range and overall grazing effect if salinity remains high enough for several months (Kimmerer et al. 2019). This could negatively affect the food web for delta smelt. Given that generally dry conditions have been persisting in the system since 2020, *P. amurensis* may have already moved upstream in response to drought conditions and therefore the extent to which the 2022 TUCP and continuing drought would add to this is uncertain.

The biological review for the 2015 February through March TUCP noted the existence of an outflow-recruitment relationship between spring (February through May) X2 and the ratio of the delta smelt 20-mm Survey index and the prior Fall Midwater Trawl index, which was based on a preliminary regression formulated by Interagency Ecological Program, Management, Analysis, and Synthesis Team (2015). Based on that

16 A SCHISM model description and a map of the North Delta Arc is provided in Appendix D of DWR (2020).

regression, the 2015 biological review described that lower outflow under the 2015 TUCP would predict a negative effect on delta smelt larval production. The 2015 biological review noted that the Interagency Ecological Program, Management, Analysis, and Synthesis Team (2015) called for more sophisticated life cycle modeling and publication in a peer review journal to draw firm conclusions. Subsequent analysis in a peer review journal using a nonlinear state space model by Polansky et al. (2021) found statistical support for both a negative effect of March through May X2 and Export: Inflow (E:I) ratio on recruitment of delta smelt. Thus, the most recent analysis from Polansky et al. (2021) suggests that the TUCP could result in negative effects to delta smelt, based on higher March through May X2 under the TUCP (~82.3 km) relative to the base case (78.5 km). As previously noted, Polansky et al. (2021: Figure 1b) found that post-larval delta smelt survival was positively related with June–August Delta outflow, indicating a potential negative effect of the TUCP (mean June–August Delta outflow = ~3,800 cfs) relative to baseline (~4,800 cfs), although with appreciable uncertainty based on the width of the credible intervals in their statistical relationship.

<u>Conclusions for Delta Smelt</u>

Implementation of the TUCP would result in low entrainment risk to delta smelt in spring 2022 because south Delta exports under the TUCP would be restricted to low levels (1,500 cfs or less) and the existing entrainment risk management under the USFWS (2019) Biological Opinion and the CDFW (2020) ITP would continue.

The TUCP has the potential to result in negative changes to delta smelt and their habitat relative to the base case. This includes less zooplankton prey in the low salinity zone and higher salinity leading to a reduction in habitat quality in portions of the range such as the lower Sacramento River as well as lower extent of low salinity habitat in the North Delta Arc. Preliminary analyses discussed in the 2015 biological review and more recent peer-reviewed analyses suggest the potential for negative effects to delta smelt recruitment and post-larval survival resulting from less Delta outflow under the TUCP.

Longfin Smelt

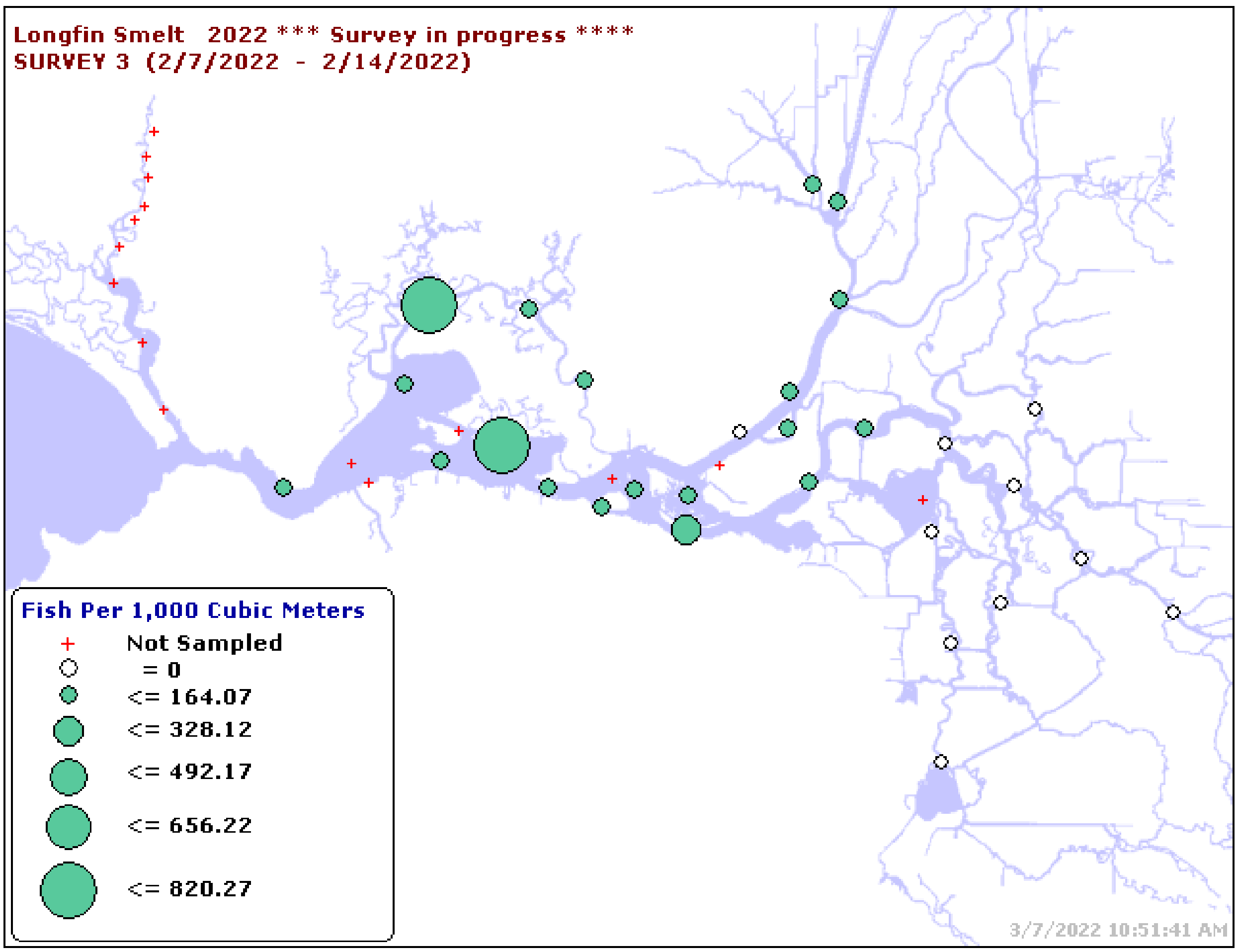
<u>Presence and Life Stages of Longfin Smelt</u>

The 2021 CDFW Fall Midwater Trawl abundance index for longfin smelt was 323, the highest since 2011. This was greater than the mean for the past two decades (2002–2021: 258), although considerably less than the full survey period (1967–2021) mean of 6,453. The most recent Smelt Larva Survey data from February 7–14, 2022, indicate greatest density of longfin smelt larvae in Honker Bay/Suisun Marsh, with catches occurring upstream to Fishermans Cut on the San Joaquin River and into the Cache Slough Complex on the Sacramento River side of the Delta (Figure LFS1). Distribution data from drought conditions in 2021 may be generally representative of the distribution that could occur in spring 2022. During February through March 2021, within areas sampled by the Smelt Larva Survey,[17] larval and early juvenile longfin smelt occurred in highest density in or near Suisun Bay and at the confluence of the Sacramento and

17 Although it has been noted that surveys for longfin smelt do not capture the full distribution of the species (e.g., Grimaldo et al. 2020), the more landward distribution in drier hydrological conditions (Grimaldo et al. 2020) suggests that Smelt Larva Sampling in 2021 likely covered most of the main distribution.

San Joaquin Rivers (Figures LFS2, LFS3, LFS4). During March through June 2021, larval/early juvenile longfin smelt density in 20-mm Survey sampling generally was greatest in the lower Sacramento River (Figures LFS5, LFS6, LFS7, LFS8, LFS9, LFS10). Although both the Smelt Larva Survey and 20-mm Survey indicated presence of longfin smelt larvae/early juveniles in or near the south Delta, their density in the south Delta was very low relative to other areas (Figures LFS2, LFS3, LFS3, LFS5, LFS6, LFS7, LFS8, LFS9, LFS10). The number of longfin smelt juveniles salvaged in 2021 was 0 in February 2021, 78 in March 2021, 483 in April 2021, 304 in May 2021, and 0 in June 2021 during a period of minimal south Delta exports.[18] Sixteen juvenile longfin smelt had been salvaged in 2022 up to the date of preparation of this biological review (early March 2022), with 12 at the TFCF and four at the Skinner Fish Collection Facility (SFCF) in March.[19]

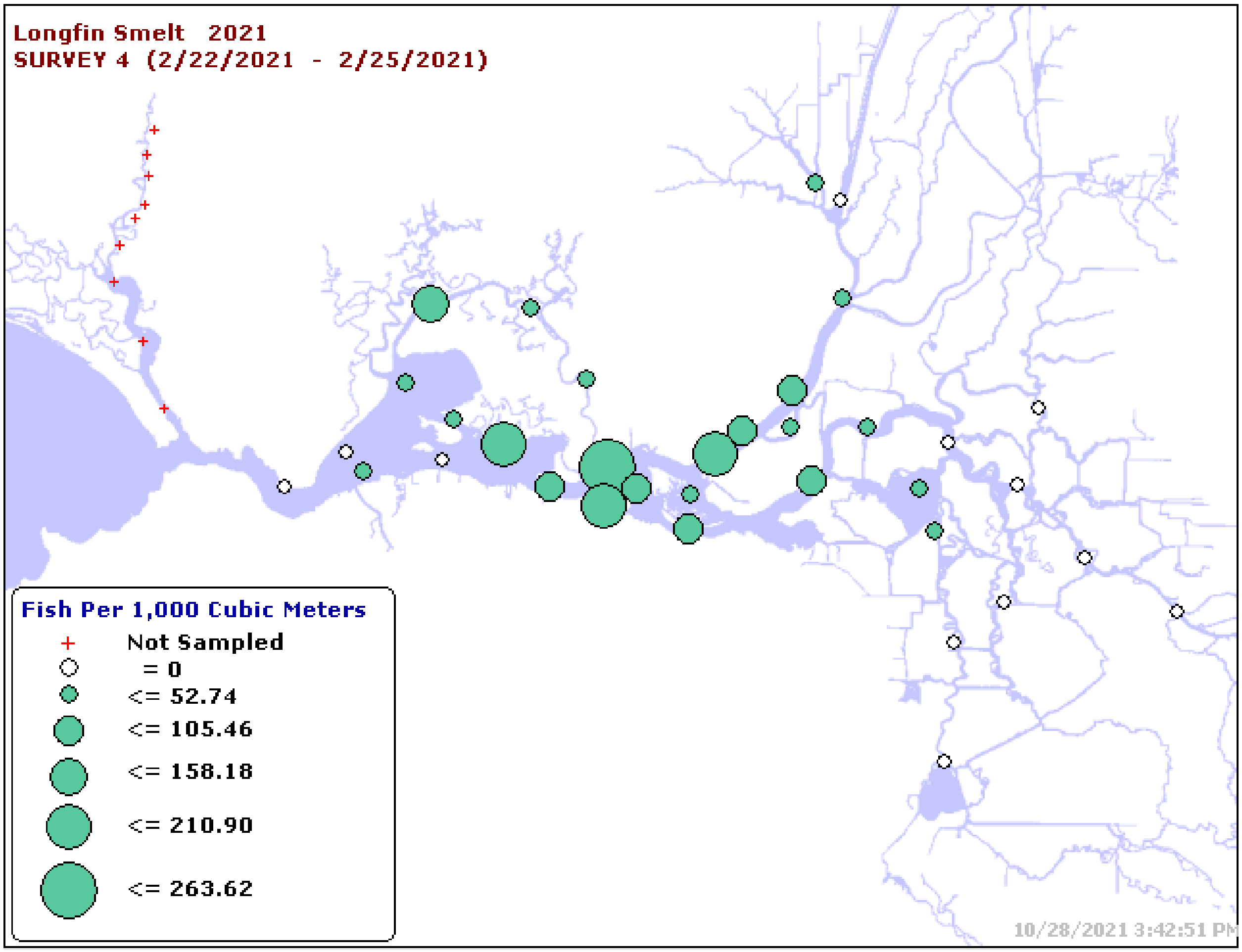
Figure LFS1. Distribution of Longfin Smelt from Smelt Larva Survey 3, February 7–14, 2022.



Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

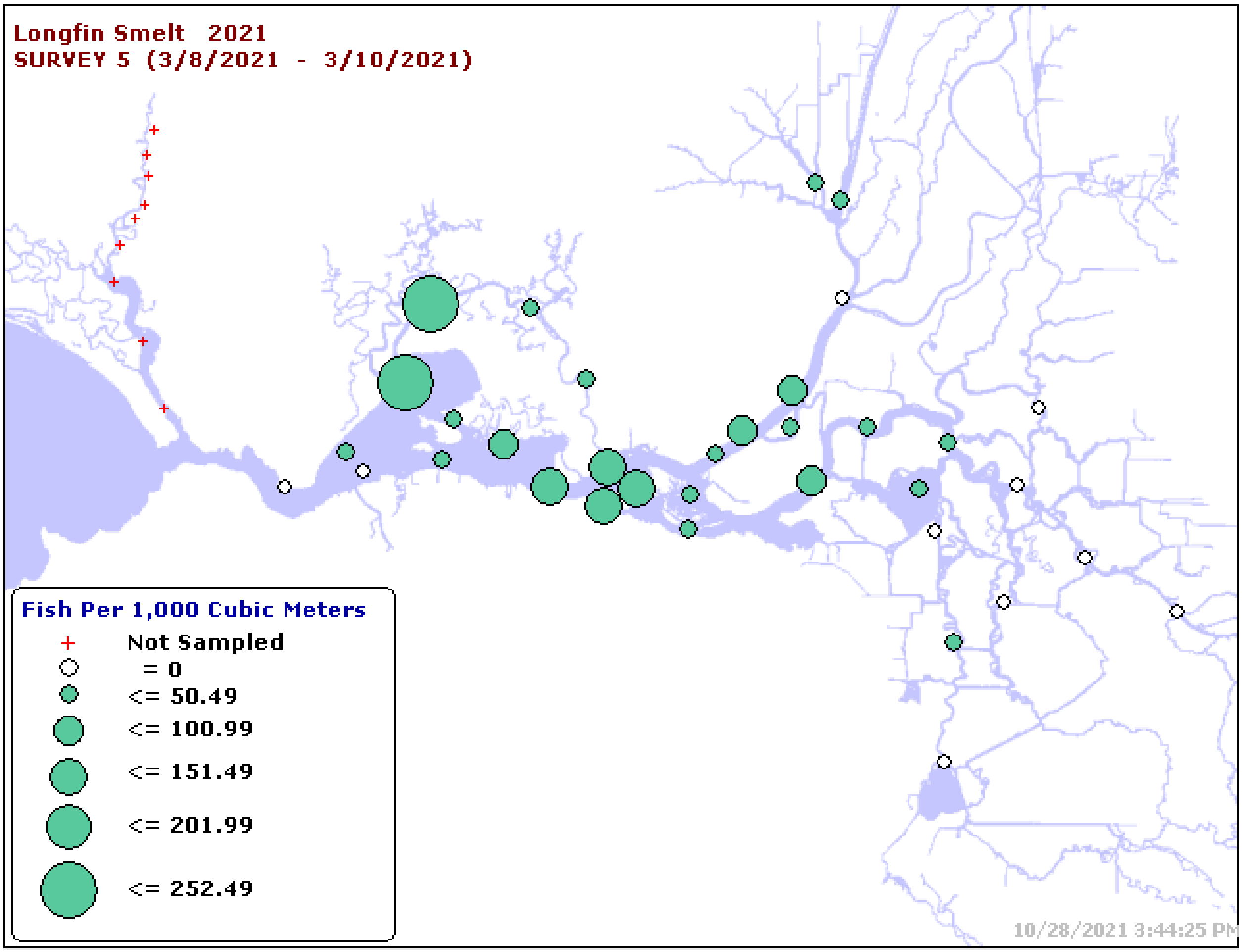
18 Data from https://apps.wildlife.ca.gov/Salvage/Chart/AcrefeetSalvage?Adipose=All&SampMethod=Both&orgCode=25&orgDes=Longfin%20Smelt&endDate=03%2F07%2F2022%2000%3A00%3A00&StartDate=10%2F01%2F2020%2000%3A00%3A00&ShowValue=False.
19 Data from https://apps.wildlife.ca.gov/Salvage/Chart/AcrefeetSalvage?Adipose=All&SampMethod=Both&orgCode=25&orgDes=Longfin%20Smelt&endDate=03%2F13%2F2022%2000%3A00%3A00&StartDate=10%2F01%2F2021%2000%3A00%3A00&ShowValue=False

Figure LFS2. Distribution of Longfin Smelt from Smelt Larva Survey 4, February 22–25, 2021.



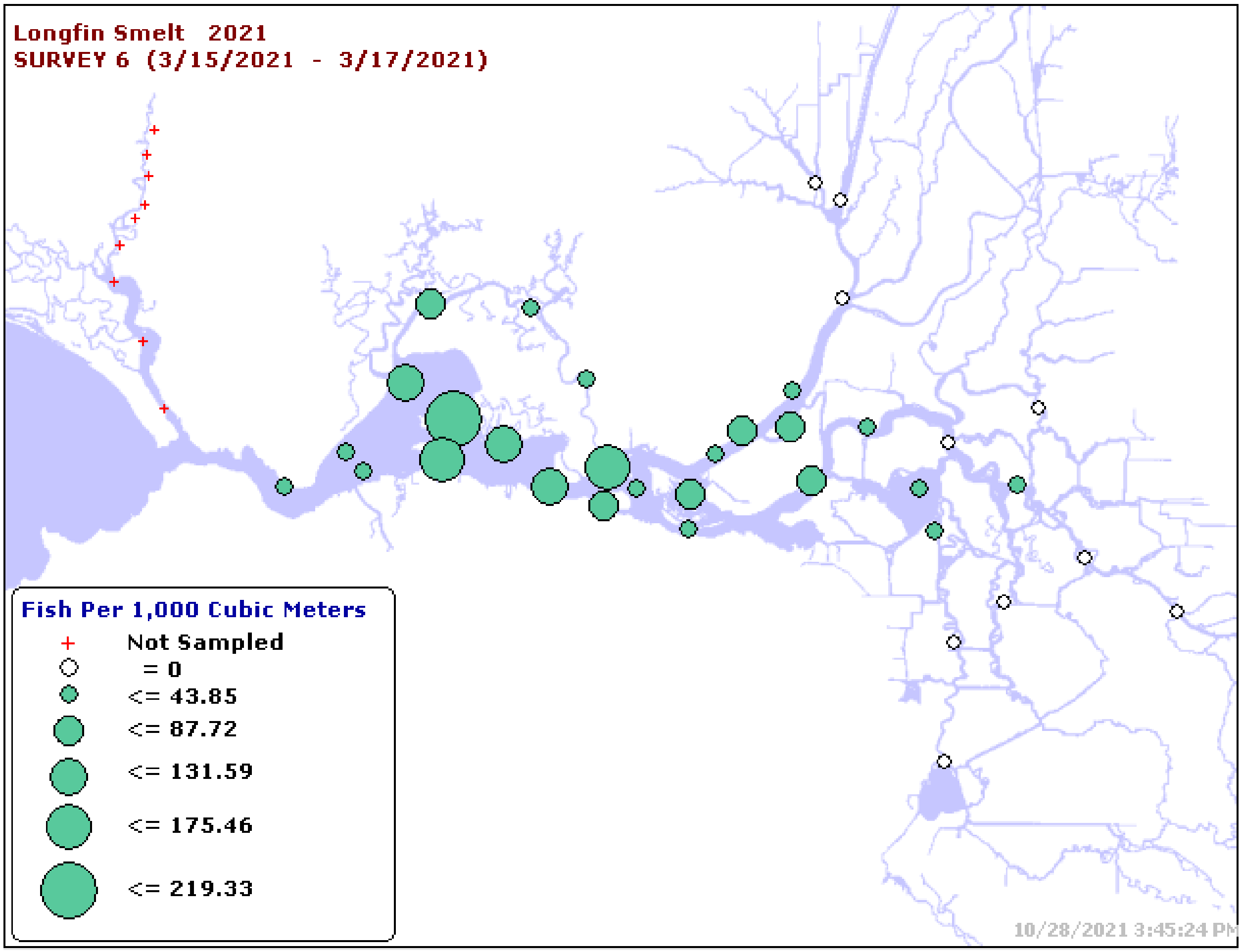
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

Figure LFS3. Distribution of Longfin Smelt from Smelt Larva Survey 5, March 8–10, 2021.



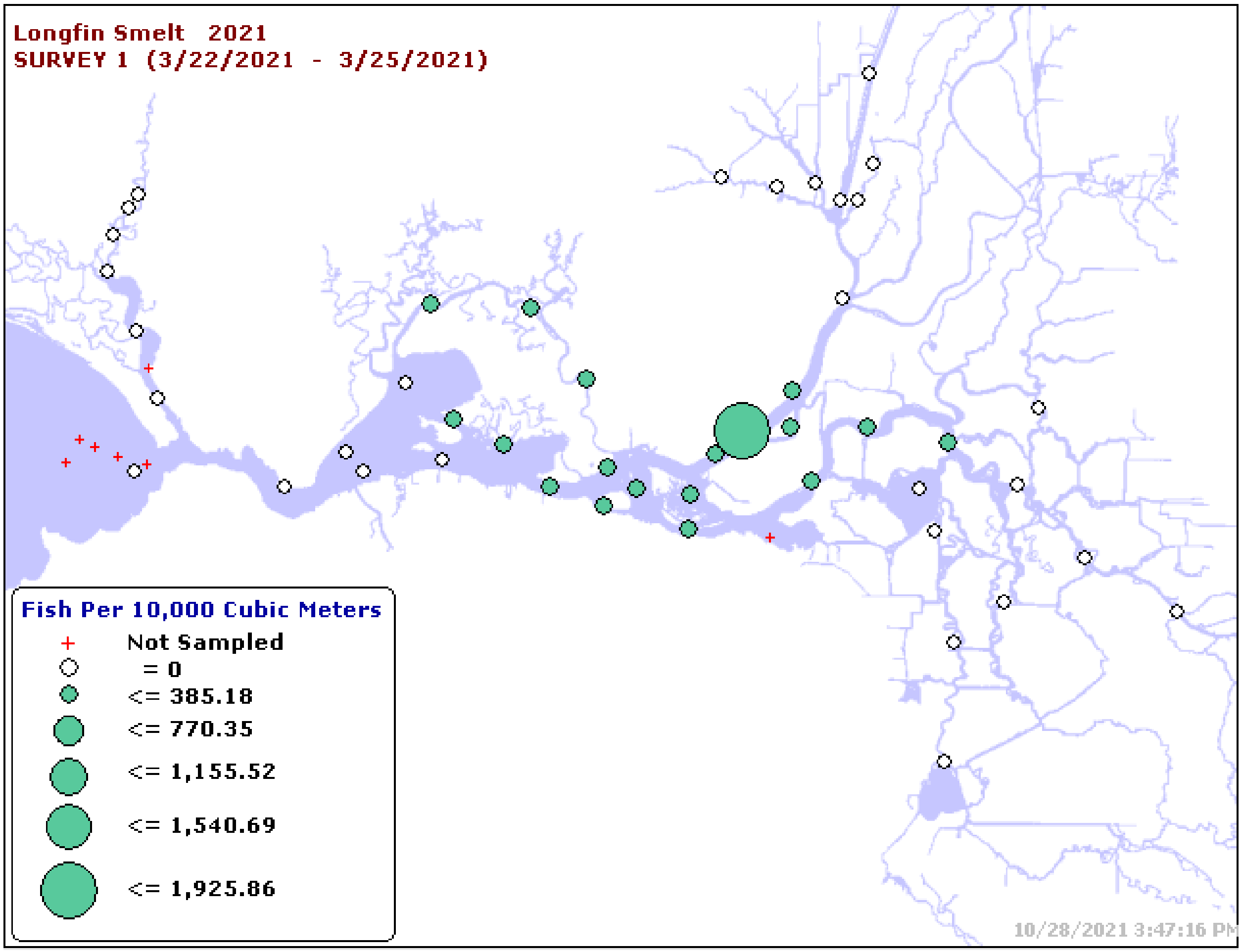
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

Figure LFS4. Distribution of Longfin Smelt from Smelt Larva Survey 6, March 15–17, 2021.



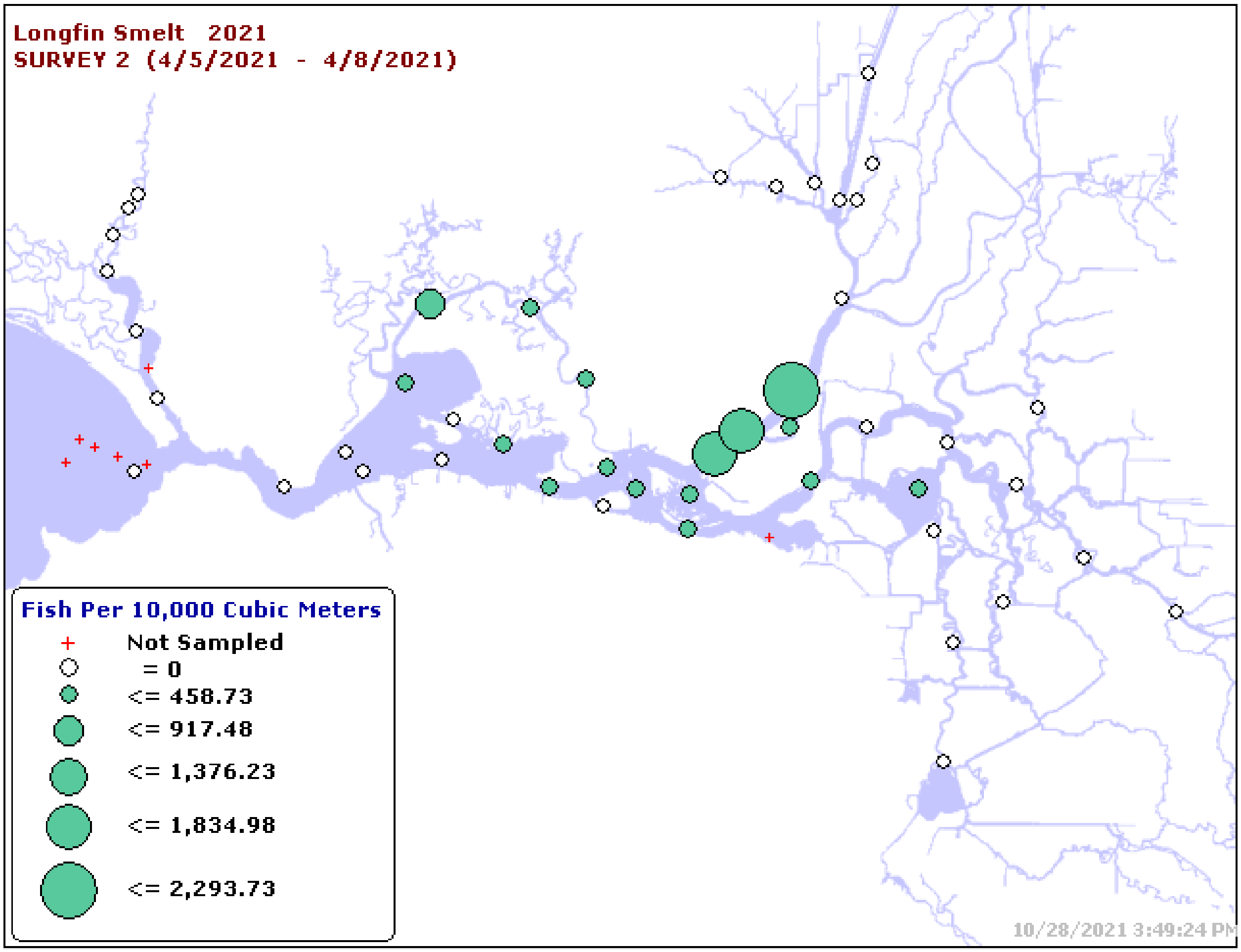
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

Figure LFS5. Distribution of Longfin Smelt from 20-mm Survey 1, March 22–25, 2021.



