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

December 1, 2021

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 February 1 through April 30, 2022. Reclamation and DWR are requesting to modify certain terms as the Projects storage and inflow may not be enough to meet D-1641 requirements and additional operational flexibility of the Projects is needed to support Reclamation and DWR's priorities: 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 maintain cool river temperatures for various runs of Chinook salmon; 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 of the extraordinarily dry conditions of water year (WY) 2020 and WY 2021 in combination with the potential of low future precipitation and low reservoir storage that would require management of water resources in 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.

California experienced its warmest statewide monthly average temperatures ever recorded in June and July, 2021[1] and 2020 to 2021 was the third driest on record for the Northern Sierra 8-station index. Under dry conditions, it is projected that by December 31, 2021, Shasta Reservoir storage will be at 1.1 MAF (40% of historical average), Lake Oroville storage will be at 1.1 MAF (60% of historical average) and Folsom Reservoir storage will be at 336 TAF (84% of historical average). This is a projected decrease of approximately 1.05 MAF from the combined reservoir storage of 3.56 MAF on December 31, 2020. The precise combination of environmental conditions and hydrologic factors that we will be experiencing early in 2022 cannot be predicted. However, it is reasonable to prepare for the need to operate the Projects with the modifications identified in this TUCP in order to conserve water supplies for potential prolonged drought conditions.

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. While the exact hydrologic and

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

environmental conditions of 2022 cannot be known in advance, the conditions of 2021 have left the Projects in a precarious state, with little water to manage even under slight drought conditions next year.

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

Table 1: Summary of 2022 TUCP Operations Framework

Timeframe	Proposed D-1641 Action(s)
February 1 through April 30, 2022	**Modify NDOI Requirement**[1] • NDOI no less than 4,000 CFS monthly average, with a 7-day average no less than 3,000 CFS – combined exports no more than 1,500 CFS **OR** • NDOI no less than 7,100 CFS on a three-day average or when EC at Collinsville is below 2.64 mmhos/cm on a daily or 14-day average (Spring X2 met through Collinsville only) – Chipps days not required (D1641 Table 4) – No water quality requirement for Feb 1st to 14th – Combined exports operate as needed to allow capture of unregulated flows subject to ESA and CESA and DCC gates closed
	Allow DCC Flexibility[2] • Open the DCC gates as needed to maintain water quality standards at interior Delta M&I locations
	Modify Vernalis Requirement[3,4] • Vernalis baseflow no less than 710 CFS on a monthly average and 7-day average no less than 80 percent of baseflow (568 CFS), where the higher flow objective, based on Chipps days, is not required.

CFS = cubic feet per second
DCC = Delta Cross Channel
Electrical conductivity = EC
mmhos/cm = millimhos per centimeter
M&I = municipal and industrial
NDOI = Net Delta Outflow Index
X2 = Delta Outflow Requirements

NOTES:
1. Delta Outflow from February to June in all year types is defined in D-1641 Table 3 Footnote 10
2. Delta Cross Channel Gates are closed from February to May 20 in all year types
3. River Flows- San Joaquin River at Airport Way, Vernalis in critical years from February to June will be 710 or 1,140 cfs
4. Stanislaus contribution will follow the Stepped Release Plan Daily Hydrograph flows which include a base flow of 200 cfs for critical, dry and below normal year types.

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.

On October 21 and October 22, 2021, Reclamation and DWR met with the National Marine Fisheries Service (NMFS), United States Fish and Wildlife (USFWS), California Department of Fish and Wildlife (CDFW), and the Water Board, to discuss the TUCP Biological Review outline and Biological Review analyses methodology. Information from those meetings was incorporated into the development of the TUCP Biological Review.

In addition, from February 1 through April 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 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.

If sufficient precipitation were to occur to recover upstream storage, then Reclamation and DWR could resume operating to the D-1641 objectives and this TUCP would not be required. However, if even modest drought conditions in the Delta watershed persist, it is unlikely that Reclamation and DWR would be able to confidently make such a determination early in 2022. 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 course of the declared drought emergency.

We urge the Water Board to approve this TUCP and look forward to cooperatively working with the 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.

Karla Nemeth

Karla A. Nemeth
Director
Department of Water Resources

Ernest Conant

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 02/01/2022 to 04/30/2022 .