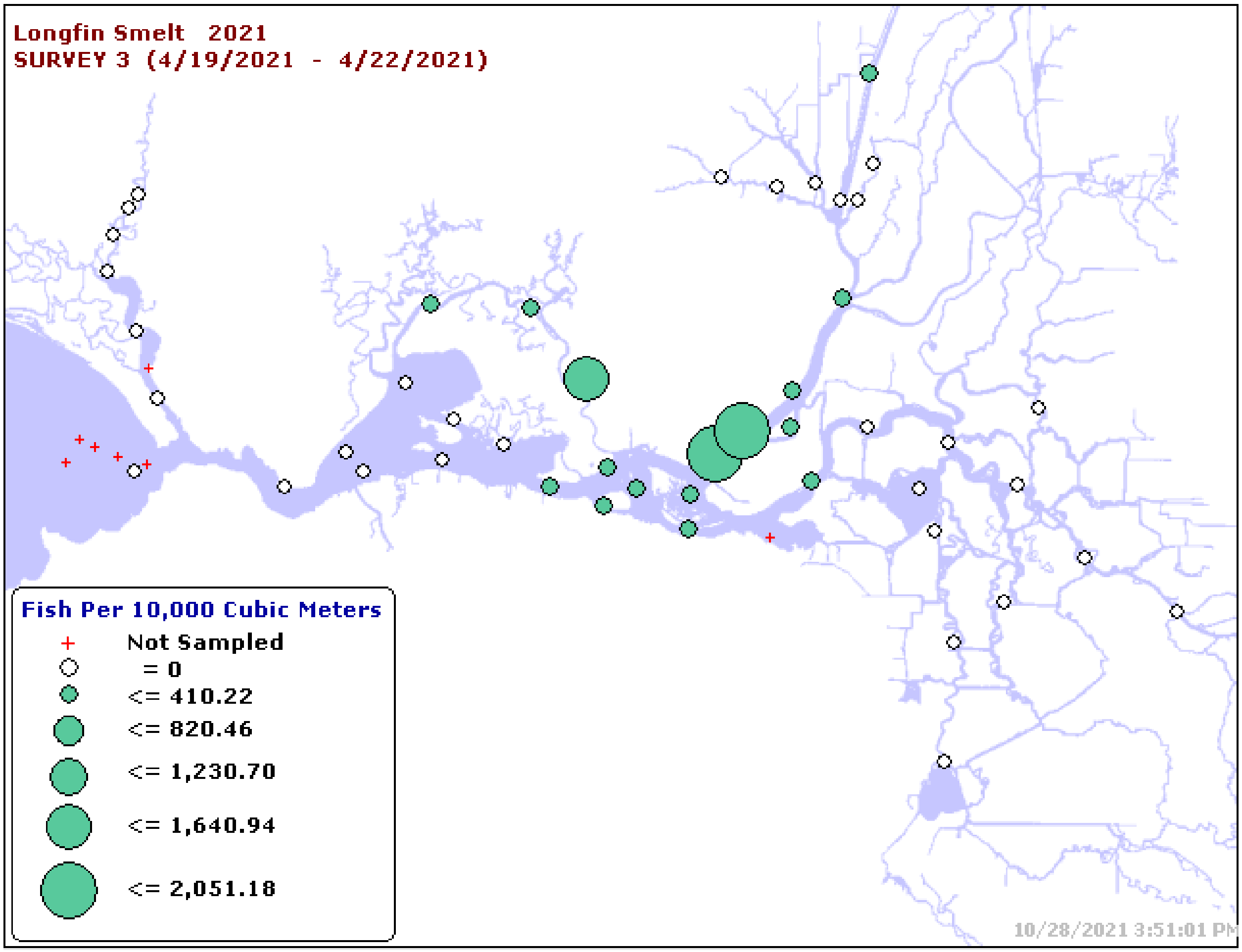
Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS6. Distribution of Longfin Smelt from 20-mm Survey 2, April 5–8, 2021.



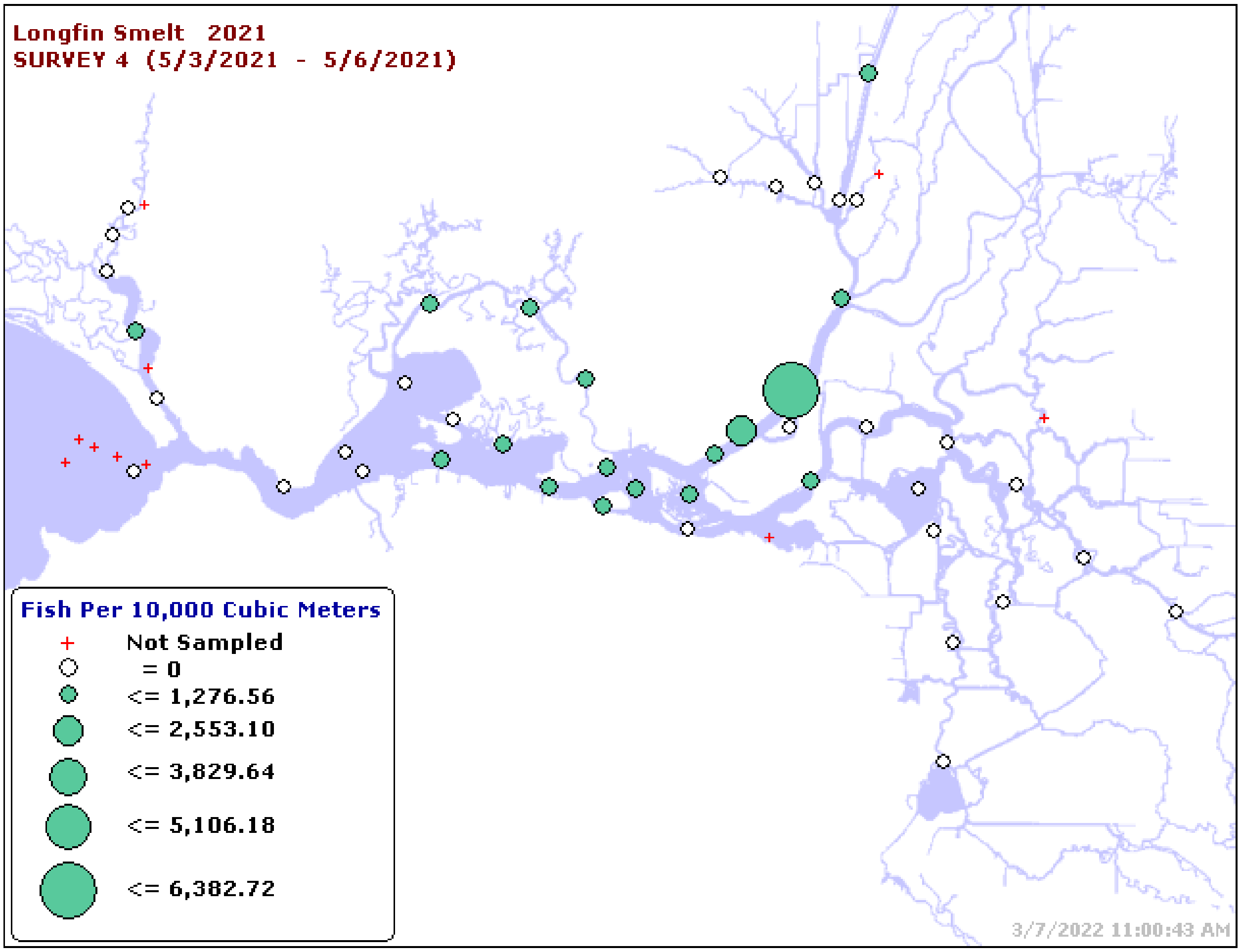
Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS7. Distribution of Longfin Smelt from 20-mm Survey 3, April 19–22, 2021.



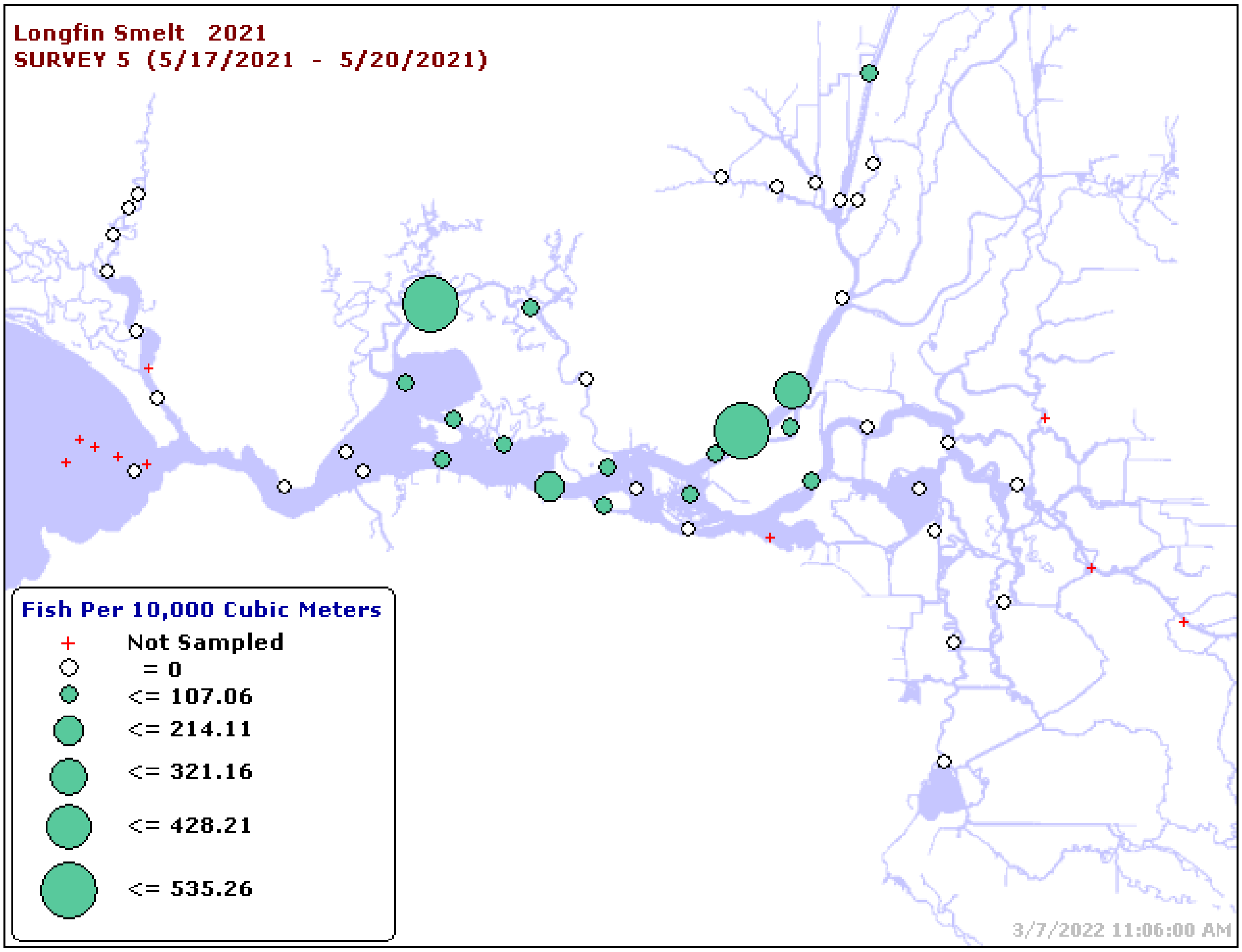
Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS8. Distribution of Longfin Smelt from 20-mm Survey 4, May 3–6, 2021.



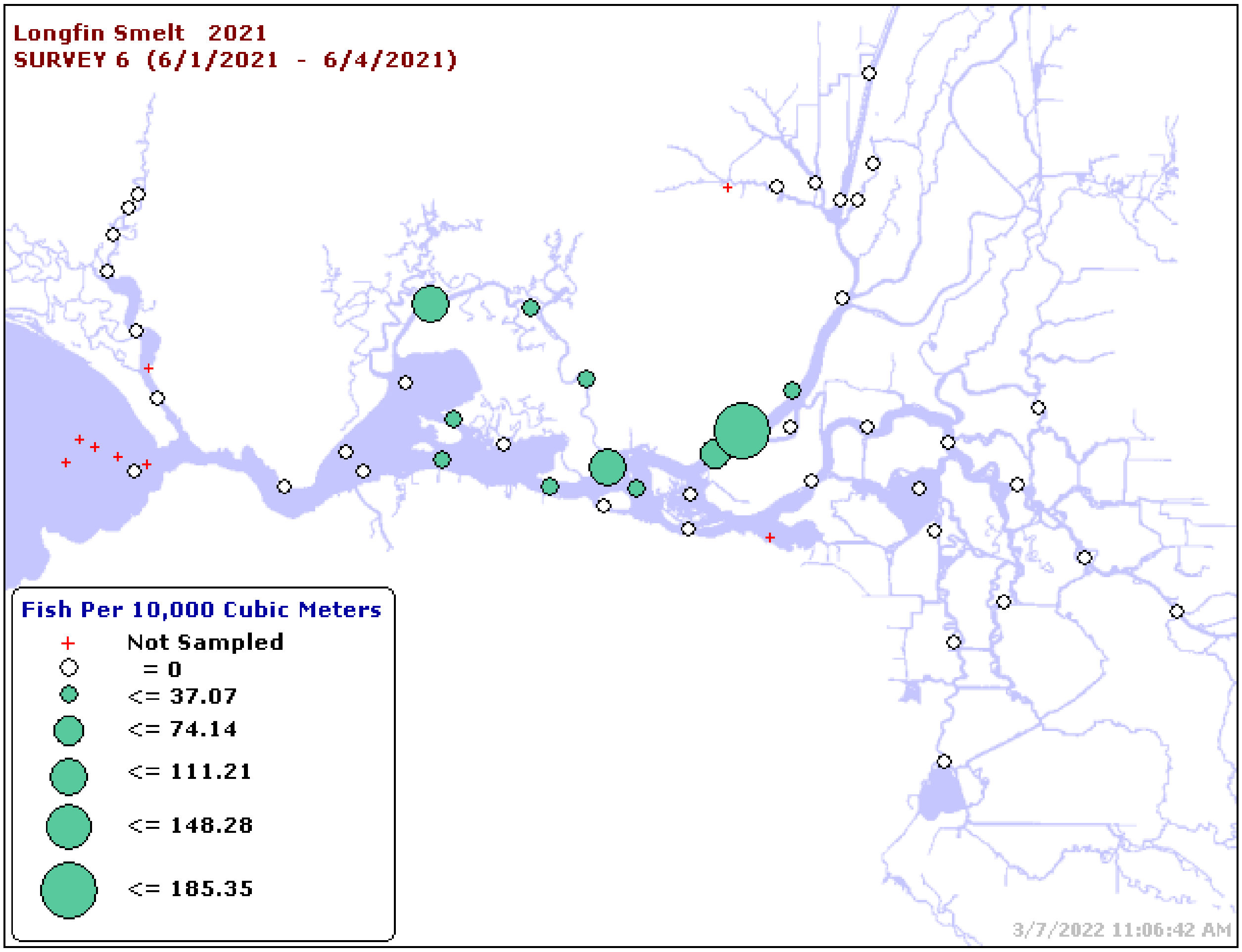
Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS9. Distribution of Longfin Smelt from 20-mm Survey 5, May 17–20, 2021.



Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS10. Distribution of Longfin Smelt from 20-mm Survey 5, June 1–4, 2021.



Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Impacts of TUCP on Longfin Smelt

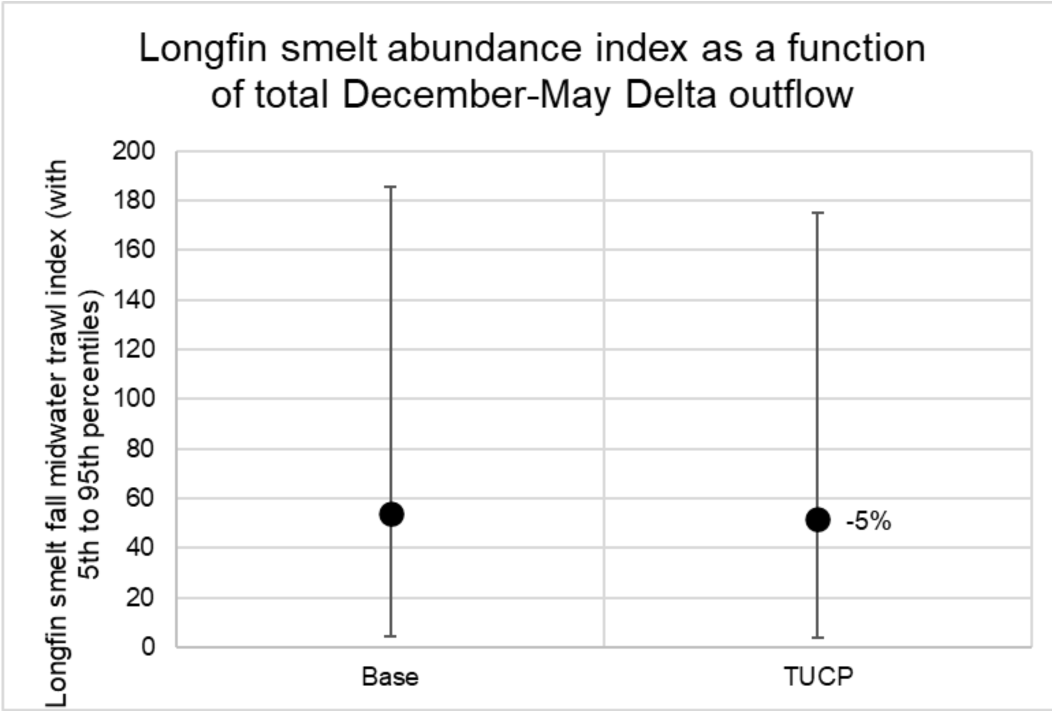
The status of longfin smelt and the impacts of flow and water project operations were recently summarized in the DWR SWP ITP Application under CESA (DWR 2019). The range of drivers affecting population trends is broad, but it is clear that drought conditions cause major stresses for the population.

As noted above in *Presence and Life Stages of Longfin Smelt*, longfin smelt were salvaged at the south Delta export facilities during March and April 2021. The overall distribution of the species during this time period indicates that most of the juvenile population was not at risk of entrainment (see Figures LFS3, LFS4, LFS5, LFS5, LFS6, LFS7, LFS8, LFS9, LFS10). During the TUCP period overlapping with potential south Delta entrainment of longfin smelt (April–June 2022), south Delta exports would be at minimal levels (<1,500 cfs) under the base case and TUCP, resulting in low negative levels of Old and Middle River flows (Table WR5) and low positive QWEST (net flow in the lower San Joaquin River; Table DS1), both indicators of low south Delta entrainment risk. There will be continued risk assessment and, as necessary, operational adjustments as part of CDFW (2020) ITP implementation to limit entrainment risk for longfin smelt.

The TUCP will reduce Delta outflow relative to the base case. There are statistically significant relationships between longfin smelt abundance indices and winter-spring Delta outflow or X2 (e.g., Kimmerer et al. 2009; Thomson et al. 2010; Nobriga and Rosenfield 2016). The potential for negative effects on longfin smelt was assessed with a new method estimating fall midwater trawl index as a function of parental stock size (represented by fall midwater trawl index two years earlier), a coefficient to account for the Pelagic Organism Decline, and total December through May Delta outflow (see method description in Appendix B *Longfin Smelt Delta Outflow-Abundance Index Analysis*). The results of this analysis indicated that although lower December through May Delta outflow under the TUCP could lead to lower longfin smelt abundance than under the base case, the differences are small (5% lower mean; Figure LFS11). Based on the statistical model, the probability of longfin smelt Fall Midwater Trawl index under the TUCP being less than the base case is 0.51. This relatively even probability is because of the variability in the model that is not related to Delta outflow. Such variability was well illustrated by the 2021 fall midwater trawl index of 323, which occurred despite drought conditions in December–May 2021 and a relatively low (44) fall midwater trawl index two years earlier; as previously noted, 2021 had the highest fall midwater trawl index since the high outflow year of 2011. Any differences between the TUCP and the base case in longfin smelt abundance would likely be minor relative to the overall effect of the drought hydrology.

As described previously for delta smelt and, in the discussion related to *Ecosystem Impacts*, the TUCP has the potential to result in lower zooplankton prey (*E. affinis* and *N. mercedis*) for longfin smelt than the base case, although *N. mercedis* is a minor component of the overall mysid assemblage and there is not a statistically significant relationship for mysids as a whole with Delta outflow (Figure ZOOP1) and so the TUCP would have very limited effects on the overall mysid assemblage.

Figure LFS11. Longfin Smelt Fall Midwater Trawl Index as a Function of Total December through May Delta Outflow.



Note: Circles represent mean of posterior predictive distribution, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 5th–95th percentiles from the posterior predictive distribution. See Appendix B for additional description of the statistical model.

Conclusions for Longfin Smelt

Based on historical observations and continuing drought hydrology in spring 2022, longfin smelt are likely to experience relatively poor recruitment of juveniles in 2022, although recruitment in 2021 was relatively high despite the drought. Lower Delta outflow could have limited negative effects on longfin smelt prey. The reduction in outflow due to the TUCP may have some negative impact on longfin smelt abundance based on observed correlations between abundance indices and Delta outflow, though this effect likely would be difficult to quantify given the generally poor environmental conditions due to the drought and statistical analysis suggesting that the probability of a lower abundance index under the TUCP relative to the base case is not greatly different than 0.5 (i.e., 50% chance). The TUCP is unlikely to appreciably increase entrainment of longfin smelt during spring 2022 at the south Delta export facilities because of restricted exports under the TUCP and restrictions being implemented or that would be implemented under the CDFW (2020) ITP to limit entrainment risk.

Other Native and Nonnative Species

The Delta is a large network of tidally influenced channels located at the confluence of the Sacramento and San Joaquin rivers that is the most important and complex geographic area in California for anadromous fish production, estuarine fish species, introduced fish species, and distribution of water resources for numerous beneficial uses.

In addition to the rare, threatened, and endangered species described and analyzed above, the Delta provides shallow open-water and emergent marsh habitat for a variety of common, native and nonnative, resident and migratory fish and macroinvertebrates, including several recreationally important fish species. The purposeful and unintentional introductions of nonnative fish, macroinvertebrates, and aquatic plants have contributed to a substantial change in the species composition, trophic dynamics, and competitive interactions affecting the population dynamics of native Delta species.

Water quality variables such as temperature, salinity, turbidity, dissolved oxygen, pesticides, pH, nutrients (nitrogen and phosphorus), dissolved organic carbon, chlorophyll, and mercury may influence habitat and food-web relationships in the Delta. Water quality conditions in the Delta are influenced by natural environmental processes (including floods and droughts), water management operations, and waste discharge practices. Delta water quality conditions can vary dramatically because of year-to-year differences in runoff and upstream water storage releases, and seasonal fluctuations in Delta flows.

Concentrations of materials in inflowing rivers are often related to streamflow volume and season. Transport and mixing of materials in Delta channels are strongly dependent on river inflows, tidal flows, agricultural diversions, drainage flows, wastewater effluents, and exports. Water quality objectives and concerns are associated with each beneficial use of Delta water.

Droughts have broad-scale impacts on aquatic ecosystems and aquatic communities, including changes to the physical environment and biological communities (Bogan et al. 2015). For example, drought conditions can provide opportunities for invasive species to become established in a new system, with cascading impacts on communities even after drought conditions recede (Beche et al. 2009).

Mahardja et al. (2021) examined over five decades of fish monitoring data from the Delta, including 2014 and 2015 TUCP years, to evaluate the resistance and resilience of fish communities to disturbance from prolonged drought events. High resistance was defined by the lack of decline in species occurrence from a wet to a subsequent drought period, while high resilience was defined by the increase in species occurrence from a drought to a subsequent wet period.

Mahardja et al. (2021) found some unifying themes connecting the multiple drought events over the 50-yr period. Pelagic fishes consistently declined during droughts (low resistance), but exhibit a considerable amount of resiliency and often rebound in the subsequent wet years. However, full recovery did not occur in all wet years following droughts, leading to permanently lower baseline numbers for some pelagic fishes over time. In contrast, littoral fishes seem to be more resistant to drought and may even increase in occurrence during dry years.

Impacts of TUCP on Other Native Species

The TUCP period would likely overlap with some juvenile fall-run Chinook salmon rearing and migration through the Delta. Based on the results from the spreadsheet implementation of the Perry et al. (2018) modeling and ECO-PTM and as discussed for winter-run and spring-run Chinook salmon, less Delta inflow under the TUCP could result in increased juvenile Chinook salmon entry into the low-survival interior Delta through Georgiana Slough and the Delta Cross Channel, when open, and reduced through-Delta survival (Tables WR3 and WR4; Figures WR6, WR7, and WR8). Entrainment at the south Delta export facilities would be expected to be low under the TUCP because of restrictions on south Delta exports. Very few adult fall-run Chinook salmon would be expected to migrate through the Delta during the TUCP period; the peak of the overall potential June through December migration period is September/October (Moyle et al. (2017: 47).

As previously discussed for green sturgeon, NMFS (2018: 12) noted that there are positive correlations between white sturgeon (*Acipenser transmontanus*) and Delta outflow, which have previously been used to infer potential impacts on green sturgeon (ICF International 2016: 5-197 to 5-205). Any impacts on white sturgeon as a result of changes in flow under the TUCP may be limited primarily because the largest sturgeon recruitment occurs in wetter years (Fish 2010); as previously noted for green sturgeon, 2022 would be a drier year regardless of implementation of the TUCP and it is uncertain the extent to which the difference in drought-year-flows between the TUCP and the base case would result in differing impacts to white sturgeon compared to the potential impacts that may occur between much broader ranging hydrological conditions (i.e., different water year types). Application of the statistical relationships between white sturgeon year-class strength and April through May and March through July Delta outflow (ICF International 2016: 5-197 to 5-205) gives negative estimates of year-class strength under the base case and the TUCP, supporting the conclusion that very little recruitment may occur under either the base case or the TUCP.

Abundance indices of starry flounder (*Platichthys stellatus*) and California bay shrimp (*Crangon* spp.), two estuarine and coastal taxa occurring in the San Francisco Estuary, have statistically significant negative correlations with X2 (Kimmerer 2002; Kimmerer et al. 2009), indicating a positive relationship with Delta outflow. The correlation for California bay shrimp is with March through May X2 and for starry flounder is March through June X2, both of which overlap the TUCP period. Application of the regression coefficients from Kimmerer et al. (2009) gives differences in bay shrimp mean abundance index of 20% less than the base case for the TUCP. A similar analysis for starry flounder gives a difference in mean abundance index of 27% less than the base case for the TUCP. Note that prediction intervals were not calculated because the analysis only used the mean coefficients provided by Kimmerer et al. (2009), but as shown by earlier analyses, prediction intervals from such analyses are generally quite broad (see Figure ECO1). In addition, starry flounder distribution is not restricted solely to the San Francisco Estuary and it is not known how abundance in the Estuary—possibly reflecting increased upstream movement and retention with greater Delta outflow (Kimmerer et al. 2009)—relates to the overall species abundance across the species' range from Alaska to southern California.

Resilience to low flow and drought conditions for those species described above and other native fishes, appears to be contingent on the suite of environmental factors critical to each species and how they relate to the increased flow during post-drought periods. Mahardja et al. (2021) found that the Delta-endemic Sacramento splittail

(*Pogonichthys macrolepidotus*) demonstrated low resistance to drought, but consistently recovered during subsequent wet years. This is consistent with the current understanding that the relatively long-lived Sacramento splittail (Daniels and Moyle 1983) depend on strong year classes that are recruited during wet years when floodplain habitat is available for spawning (Sommer et al. 1997, Moyle et al. 2004). While the reduction in Delta inflow and outflow due to the TUCP may have some negative impact on splittail and other native fish, the effect may be difficult to quantify given the already poor environmental conditions due to the drought. Although Delta inflow would be appreciably greater during April through June under the base case than the TUCP, low flows under all cases would likely result in minimal, if any, inundation of floodplain habitat important to splittail and other native fish; should storm events occur resulting in floodplain inundation (e.g., overtopping of Fremont Weir and resulting flooding of Yolo Bypass), these events would be present under all cases.