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 12/01/21 at Sacramento, California.

Karla Nemeth
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 February 1 through April 30, 2022. Reclamation and DWR are requesting to modify certain terms as the Projects storage and inflow may not be enough to meet D-1641 requirements and additional operational flexibility of the Projects is needed. These modifications are urgently needed because of the extraordinarily dry conditions of water year (WY) 2020 and WY 2021 in combination with the potential of low future precipitation and low reservoir storage that would require management of water resources in 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.

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 to systemically recover upstream storage, then the Projects could resume operating to the D-1641 objectives and this TUCP would not be required. However, if even modest drought conditions in the Delta watershed persist, it is unlikely that Reclamation and DWR would be able to confidently make such a determination early in 2022. Therefore, 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 February through April Temporary Urgency Change Petition," and Attachment 3 “Summary of Primary Modeling Assumptions for February through April 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 12/01/21 at Sacramento, California.

Karla Nemeth

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 FEBRUARY-APRIL 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 February 1 through April 30, 2022. Reclamation and DWR are requesting to modify certain terms as the Projects storage and inflow may not be enough to meet D-1641 requirements and additional operational flexibility of the Projects is needed to support Reclamation and DWR’s priorities: 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 maintain cool river temperatures for various runs of Chinook salmon; 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 and WY 2021 in combination with the potential of low future precipitation and low reservoir storage that would require management of water resources in 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.

Below is a summary of current drought conditions and the TUCP submitted in 2021, anticipated conditions and actions for 2022, the need for a change petition in 2022, the requested changes for 2022, and agency coordination that will occur throughout the 2022 TUCP period.

I. A. Summary of Current Drought Conditions and 2021 TUCP

California experienced its warmest statewide monthly average temperatures ever recorded in June and July, 2021[1] and 2020 to 2021 was the third driest on record for the Northern Sierra 8-station index.

Water Year 2021 started with dry conditions, but due to significant and uncharacteristic warm temperatures and deficits in watershed runoff, hydrology in late April 2021 significantly deteriorated, especially in the Sacramento River. In spite of well-below average rainfall, the measured snowpack in March 2021 suggested sufficient spring reservoir inflow to meet D-1641 water quality and flow requirements. Conditions significantly changed at the end of April 2021 when the expected reservoir inflow from snowmelt failed to materialize. 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, given recent norms, extremely low rainfall, dry soils, continued dry and warm conditions, and the importance of water quality in the Delta, posed significant challenges to the management of the Projects. In addition, the May 1, 2021 Bulletin 120 (B120) hydrological projections indicated significant risks to maintaining minimum health and safety supplies, temperature control, minimum instream flow, power generation, and the ability to repel salinity 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 to meet all water right permit obligations for Delta outflow and water quality 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 have 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

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

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

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 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 prevent saltwater contamination of CVP, SWP, and other water supplies. On October 1, 2021, the Projects began the 2022 WY 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.

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

I.B. Anticipated Conditions and Actions for 2022

On October 21, 2021, the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center released their long-range outlook for November 2021 through January 2022 indicating an equal chance of below or above normal precipitation and an increased probability of leaning-above normal temperatures. The precipitation outlook for January 2022 through March 2022 indicates an increased probability of below normal precipitation 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 1** NOAA Seasonal Precipitation Outlooks and **Figure 2** 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:

- <u>Upstream Reservoirs</u>. The Projects' upstream reservoirs will be operated through the winter and spring 2022 to preserve and build storage. As indicated above, upstream storages in January 2022 are anticipated to be well below average. Reclamation and DWR will be striving to increase cold water resources in the winter and spring for Project reservoirs where temperature management is needed later in the year.

- <u>Water Supply.</u> The Projects will be operated to maintain minimum combined exports at a level to meet health and safety demands and lessen critical economic losses to agricultural, municipal and industrial uses due to water shortages through project water deliveries by facilitating south of Delta transfers

[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

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

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 throughout the year 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 either be delivered to meet minimum health and safety 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 earlier this year to help repel salinity and maintain Delta water quality. Due to current conditions in the Delta and current hydrologic forecasts, the EDB at West False River will remain in-place into 2022 and the EDB will be notched between January 10, 2022 through April 10, 2022. In accordance with the Emergency Proclamation, additional emergency drought salinity barriers in the Delta are being considered to further manage salinity intrusion that may be created by persistent drought conditions in 2022 and the lack of available water in the upstream reservoirs.