Impacts of TUCP on Nonnative Species

According to Mahardja et al. (2021), nonnative pelagic fishes of the Delta (e.g., threadfin shad (*Dorosoma petenense*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*)) generally exhibited low drought resistance and high resilience during the study period. However, these nonnative pelagic fish species did not demonstrate synchronous decline and rebound throughout every drought cycle. There is a lack of information on the flow-related mechanisms that would affect the abundance and distribution of these species; however, previous studies indicated that availability of suitable freshwater habitat may increase their occurrence during wet years (Feyrer et al. 2007, Kimmerer et al. 2009). Application of statistical relationships from Kimmerer et al. (2009) that estimate American shad abundance indices as a function of mean February through May X2 gave mean estimates for the bay midwater trawl survey that were 12% less than the base case for the TUCP, and mean estimates for the fall midwater trawl survey that were 9% less than the base case for the TUCP. Application of statistical relationships from Kimmerer et al. (2009) that estimate juvenile striped bass abundance or survival indices from several different surveys as a function of mean April through June X2 gave mean estimates that were 14–31% less than the base case for the TUCP.

The nonnative littoral fish species included in the Mahardja et al. (2021) analysis (e.g., largemouth bass (*Micropterus salmoides)*, bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), and Mississippi silverside) are generally considered warm-water and drought-tolerant species and, as such, they rarely show decline during droughts. Numbers of largemouth bass, bluegill, and redear sunfish seem to have progressively increased between 1995 and 2011 (Mahardja et al. 2021), possibly due to the expansion of invasive submerged aquatic vegetation in the Delta over the past decade or two that have been associated with drought (Conrad et al. 2016, Santos et al. 2016, Kimmerer et al. 2019). On the other hand, Mississippi silverside appears to have a negative association with freshwater flow that led to a mostly positive drought resistance (Mahardja et al. 2016; see also discussion above in *Ecosystem Impacts*).

Conclusions for Other Native and Nonnative Species

The reduction in outflow due to the TUCP may have negative and/or positive impacts on other native and nonnative species, including the migratory, pelagic, and littoral species described above. Species with positive correlations with Delta outflow such as striped bass and American shad may be negatively affected, whereas species with negative correlations such as Mississippi silversides may be positively affected.

V. Coordination with Water Operations and Watershed Monitoring Technical Teams

Reclamation and DWR convene the WOMT and Watershed Monitoring Workgroups for each of the Upper Sacramento, Clear Creek, American, Delta, and Stanislaus watersheds (Watershed Monitoring Workgroups). DWR convenes a Feather River Operations Group. Each of the Watershed Monitoring Workgroups are responsible for real-time synthesis of fisheries monitoring information (e.g., Rotary Screw Traps, Enhanced Delta Smelt Monitoring Program, Trawls, other status and trends monitoring) and providing recommendations on scheduling specific volumes of water and implementing protective measures as specified in the 2020 Record of Decision, ITP, and FERC licenses. The Delta Monitoring Workgroup is responsible for integrating species information across watersheds, including delta and longfin smelt and winter-run Chinook salmon and other salmonids and sturgeon. In addition to Delta Watershed Monitoring Workgroup, the program includes Smelt Monitoring Team and Salmonid Monitoring Team. The Watershed Monitoring Workgroups include technical representatives from federal and state agencies and stakeholders and will provide information to Reclamation and DWR on species abundance, species distribution, life stage transitions, and relevant physical parameters.

The WOMT, comprised of agency managers, coordinates the implementation of water operations under the 2020 Record of Decision, as well as for the 2020 ITP, and NMFS and USFWS 2019 biological opinions. WOMT oversees the Watershed Monitoring Workgroups, seeks to resolve disagreements within the technical teams, and elevates policy decisions to the Directors of the agencies where necessary. This management-level team was established to facilitate timely decision-support and decision-making. The goal of WOMT is to resolve disagreements between technical staff from each agency; however, the participating agencies retain their authorized roles and responsibilities as set forth in the 2020 Record of Decision and 2020 ITP.

As part of implementation of the April through June 2022 TUCP, DWR and Reclamation will coordinate with the State Water Board, CDFW, NMFS, and USFWS at WOMT meetings. This process allows the regulatory agencies to stay up to date on information and provide feedback on potential project operations and related impacts on an ongoing basis as the drought is addressed. As a result of this coordination, DWR and Reclamation may submit to the State Water Board additional information on developing standards appropriate for operation of the CVP/SWP during the drought. For example, DWR and Reclamation will continue to coordinate with Long-term Operation Agency Coordination working groups to continue the robust monitoring program and used in the 2021 and 2022 Drought Contingency Plans and Drought Ecosystem Monitoring and Synthesis Plan with updates to the Long-Term Operation Agency Coordination Team. Summary descriptions of the Drought Contingency Plan and Drought Ecosystem Monitoring and Synthesis Plan are provided below.

Drought Contingency Plan

The 2022 Drought Contingency Plan (DWR and Reclamation 2022) was prepared by DWR and Reclamation in an effort to provide updated information about areas of potential concern given the current dry hydrology of 2022. The Drought Contingency Plan was submitted by DWR on February 4, 2022 (for February 1-September 30, 2022), to CDFW in response to Condition 8.21 of CDFW's ITP (CDFW 2020). Concurrently, the Drought Contingency Plan was shared with the agencies through WOMT.

Over the past two years, as part of implementing 2019 Biological Opinions and ITP, DWR and Reclamation have worked with CDFW, NMFS USFWS, and the State Water Board to identify actions that could potentially be implemented during a drought (not specifically for WY 2022) to manage the State's limited water supplies and protect species. These actions, known as the Drought Toolkit (Reclamation 2021), describe the anticipated coordination, process, planning and potential drought response actions in the event of a drought. DWR and Reclamation are committed to continued development of the Drought Toolkit and will continue to coordinate with the CDFW, NMFS, USFWS, and the State Water Board as any actions from that Toolkit are being considered for implementation in WY 2022.

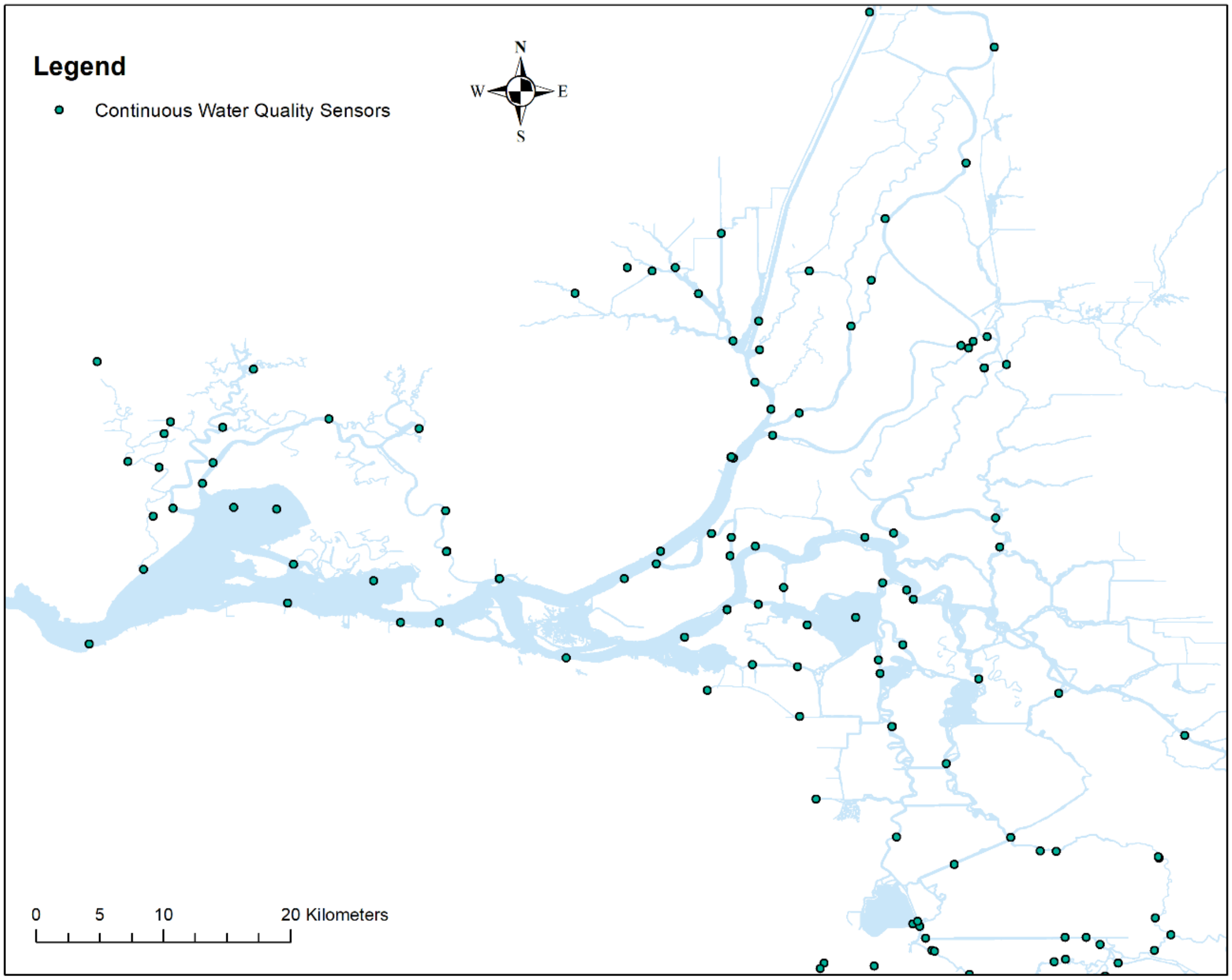
Prior to this petition, DWR and Reclamation provided weekly hydrology and condition updates through WOMT. DWR and Reclamation have met with the State Water Board staff and with representatives of CDFW, NMFS and USFWS, to discuss the elements of this petition, and will continue to provide updates and to seek their input on how best to manage multiple needs for water supply. In addition, as part of this petition, DWR and Reclamation will continue to coordinate with Long-term Operation Agency working groups to continue the robust monitoring programs in the 2022 Drought Contingency Plan. DWR shall also provide the State Water Board an updated harmful algal blooms (HABs) report in March 2023.

<u>Drought Ecosystem Monitoring and Synthesis Plan</u>

The 2022 Drought Contingency Plan includes ecosystem monitoring to assess the impact of drought and drought actions. The monitoring plan will outline the data collection and analysis that will be implemented to evaluate ecosystem responses to the current drought in the Delta and Suisun Marsh, as well as the impacts of the TUCP. Data collection will rely primarily on existing monitoring, with the addition of a few special studies. Data will be integrated and compared to previous droughts and previous wet periods to detect ecosystem changes. These changes will be compiled and synthesized into a report and be incorporated into updates for the Drought Toolkit to inform future dry year actions.

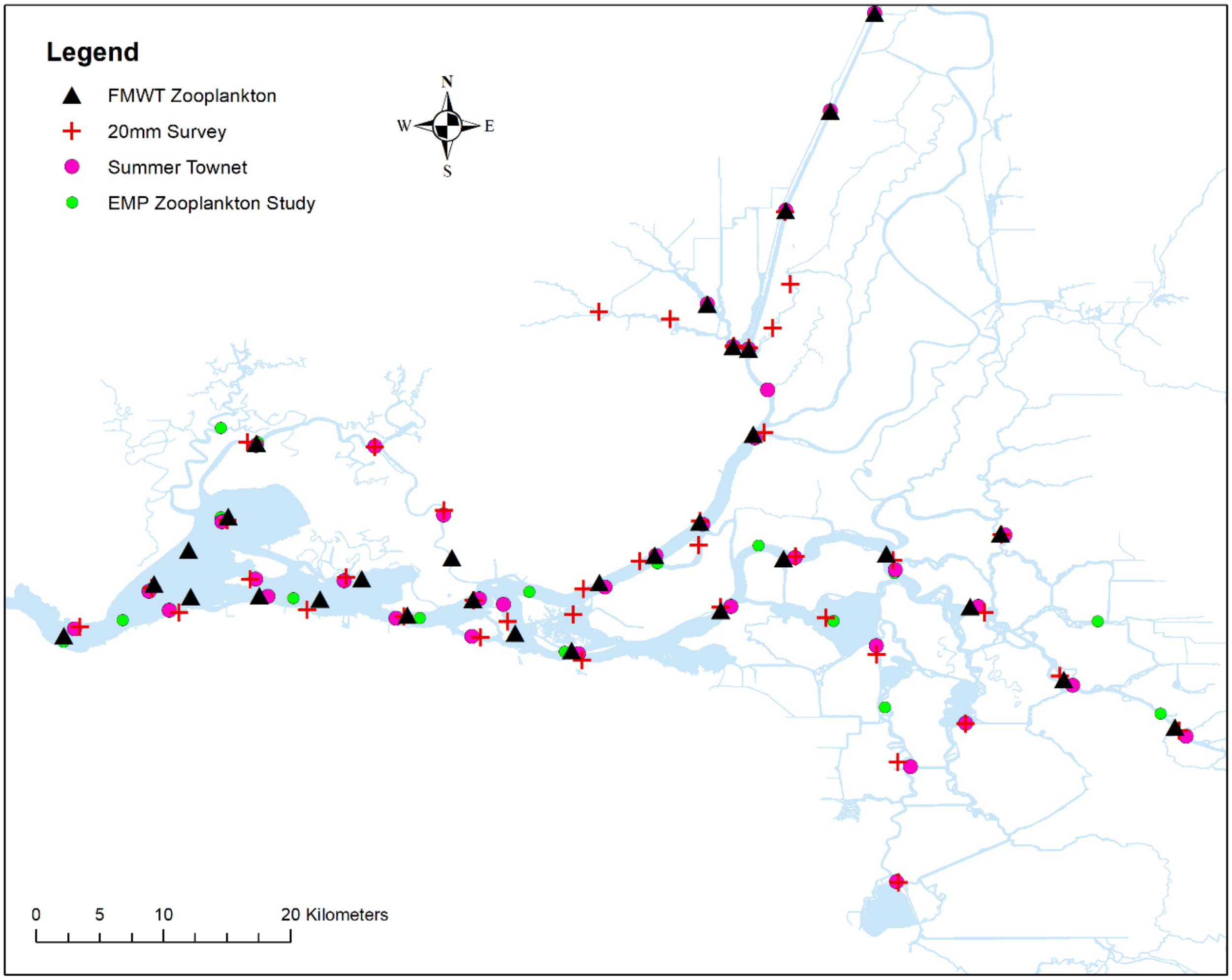
Monitoring covers the legal Delta and Suisun Marsh (Figures MON1 through MON4). In some cases, it will include limited data collection outside these areas where necessary to describe habitat for anadromous species.