Figure 1: NOAA Seasonal Precipitation Outlook

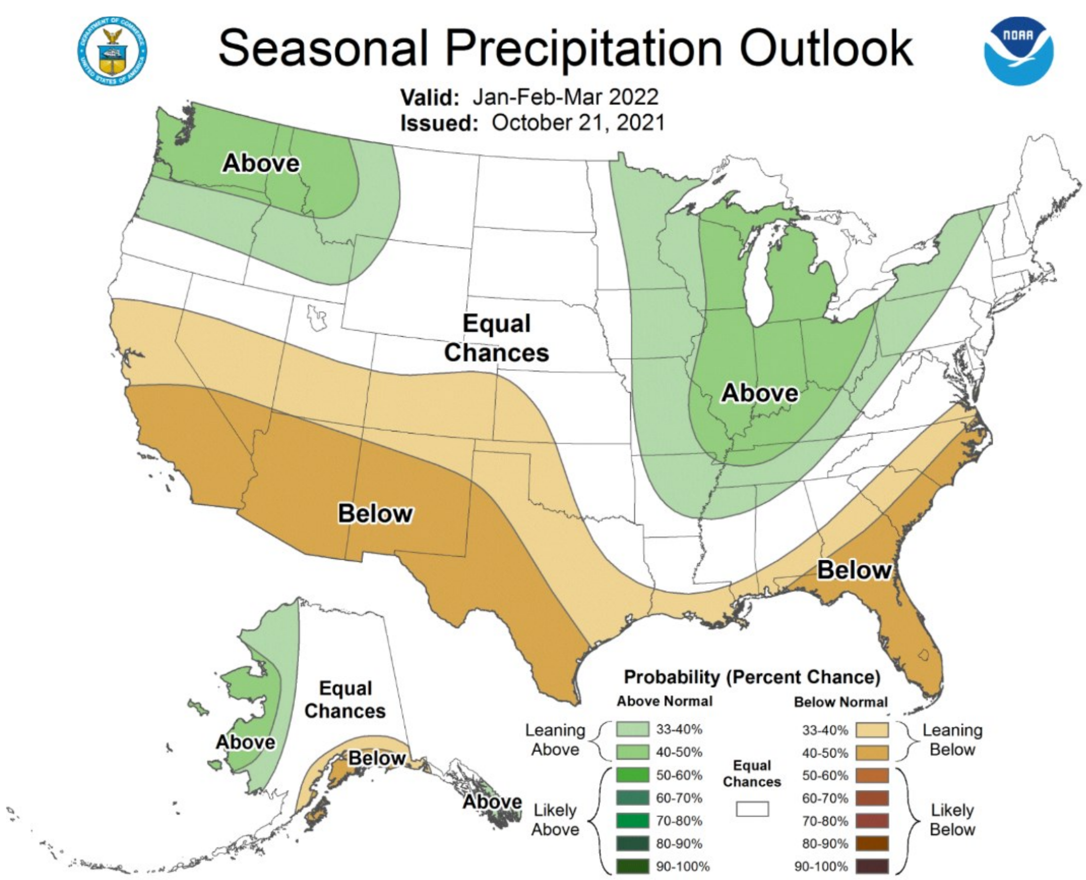
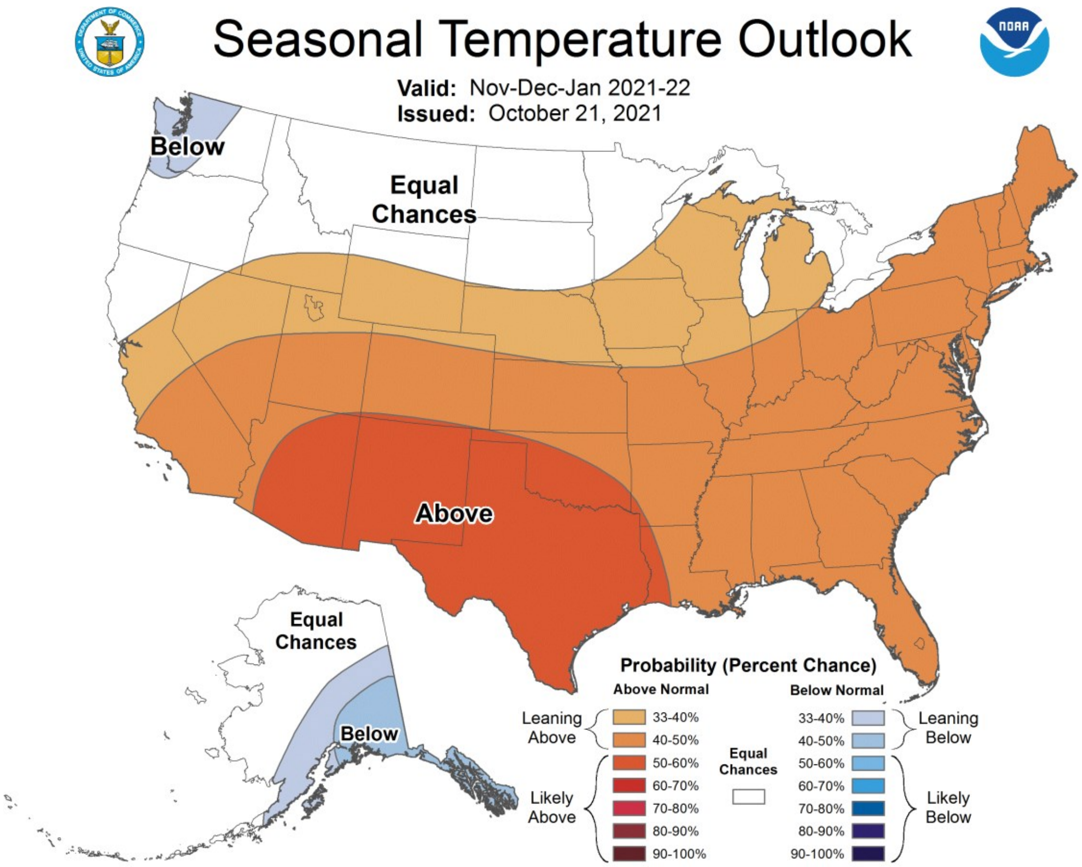


Figure 2: NOAA Seasonal Temperature Outlook



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

While the exact hydrologic and environmental conditions of 2022 cannot be known in advance, the conditions of WY 2020 and WY 2021 have left the Projects in a precarious position, with the potential of very low storage to manage all Project obligations under even an above normal water year. Available forecasts suggest an elevated risk for continued drought conditions in 2022. Reclamation and DWR are therefore requesting the State Water Board to temporarily modify certain terms and conditions defined by D-1641 from February 1 through April 30, 2022, as described below (**Table 1**).

This TUCP proposes to modify certain terms of the Projects' water rights permits from what is currently provided in D-1641 from February 1 through April 30, 2022. These modifications are necessary because of the extraordinarily dry conditions of WY 2020 and WY 2021 in combination with the potential of limited future precipitation and low reservoir storage 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.

I.D. Requested Change

Under these conditions, DWR and Reclamation are requesting the State Water Board temporarily modify certain terms and conditions in D-1641 on the Projects' water rights for the period from February 1 through April 30, 2022, as summarized in Table 1 and described further below.

1) Modification of NDOI Requirement (February 1 through April 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.

Reclamation and DWR petition the State Water Board to temporarily modify the Delta outflow standard during the months of February through April to allow an NDOI no less than 4,000 cfs monthly average (with a 7-day average no less than 3,000 cfs), which is consistent with the potential persistent dry conditions facing California than the levels currently contained within D-1641 Table 3 and footnotes. Reclamation and DWR also request that if the Eight River Index for January is more than 650 TAF, the State Water Board waive the “starting gate” salinity requirement as specified in footnote 10 of Table 3. Modification of the NDOI and “starting gate” requirement is necessary because of the extraordinarily dry conditions of the past several years in combination with the potential of limited future precipitation, low reservoir storage, and the competing demands on water supply of fish and wildlife protection, Delta salinity control, and critical water supply needs, and because the requirement imposes a substantial water cost to upstream reservoir storage in order to meet 2.64 millimhos per centimeter for at least one day at Collinsville between February 1 and February 14.