Figure MON1. Continuous water quality sensors in the Delta and Suisun Marsh.



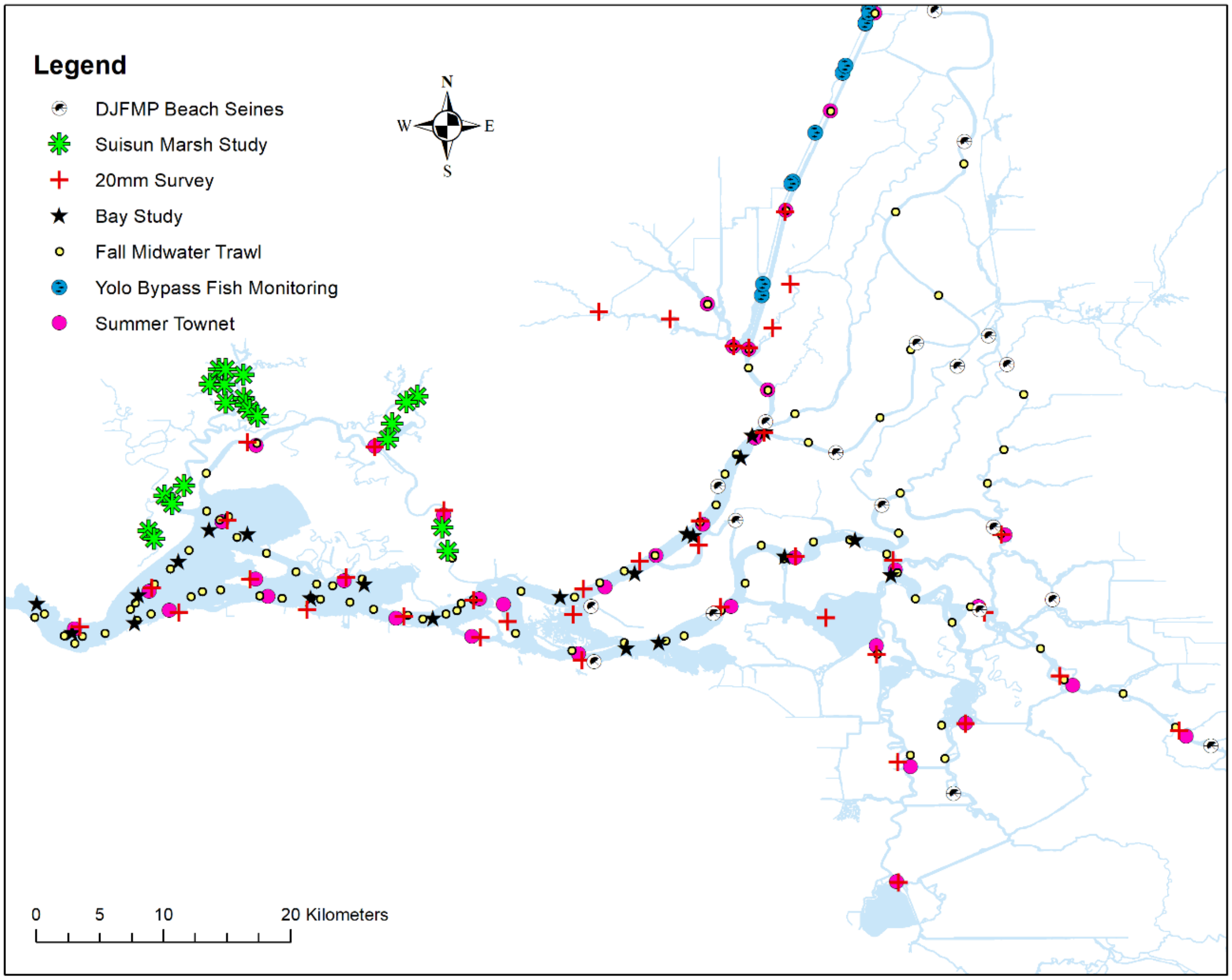
Source: DWR and IEP 2021.

Figure MON2. IEP Zooplankton sample stations in the Delta and Suisun Bay/ Marsh. FMWT zooplankton are collected monthly, Sept-December, 20mm area collected twice per month, March-June, Summer Townet samples are collected twice per month, June-August, and EMP samples are collected once per month year-round.



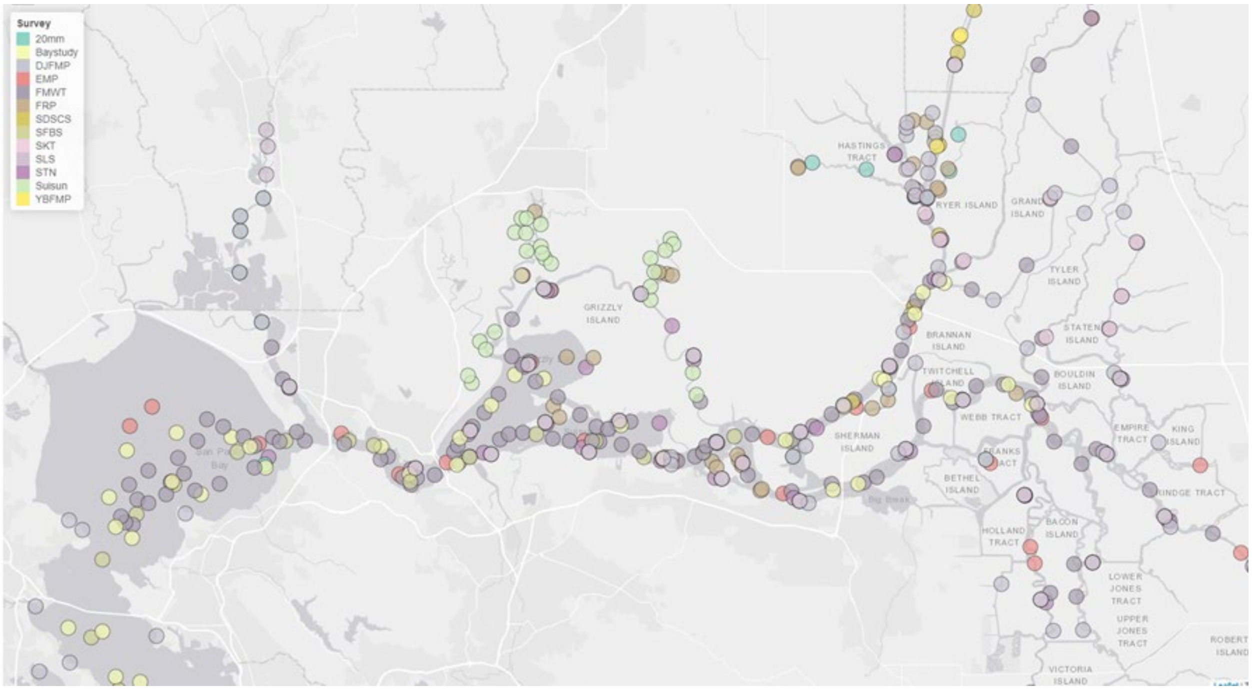
Source: DWR and IEP 2021.

Figure MON3. IEP Fish sample stations in the Delta and Suisun Bay/Marsh. The Enhanced Delta Smelt Monitoring Survey does not have fixed sites, so is not shown here.



Source: DWR and IEP 2021.

Figure MON4. Zooplankton and Fish sample stations in the Delta and Suisun Bay/Marsh (13 Bay-Delta monitoring programs).



Source: https://deltascience.shinyapps.io/monitoring/.

VI. References

Barros, A. 2021. Zooplankton Trends in the Upper SFE, 1974-2018. *IEP Newsletter* 40(1): 5-14.

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza. 2010. *2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Interagency Ecological Program, Sacramento, CA.

Beche, L. A., P. G. Connors, V. H. Resh, and A. M. Merenlender. 2009. Resilience of fishes and invertebrates to prolonged drought in two California streams. *Ecography* 32:778–788.

Berg M and Sutula M. 2015. *Factors affecting growth of cyanobacteria with special emphasis on the Sacramento-San Joaquin Delta*. Southern California Coastal Water Research Project Technical Report 869, August 2015.

Bogan, M. T., K. S. Boersma, and D. A. Lytle. 2015. Resistance and resilience of invertebrate communities to seasonal and supraseasonal drought in arid-land headwater streams. *Freshwater Biology* 60:2547–2558.

Buchanan, R. A., P. L. Brandes, and J. R. Skalski. 2018. Survival of Juvenile Fall-Run Chinook Salmon through the San Joaquin River Delta, California, 2010–2015. *North American Journal of Fisheries Management* 38(3):663-679.

Buchanan, R. A., E. Buttermore, and J. Israel. 2021. Outmigration Survival of a Threatened Steelhead Population through a Tidal Estuary. *Canadian Journal of Fisheries and Aquatic Sciences*. DOI: dx.doi.org/10.1139/cjfas-2020-0467.

California Department of Fish and Wildlife (CDFW). 2020. California Endangered Species Act Incidental Take Permit No. 2081-2019-066-00. *Long-Term Operation of the State Water Project in the Sacramento San Joaquin Delta*. Sacramento, CA: California Department of Fish and Game, Ecosystem Conservation Division.

California Department of Water Resources (DWR). 2019. *Incidental Take Permit Application for Long-Term Operation of the California State Water Project*. December 13.

California Department of Water Resources (DWR) and Interagency Ecological Program (IEP). 2021. *Drought Ecosystem Monitoring and Synthesis Plan (2021-2023)*. May 13, 2021.

California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation). 2022. *State Water Project and Central Valley Project Drought Contingency Plan February 1, 2022 – September 30, 2022*.

California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation). 2021b. *2021 Temporary Urgency Change Petition Regarding Delta Water Quality*. May 17.

Conrad, J. L., A. J. Bibian, K. L. Weinersmith, D. De Carion, M. J. Young, P. Crain, E. L. Hestir, M. J. Santos, and A. Sih. 2016. Novel Species Interactions in a Highly Modified Estuary: Association of Largemouth Bass with Brazilian Waterweed *Egeria densa*. *Transactions of the American Fisheries Society* 145(2):249-263.

Daniels, R., and P. Moyle. 1983. Life history of the splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in the Sacramento-San Joaquin Estuary. *Fishery Bulletin* 81:647–65.

del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science* 11(1).

Durand, J., W. Fleenor, R. McElreath, M. J. Santos, and P. Moyle. 2016. Physical Controls on the Distribution of the Submersed Aquatic Weed *Egeria densa* in the Sacramento–San Joaquin Delta and Implications for Habitat Restoration. *San Francisco Estuary and Watershed Science* 14(1).

Feyrer, F., M. L. Nobriga, and T. R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 64:723–734.

Fish, M. A. 2010. A White Sturgeon Year-Class Index for the San Francisco Estuary and Its Relation to Delta Outflow. *Interagency Ecological Program Newsletter* 23(2):80-84.

Gingras, M., J. DuBois, and M. Fish. 2013. Further Investigations into San Francisco Estuary White Sturgeon (*Acipenser transmontanus*) Year-Class Strength. *IEP Newsletter* 26(4):10-12.

Glibert, P.M., Dugdale, R.C., Wilkerson, F., Parker, A.E. Alexander, J., Antell, E., Blaser, S. Johnson, A., Lee, J, Lee, T., Muraskoa, S., Strong, S. 2014. Major – but rare – spring blooms in 2014 in San Francisco Bay Delta, California, a result of the long-term drought, increased residence time, and altered nutrient loads and forms. Journal of Experimental Marine Biology and Ecology 460: 8-18. https://doi.org/10.1016/j.jembe.2014.06.001

Greenwood, M. 2018. *Potential Effects on Zooplankton from California WaterFix Operations*. Technical Memorandum to California Department of Water Resources. July 2. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/petitioners_exhibit/dwr/part2_rebuttal/dwr_1349.pdf. Accessed: November 8, 2021.

Grimaldo, L., J. Burns, R. E. Miller, A. Kalmbach, A. Smith, J. Hassrick, and C. Brennan. 2020. Forage Fish Larvae Distribution and Habitat Use During Contrasting Years of Low and High Freshwater Flow in the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 18(3).

Hamilton, S. A., and D. D. Murphy. 2020. Use of affinity analysis to guide habitat restoration and enhancement for the imperiled delta smelt. *Endangered Species Research* 43:103-120.

Hartman, R., E. Ateljavich, M. Berg, K. Bouma-Gregson, D. Bosworth, N. Rasmussen, T. Flynn, and T. Pennington. 2021. Report on the Impact of the Emergency Drought Barrier on Harmful Algal Blooms and Aquatic Weeds in the Delta, Sacramento: California Department of Water Resources. 86p., https://www.waterboards.ca.gov/drought/tucp/docs/2021/20211215_cond8-report.pdf

Hennessy, A., and Z. Burris. 2017. *Preliminary analysis of current relationships between zooplankton abundance and freshwater outflow in the upper San Francisco Estuary*. Memorandum to S. Louie, Senior Environmental Scientist, California Department of Fish and Wildlife, Water Branch. February 21. Stockton, CA: California Department of Fish and Wildlife, Bay-Delta Region.

Heublein, J., R. Belmer, R. D. Chase, P. Doukakis, M. Gingras, D. Hampton, J. A. Israel, Z. J. Jackson, R. C. Johnson, O. P. Langness, S. Luis, E. Mora, M. L. Moser, L. Rohrbach, A. M. Seesholtz, T. Sommer, and J. S. Stuart. 2017a. *Life History and Current Monitoring Inventory of San Francisco Estuary Sturgeon*. National Marine Fisheries Service, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-589.

Heublein, J., R. Bellmer, R. D. Chase, P. Doukakis, M. Gingras, D. Hampton, J. A. Israel, Z. J. Jackson, R. C. Johnson, O. P. Langness, S. Luis, E. Mora, M. L. Moser, L. Rohrbach, A. M. Seesholtz, and T. Sommer. 2017b. *Improved Fisheries Management Through Life Stage Monitoring: The Case for the Southern Distinct Population Segment of North American Green Sturgeon and the Sacramento-San Joaquin River White Sturgeon*. NOAA-TM-NMFS-SWFSC-588.

Hobbs, J., P. B. Moyle, N. Fangue, and R. E. Connon. 2017. Is extinction inevitable for Delta Smelt and Longfin Smelt? An opinion and recommendations for recovery. *San Francisco Estuary and Watershed Science* 15(2).