a. Modification of Export Limits

Reclamation and DWR request that the maximum Export Limits included in Table 3 of D-1641 be modified as follows: During February through April, when footnote 10 of Table 3 of D--1641 is not being met, or when the DCC gates are open during a period inconsistent with footnote 23 of Table 3 of D-1641, the combined maximum SWP and CVP export rate at the Clifton Court Forebay Intake and C.W. “Bill” Jones Pumping Plant will be no greater than 1,500 cfs on a 3-day running average. However, when precipitation and runoff events occur that allow the DCC gates to be closed and footnote 10 of Table 3 of D-1641 to be met at Collinsville [3-day average Delta Outflow of 7,100 cfs, or electrical conductivity of 2.64 millimhos per centimeter on a daily or 14-day running average at the confluence of the Sacramento and the San Joaquin rivers (Collinsville station C2) if applicable], even when additional Delta Outflow requirements contained in Table 4 of D-1641 are not being met, Reclamation and DWR request that exports of natural and unregulated (e.g., precipitation-generated runoff) surface flows are permitted up to D-1641 Export Limits contained in Table 3, in compliance with applicable laws and regulations including federal Endangered Species Act (ESA) and California ESA (CESA). This maximum export assumes the DCC is closed.

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[6] D-1641 Table 3 Footnote 10

Table 1: Summary of 2022 TUCP Operations Framework

<table>
<tr><th rowspan="2">Timeframe</th><th rowspan="2">Proposed D-1641 Action(s)</th><th colspan="3">Modeled Operational Management Scenarios[5]</th></tr>
<tr><th>TUCP</th><th>TUCP w/DCC</th><th>TUCP w/X2</th></tr>
<tr><td rowspan="4">February 1 through April 30, 2022</td><td>Modify Net Delta Outflow Index (NDOI) Requirement[1]
• NDOI no less than 4,000 CFS monthly average, with a 7-day average no less than 3,000 CFS
− combined exports no more than 1,500 CFS
OR</td><td>X</td><td></td><td></td></tr>
<tr><td>• NDOI no less than 7,100 CFS on a three-day average or when electrical conductivity (EC) at Collinsville is below 2.64 mmhos/cm on a daily or 14-day average (Spring X2 met through Collinsville only)
− Chipps days not required (D1641 Table 4)
− No water quality requirement for Feb 1st to 14th
− Combined exports operate as needed to allow capture of unregulated flows subject to ESA and CESA and DCC gates closed</td><td></td><td></td><td>X</td></tr>
<tr><td>Allow DCC Flexibility[2]
• Open the DCC gates as needed to maintain water quality standards at interior Delta M&I locations</td><td></td><td>X</td><td></td></tr>
<tr><td>Modify Vernalis Requirement[3,4]
• Vernalis baseflow no less than 710 CFS on a monthly average and 7-day average no less than 80 percent of baseflow (568 CFS), where the higher flow objective, based on Chipps days, is not required.</td><td>X</td><td>X</td><td>X</td></tr>
</table>

CESA = California Endangered Species Act
CFS = cubic feet per second
DCC = Delta Cross Channel
EC = Electrical conductivity
ESA: Endangered Species Act
mmhos/cm = millimhos per centimeter
M&I = municipal and industrial
NDOI = Net Delta Outflow Index
X2 = Delta Outflow Requirements

NOTES:
1. Delta Outflow from February to June in all year types is defined in D-1641 Table 3 Footnote 10
2. Delta Cross Channel Gates are closed from February to May 20 in all year types
3. River Flows- San Joaquin River at Airport Way, Vernalis in critical years from February to June will be 710 or 1,140 cfs
4. Stanislaus contribution will follow the Stepped Release Plan Daily Hydrograph flows which include a base flow of 200 cfs for critical, dry and below normal year types.
5. Modeled Operational Management Scenarios refers to the DSM2 simulated hydrologic scenarios that were completed to analyze conditions associated with the Proposed D-1641 actions.