ICF International. 2016. *Biological Assessment for the California WaterFix*. July. (ICF 00237.15.) Sacramento, CA. Prepared for U.S. Department of the Interior, Bureau of Reclamation, Sacramento, CA.

Interagency Ecological Program, Management, Analysis, and Synthesis Team. 2015. *An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish*. Technical Report 90. January. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, CA.

Jungbluth, M. J., J. Burns, L. Grimaldo, A. Slaughter, A. Katla, and W. Kimmerer. 2021. Feeding habits and novel prey of larval fishes in the northern San Francisco Estuary. *Environmental DNA*. DOI: 10.1002/edn3.226.

Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? *Marine Ecology Progress Series* 243: 39-55.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? *Estuaries and Coasts* 32(2):375-389.

Kimmerer, W., F. Wilkerson, B. Downing, R. Dugdale, E. S. Gross, K. Kayfetz, S. Khanna, A. E. Parker, and J. Thompson. 2019. Effects of Drought and the Emergency Drought Barrier on the Ecosystem of the California Delta. *San Francisco Estuary and Watershed Science* 17(3).

Lehman, P., G. Boyer, M. Satchwell, S. Waller. 2008. The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in San Francisco Estuary. *Hydrobiologia* 600:187-204

Lehman, P., T. Kurobe, S. Lesmeister, C. Lam, A. Tung, M. Xiong, and S. Teh. 2018. Strong differences characterize *Microcystis* blooms between successive severe drought years in the San Francisco Estuary, California, USA. *Aquatic Microbial Ecology* 81(3):293-299.

Lehman, P., K. Marr, G.L. Boyer, S. Acuna, S. Teh. 2013. Long-term trends and causal factors associated with Microcystis abundance and toxicity in San Francisco Estuary and implications for climate change impacts. *Hydrobiologia* 718:141-158

Mahardja, B., J. L. Conrad, L. Lusher, and B. Schreier. 2016. Abundance Trends, Distribution, and Habitat Associations of the Invasive Mississippi Silverside (*Menidia audens*) in the Sacramento–San Joaquin Delta, California, USA. *San Francisco Estuary and Watershed Science* 14(1).

Mahardja, B., V. Tobias, S. Khanna, L. Mitchell, P. Lehman, T. Sommer, L. Brown, S. Culberson, and J. L. Conrad. 2021. Resistance and resilience of pelagic and littoral fishes to drought in the San Francisco Estuary. *Ecological Applications* 31(2): e02243.

Marcinkevage, A.C. 2022. Letter to Kristin White, U.S. Bureau of Reclamation, with winter-run Chinook salmon Juvenile Production Estimate from Brood Year 2021 expected to the enter the Delta in water year 2022. Sacramento, CA: National Marine Fisheries Service. January 20.

Marston, D., C. Mesick, A. Hubbard, D. Stanton, S. Fortmann-Roe, S. Tsao, and T. Heyne. 2012. Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*). *San Francisco Estuary and Watershed Science* 10(4).

Miller, W. J., B. F. J. Manly, D. D. Murphy, D. Fullerton, and R. R. Ramey. 2012. An Investigation of Factors Affecting the Decline of Delta Smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary. *Reviews in Fisheries Science* 20(1):1-19.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of Sacramento Splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. *San Francisco Estuary and Watershed Science* 2:1–47.

Moyle, P., R. Lusardi, P. Samuel, and J. Katz. 2017. *State of the Salmonids: Status of California's Emblematic Fishes 2017*. Center for Watershed Sciences, University of California, Davis and California Trout, San Francisco, CA.

National Marine Fisheries Service (NMFS). 2018. *Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*)*. California Central Valley Area Office, National Marine Fisheries Service, Sacramento, CA.

National Marine Fisheries Service. 2019. *Biological Opinion on the Long-term Operation of the Central Valley Project and State Water Project*. October 21. National Marine Fisheries Service, Silver Spring, Maryland.

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. *Transactions of the American Fisheries Society* 145(1):44-58.

Perry, Russell. Research Fisheries Biologist, Quantitative Fisheries Ecology Section, USGS Western Fisheries Research Center, Columbia River Research Laboratory, Cook, WA. June 18, 2019—Email containing Excel file <North Delta Routing Management Tool v2.1.xlsx> sent to Marin Greenwood, Aquatic Ecologist, ICF, Sacramento, CA.

Perry, R. W., A. C. Pope, J. G. Romine, P. L. Brandes, J. R. Burau, A. R. Blake, A. J. Ammann, and C. J. Michel. 2018. Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. *Canadian Journal of Fisheries and Aquatic Sciences* 75(11):1886-1901.

Perry, R. W., A. C. Pope, and V. K. Sridharan. 2019. *Using the STARS model to Evaluate the Effects of the Proposed Action for the Reinitiation of Consultation on the Coordinated Long-term Operation of the Central Valley and State Water Project*. Open-File Report 2019-1125, Reston, VA.

Polansky, L., K. B. Newman, M. L. Nobriga, and L. Mitchell. 2018. Spatiotemporal Models of an Estuarine Fish Species to Identify Patterns and Factors Impacting Their Distribution and Abundance. *Estuaries and Coasts* 41(2):572-581.

Polansky, L., K. B. Newman, and L. Mitchell. 2021. Improving inference for nonlinear state-space models of animal population dynamics given biased sequential life stage data. *Biometrics* 77(1):352-361.

Romine, J. G., R. W. Perry, S. J. Brewer, N. S. Adams, T. L. Liedtke, A. R. Blake, and J. R. Burau. 2013. *The Regional Salmon Outmigration Study--survival and migration routing of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta during the winter of 2008-09*. USGS Open-File Report 2013-1142. U.S. Geological Survey, Reston, VA.

Santos, M. J., S. Khanna, E. L. Hestir, J. A. Greenberg, and S. L. Ustin. 2016. Measuring landscape-scale spread and persistence of an invaded submerged plant community from airborne remote sensing. *Ecological Applications* 26:1733–1744.

Schreier, B. M., M. R. Baerwald, J. L. Conrad, G. Schumer, and B. May. 2016. Examination of Predation on Early Life Stage Delta Smelt in the San Francisco Estuary Using DNA Diet Analysis. *Transactions of the American Fisheries Society* 145(4):723-733.

Singer, G. P., A. R. Hearn, E. D. Chapman, M. L. Peterson, P. E. LaCivita, W. N. Brostoff, A. Bremner, and A. Klimley. 2013. Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). *Environmental Biology of Fishes* 96(2-3):363-379.

Slater, S. B., and R. D. Baxter. 2014. Diet, Prey Selection, and Body Condition of Age-0 Delta Smelt, *Hypomesus transpacificus*, in the Upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 12(3).

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. *Transactions of the American Fisheries Society* 126:961–976.

Sommer, T. and F. Mejia. 2013. A place to call home: A synthesis of Delta Smelt habitat in the upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 11(2).

Thomson, J. R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. *Ecological Applications* 20(5):1431-1448.

U.S. Bureau of Reclamation (Reclamation). 2019. *Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Central Valley Projec*t. California Mid-Pacific Region Final Biological Assessment.

U.S. Bureau of Reclamation (Reclamation). 2021. *Draft Sacramento River Temperature Management Plan for Water Year 2021*. Prepared by Reclamation in coordination with the Sacramento River Temperature Task Group. May 5, 2021.

U.S. Bureau of Reclamation (Reclamation). 2021. *Drought Toolkit.* Prepared by Reclamation in coordination with CDFW, DWR, NMFS, USFWS, SWRCB. Available at Drought Toolkit (usbr.gov).

U.S. Fish and Wildlife Service. 2019. *Biological Opinion for the Reinitiation of Consultation on the Long Term Operation of the Central Valley Project and State Water Project*. USFWS Pacific Southwest Region. Sacramento, CA.

Visser. P., B. Ibelings, L. Mur. 1995. Autumnal sedimentation of *Microcystis* is the result of an increase in carbohydrate ballast, triggered by a decrease in water temperature. *J. Plankton Res*. 17:919-933.

Visser P., B. Ibelings, L. Mur, A. Walsby. 2005. *The ecophysiology of the harmful cyanobacterium* Microcystis. In: Huisman J, Matthijs HCP, Visser PM (eds), Harmful Cyanobacteria. Springer, Dordrecht, pp. 109-142.

Wang, X. 2019. *ECO-PTM Model Development*. Pages 1-i to 1-18 in: Yu, M., R. Suits, and J. Anderson. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 40th Annual Progress Report to the State Water Resources Control Board in Accordance with Water Right Decisions 1485 and 1641. December. Sacramento, CA: California Department of Water Resources.

Williamson, K. and B. May. 2005. Homogenization of Fall-Run Chinook Salmon Gene Pools in the Central Valley of California, USA. *North American Journal of Fisheries Management* 25:993–1009.

Windell, S., P. L. Brandes, J. L. Conrad, J. W. Ferguson, P. A. L. Goertler, B. N. Harvey, J. Heublein, J. A. Israel, D. W. Kratville, J. E. Kirsch, R. W. Perry, J. Pisciotto, W. R. Poytress, K. Reece, B. G. Swart, and R. C. Johnson. 2017. *Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) across the life cycle*. NOAA Technical Memorandum NMFS-SWFSC-586. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center Fisheries Ecology Division Santa Cruz, CA.

APPENDIX A: PARTICLE TRACKING MODELING ANALYSIS (DELTA SMELT ENTRAINMENT)

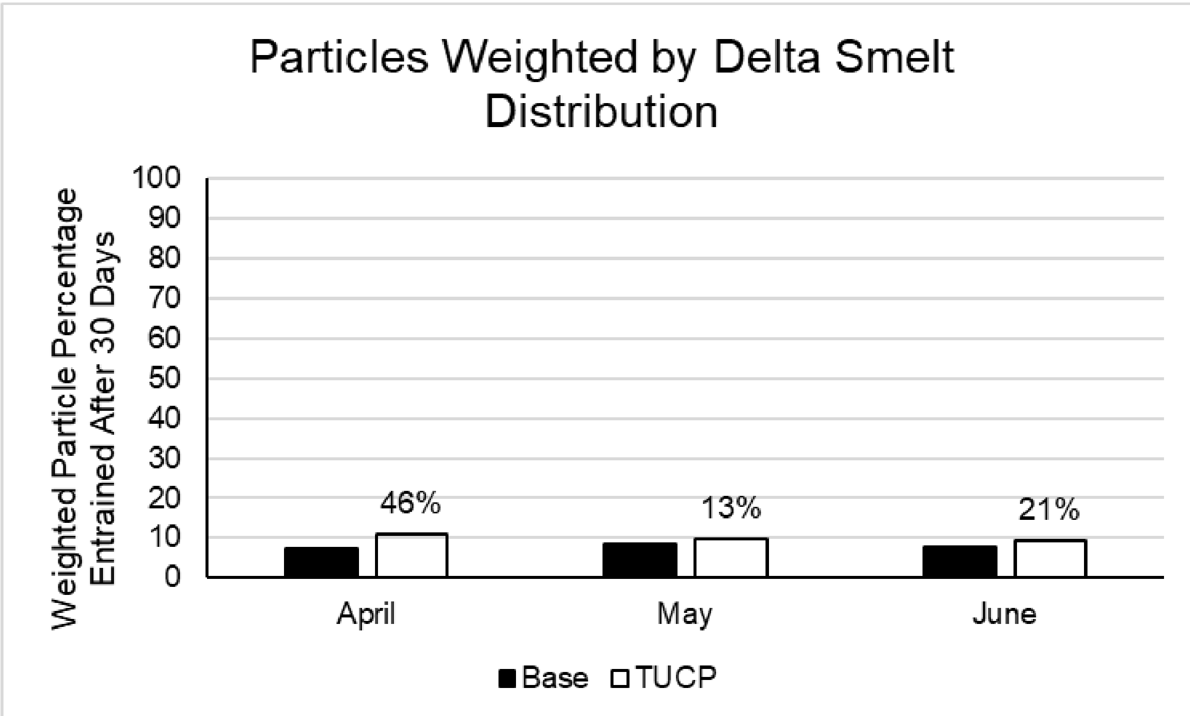
Methods

DSM2 particle tracking modeling (PTM) was used to assess hydrodynamic differences between scenarios to provide information regarding potential larval delta smelt entrainment risk at the south Delta export facilities and the Barker Slough Pumping Plant. Note that the modeling does not make assumptions regarding real-time operations, which would occur as part of water operations to limit entrainment risk under the US Fish and Wildlife Service (2019) biological opinion and California Department of Fish and Wildlife (2020) State Water Project (SWP) Incidental Take Permit (ITP). The PTM methods were recently used for the Environmental Impact Report for Long-Term Operation of the California State Water Project and are described therein (DWR 2020: Appendix E, p.E-1). The present analysis used PTM modeling for the base case and TUCP. The analysis focused on 30-day outputs for neutrally buoyant particles released at the beginning of April, May, and June 2022.

Results

The PTM weighted by delta smelt distribution for the base case resulted in entrainment of 7.5% of particles in April, ~88.6% of particles in May, and 7.7% of particles in June (Figure PTM_DS1). Under the TUCP, entrainment was 11% in April 9.7% in May, and ~99.3% in June, a relative increase over the base case of 21–46% (Figure PTM_DS1). Note that under the TUCP, Old and Middle River flows would be greater than (i.e., less negative than) the incidental take limits in the USFWS (2019: 395) biological opinion, i.e., -2,000 cfs in winter/early spring and -5,000 cfs in March–June. Old and Middle River flow management as required under the USFWS (2019: 395) biological opinion and CDFW ITP (2020: 85) would be implemented in order to ensure the incidental take limit is not exceeded.

Figure PTM_DS1. Percentage of Particles Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant Weighted by Delta Smelt Distribution.



Note: Percentages above bars indicate relative difference between TUCP and the base case.

References

California Department of Fish and Wildlife (CDFW). 2020. *California Endangered Species Act Incidental Take Permit No. 2081-2019-066-00. Long-Term Operation of the State Water Project in the Sacramento San Joaquin Delta*. Sacramento, CA: California Department of Fish and Game, Ecosystem Conservation Division.

California Department of Water Resources (DWR). 2020. *Final Environmental Impact Report for Long-Term Operation of the California State Water Project*. March 27.

U.S. Fish and Wildlife Service. 2019. *Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project*. USFWS Pacific Southwest Region. Sacramento, CA.