2) Allow DCC Flexibility (February 1 through April 30, 2022)

D-1641 requires the closure of the DCC gates from February 1 through May 20. DWR and Reclamation request permission to open the DCC gates as needed between February 1 and April 30, 2022 for human health and safety supplies, based on conferring with the National Marine Fisheries Service (NMFS), United States Fish and Wildlife (USFWS) and California Department of Fish and Wildlife (CDFW). Opening of the DCC gates can help improve interior Delta salinity conditions. Normally, runoff, upstream releases, and the Delta inflow/outflow needed to meet the Delta Outflow requirement would assist in meeting salinity requirements in the Delta with the DCC gates closed. However, if dry hydrologic conditions occur, there may be a need to open the DCC gates to help achieve the salinity conditions in the interior and southern Delta needed for protection of municipal and industrial beneficial uses without expending large quantities of water needed for later use.

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

D-1641 requires a San Joaquin River at Airport Way Bridge, Vernalis minimum monthly average flow. Reclamation and DWR petition the State Water Board to approve a San Joaquin River flow at Vernalis river flow requirement for February through April 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 – a monthly average of no less than 710 cfs and a 7-day average no less than 20% below the monthly 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.

I. E. Agency Coordination

On October 21 and October 22, 2021, Reclamation and DWR met with the NMFS, USFWS, CDFW, and the State Water Board, to discuss the TUCP Biological Review outline and Biological Review analyses methodology. Information from those meetings was incorporated into the development of the TUCP Biological Review (see **Attachment 2**).

In addition, from February 1 through April 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 February through April 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.

Reclamation and DWR's operations of DCC will consider risk assessments based on Knights Landing Rotary Screw Trap, Delta Juvenile Fish Monitoring Program (e.g., Sacramento trawl, beach seines), as well as updated DSM2 modeling informed with recent hydrology, salinity, and tidal data, consistent with decision support processes associated with proposed DCC gate operations during drought conditions, described in the description of the proposed action for Long-term Operations of the CVP (Reclamation 2019). This information would be evaluated, in coordination with the Long-term Operation Agency Coordination Team, to determine timing and duration of the gate closure/opening associated with the TUCP.

Information on coordination with the WOMT and other technical teams is provided below and in Attachment 2 "Biological Review for the 2022 February through April Temporary Urgency Change Petition." 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.

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.

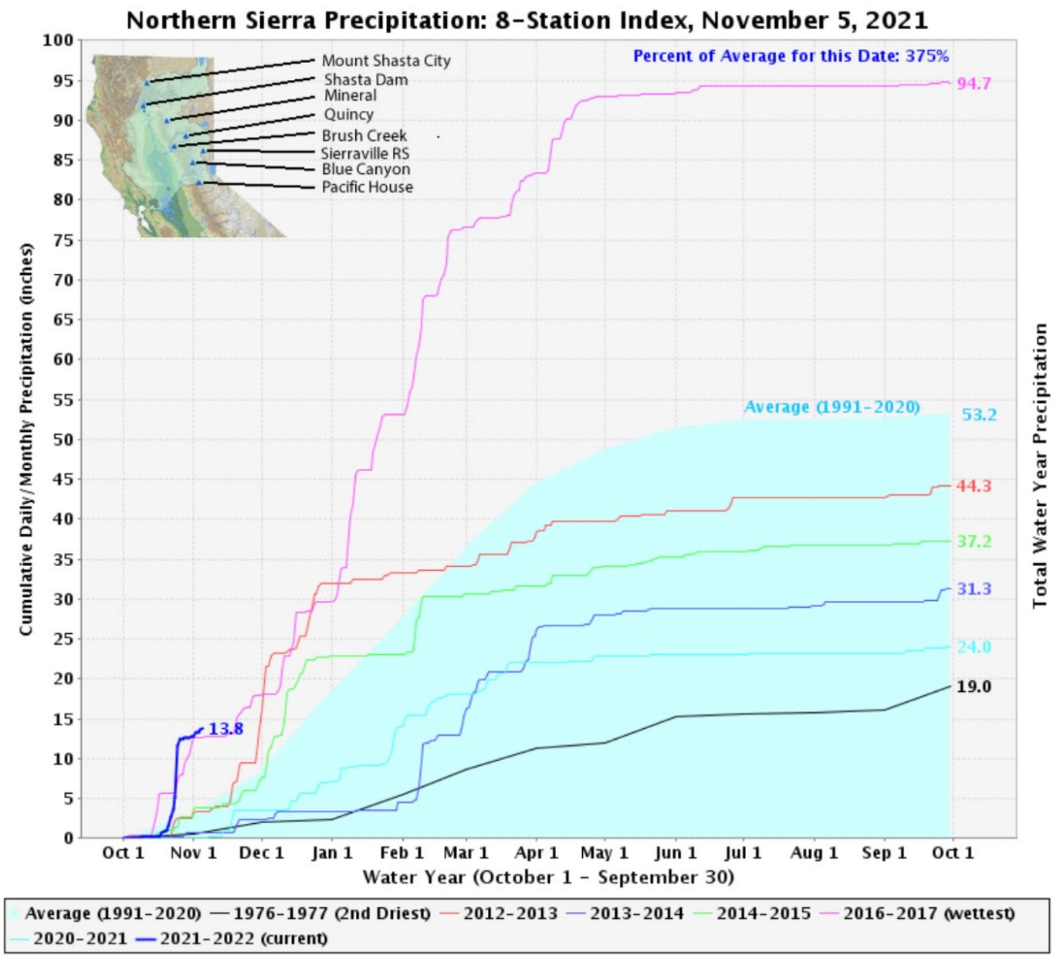
DWR and Reclamation provide the information below to support the findings necessary under California Water Code section 1435. The current hydrology and storage are critically low and the potential of drought conditions persisting into 2022. The modifications requested, along with additional actions, 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 was in the top ten driest years on record, and WY 2021 was even drier. In addition, the two-year inflow period of 2020 to 2021 was the second lowest on record (after 1976 to 1977). 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.