APPENDIX B: LONGFIN SMELT DELTA OUTFLOW–ABUNDANCE INDEX ANALYSIS

Development of Statistical Relationship

The potential effect of the TUCP on longfin smelt was investigated through development of a statistical model relating the longfin smelt fall midwater trawl abundance index to Delta outflow, the fall midwater trawl abundance index 2 years earlier (as a representation of parental stock size), and ecological regime (i.e., 1967–1987, pre-*Potamocorbula amurensis* invasion; 1988–2002, post-*P. amurensis* invasion; and 2003–2020, Pelagic Organism Decline; to represent major ecological changepoints in the Bay-Delta, e.g., Nobriga and Rosenfield 2016). Total Delta outflow (thousand acre-feet) was summed and examined for March through May and December through May, similar time periods to previous work by Mount et al. (2013) and Nobriga and Rosenfield (2016).

Twelve log-linear regression models were considered. The best (most statistically supported) of these models included the longfin smelt fall midwater trawl abundance index as a function of December through May Delta outflow, regime, and fall midwater trawl abundance index two years earlier (Tables lfs1 and lfs2). The models were fit in R (R Core Team 2012), using the brms package (Bürkner 2017): three Markov Chain Monte Carlo chains were run; flat priors were assumed; there was a 2,000-sample warm-up; 10,000 samples were retained from each chain (30,000 samples total from the posterior); and the R <1.01 indicated sampling converged on the posterior probability distribution. The Bayesian R^2 of the best model is 0.798 (50 observations), illustrated in Figure lfs1.

Table lfs1. Model Selection Results for Twelve Log-Linear Regressions of Longfin Smelt Fall Midwater Trawl Abundance Index as a Function of Delta Outflow (December–May or March–May), Ecological Regime (1967–1987, pre-*Potamocorbula amurensis* invasion; 1988–2002, post-*P. amurensis* invasion; and 2003–2020, Pelagic Organism Decline), and Abundance Index 2 Years Earlier (Log10 FMWT (yr – 2)).

Log_{10}FMWT Linear Regression Model	AIC_c	Δ AIC_c	Wt(AIC_c)	K	LL
Dec–May + Regime + Log_{10} FMWT(yr – 2)	72.79	0	0.71	6	-29.42
Mar–May + Regime + Log_{10} FMWT(yr – 2)	75.2	2.41	0.21	6	-30.62
Dec–May + Regime + Dec–May * Regime + Log_{10} FMWT(yr – 2)	78.15	5.36	0.05	8	-29.32
Mar–May + Regime + Dec–May * Regime + Log_{10} FMWT(yr – 2)	80.22	7.43	0.02	8	-30.35
Dec–May + Regime	81.07	8.28	0.01	5	-34.88
Dec–May + Regime + Dec–May * Regime	85.45	12.66	0	7	-34.45
Mar–May + Regime	85.68	12.89	0	5	-37.19
Mar–May + Regime + Mar–May * Regime	90.49	17.7	0	7	-36.97
Dec–May + Log_{10} FMWT(yr – 2)	90.65	17.86	0	4	-40.88
Mar–May + Regime + Log_{10} FMWT(yr – 2)	93.15	20.36	0	4	-42.13
Dec–May	133.76	60.97	0	3	-63.63
Mar–May	142.23	69.44	0	3	-67.87

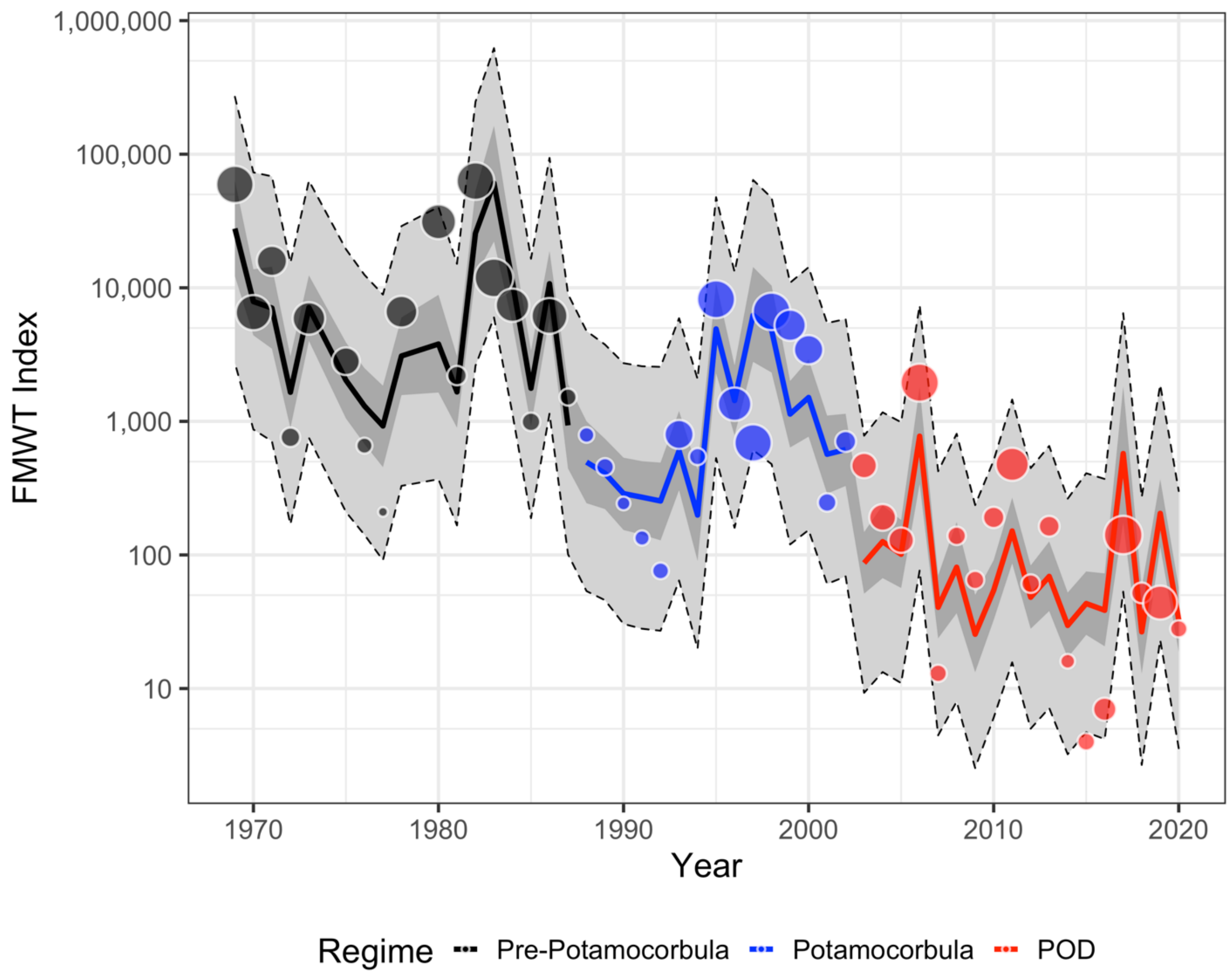
Note: AIC_c = Akaike's Information Criterion adjusted for small sample sizes; Δ AIC_c = difference in AIC_c from given model and best model; Wt(AIC_c) = AIC_c weight; K = number of estimated parameters (including the residual variance); LL = log likelihood of the model fits given the assumption of log-normally distributed residuals.

Table lfs2. Summary Results for Best Log-Linear Regression of Longfin Smelt Fall Midwater Trawl Abundance Index as a Function of Delta Outflow (December–May), Ecological Regime (1967–1987, pre-Potamocorbula amurensis invasion; 1988–2002, post-P. amurensis invasion [shown as Potamocorbula]; and 2003–2020, Pelagic Organism Decline [POD]), and Abundance Index 2 Years Earlier [Log_{10} FMWT(yr – 2)]).

Predictor	Median	CI (95%)
[$\beta_{0,1}$] Regime: Pre-Potamocorbula	2.69	1.93 – 3.45
[$\beta_{0,2}$] Regime: Potamocorbula	2.28	1.16 – 3.40
[$\beta_{0,3}$] Regime: POD	1.53	0.30 – 2.75
[β_1] Dec–May (normalized)	0.46	0.33 – 0.60
[β_2] Log10FMWT(yr – 2)	0.23	0.03 – 0.42
[σ] Sigma	0.47	0.39 – 0.59

Note: CI = confidence interval. The observed Delta outflow values were normalized by subtracting the mean and dividing by the standard deviation across years (1967–2020). The intercept corresponds to the fall midwater trawl index during the pre-*Potamocorbula* regime. Negative values for the estimated intercepts during the other regimes correspond with a decreasing average level of abundance in each successive regime (see Figure lfs1). Sigma is the square-root of the estimated residual variance. Parameters shown in square brackets for the predictors correspond with those for the best model (see equations 1 and 2 in *Assessment of TUCP* below).

Figure lfs1. Fit of Best Log-Linear Regression of Longfin Smelt Fall Midwater Trawl Abundance Index as a Function of Delta Outflow (December–May), Ecological Regime (1967–1987, pre-Potamocorbula amurensis invasion; 1988–2002, post-Potamocorbula invasion [shown as Potamocorbula]; and 2003–2020, Pelagic Organism Decline [POD]), and Abundance Index 2 Years Earlier [Log10 FMWT (yr – 2)]).



Note: The circles represent the annual historical values of the fall midwater trawl abundance index, with diameter of each circle scaled relative to December through May Delta outflow in that year. The solid lines connect the annual medians from the Bayesian posterior distribution, and the darker gray ribbons around them represent the 95% posterior probability interval for the expected fall midwater trawl index value. Colors correspond to the three modeled regimes. The lighter gray ribbon with a dashed black outline represents the 95% posterior predictive probability interval.

Assessment of TUCP

Estimates of the fall midwater trawl abundance index under the base case and the TUCP were generated from the Bayesian posterior distributions from the best model, which can be written:

$$Log_{10}[FMWT_{yr}] \sim N(\mu_{yr}, \sigma^2) \tag{1}$$

$$\mu_{yr} = \beta_{0,i} + \beta_1 Dec\text{–}May_{yr} + \beta_2 Log_{10}[FMWT_{yr-2}] \tag{2}$$

where:

$Log_{10}[FMWT_{yr}]$ is the Log_{10} value of the fall midwater trawl index in WY 2020 (i.e., 28);

Dec–May$_{yr}$ is the normalized[1] outflow level during December–May under the different cases (base case: 4,038,075 acre-feet; TUCP: 3,609,074 acre-feet)

μ_{yr} is the expected fall midwater trawl index in water year, *yr* (the pointwise posterior distribution is shown as the dark grey ribbon in Figure lfs1);

σ^2 is the residual variance parameter;

$\beta_{0,i}$ corresponds to the intercept parameter estimated with each regime: Pre-*Potamocorbula* (*i* = 1); *Potamocorbula* (*i* = 2); and POD (*i* = 3);

β_1 represents the slope parameter estimated for the relationship between the fall midwater trawl index and December through May outflow in year, *yr*;

β_2 represents the slope parameter estimated for the relationship between the expected fall midwater trawl index and the value of the index two years prior.

The formulation in Equation 2 was used to generate the expected fall midwater trawl index in 2022, conditional on the estimated relationship between the fall midwater trawl index and December through May outflow during the Pelagic Organism Decline regime (via the posteriors for the three β parameters; Table lfs2), and the modeled fall midwater trawl index value for 2020.

Draws from the posterior predictive distribution were generated by first substituting the normalized 2022 December through May outflow value for each case into Equation 2. Draws from the posterior distributions for the regression parameters and the value for $Log_{10}[FMWT_{2020}]$ were then used to derive the posterior distribution for the fall midwater trawl index in 2022 (μ_{2022}). This value was then substituted into Equation 1, and the posterior distribution for the residual variance parameter was used to generate draws from the pointwise posterior predictive distributions for the fall midwater trawl index.[2] Summaries to compare the base case and the TUCP were then calculated as the mean, 5th percentile, and 95th percentile of posterior predictive distributions for each case. The

1 Normalized Dec-May outflow values for each case were calculated by subtracting the mean and dividing by the standard deviation of observed Delta outflow values (1967–2020).
2 "~*N*" in Eqn. 1 denotes a normal (Gaussian) distribution.

probability of the 2022 fall midwater trawl index being less than the base case was calculated for the TUCP as the percentage of the posterior predictive distribution that was less than the base case.

References

Bürkner, P.-C. 2017. brms: An R Package for Bayesian Multilevel Models Using Stan. Journal of Statistical Software 80(1): 1-28.

Mount, J., W. Fleenor, B. Gray, B. Herbold, and W. Kimmerer. 2013. Panel Review of the draft Bay-Delta Conservation Plan. Prepared for the Nature Conservancy and American Rivers. September. Saracino & Mount, LLC, Sacramento, CA.

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. Transactions of the American Fisheries Society 145(1):44-58.

R Core Team. 2012. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Available: http://www.R-project.org.

ATTACHMENT 3:

APRIL 1 THROUGH JUNE 30, 2022 TEMPORARY URGENCY CHANGE PETITION SUMMARY OF PRIMARY OPERATIONAL MODELING ASSUMPTIONS BY CASE FOR MARCH THROUGH SEPTEMBER 2022

Month	Base (No TUCP) Sacramento River at Freeport (cfs)	Base (No TUCP) San Joaquin River at Vernalis (cfs)	Base (No TUCP) Computed Delta Outflow (cfs)	Base (No TUCP) Combined Exports (cfs)	TUCP Sacramento River at Freeport (cfs)	TUCP San Joaquin River at Vernalis (cfs)	TUCP Computed Delta Outflow (cfs)	TUCP Combined Exports (cfs)
March	8,300	850	8,350	1,050	8,300	850	8,350	1,050
April	9,450	1,000	8,400	1,050	6,150	700	4,350	1,500
May	9,100	950	7,100	1,050	6,150	950	4,000	1,200
June	10,850	700	7,100	1,000	7,950	700	4,000	1,200
July	8,600	500	4,000	1,000	8,600	500	4,000	1,000
August	7,550	550	3,400	1,100	7,550	550	3,400	1,100
September	6,250	650	3,000	1,600	6,250	650	3,000	1,600

Note: Values are rounded to nearest 50 cfs. Months subsequent to TUCP period (April–June) are included for analyses considering longer time periods with lagged effects.