As stated above, under dry conditions, by December 31, 2021, Shasta Reservoir storage is projected to be at 1.1 MAF (40% of historical average), Lake Oroville storage is projected to be at 1.1 MAF (60% of historical average) and Folsom Reservoir storage in projected to be at 336 TAF (84% of historical average). This is a projected decrease of approximately 1.05 MAF from the combined reservoir storage of 3.56 MAF on December 31, 2020. In addition, as stated above, the NOAA Climate Prediction Center released their long-range outlook for January 2022 through March 2022, indicating there is an increased probability of below normal precipitation for that period. As of November 5, 2021, the cumulative precipitation for WY 2022 is 13.8 inches, which is a solid start, but as demonstrated in previous dry and critical years, does not necessarily indicate a trend for the remaining water year. **Figure 2** shows the precipitation through November 5, 2021.

Figure 2: Northern Sierra 8-Station Index



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 February through April 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 potentially large outflow requirements specified in D-1641. Granting this petition will help delay the depletion of much-needed storage throughout the winter and spring in order to provide for fish and wildlife habitat, Delta water quality and exports for critical needs later in the year. The 4,000 cfs Delta outflow is the estimated minimum nominal rate assumed to maintain salinity levels below 250 mg/l chloride at all export locations specified under Table 1 of D-1641. Without a modification of the Delta outflow requirement and Vernalis requirement, Reclamation and DWR could be forced to substantially increase releases from upstream reservoirs in February through April, 2022 to meet the existing Delta outflow requirement. Estimated reservoir storage impacts includes 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 by late spring 2022 and into 2023 in a continued drought scenario. “Loss of control” describes a condition in which storages at or near dead pool 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.

D-1641 also requires closure of the DCC gates from February 1 through May 20. Through this petition, Reclamation and DWR are seeking the use of the DCC gates as a means of controlling salinity conditions in the interior Delta. Natural runoff and the Delta inflow/ outflow needed to meet the X2 requirement would normally assist in meeting salinity requirements in the Delta with the DCC gates closed, but under these extremely low flow conditions, DCC gate operations may be needed to protect interior Delta salinity conditions.

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 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 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 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 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, CDFW, NMFS and USFWS.

Additionally, as stated above, DWR and Reclamation will coordinate with the Watershed Monitoring Workgroups. Each of the Watershed Monitoring Workgroups is responsible for real-time synthesis of fisheries monitoring information and scheduling specific volumes of water. The Watershed Monitoring Workgroups 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 February 1 through April 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 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 winter/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. The expected water savings is intended to provide a benefit to upstream storage and allow for some level of salinity and temperature control later in season. Analyses provided in Attachment 2, *Biological Review for the 2022 February through April 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 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 of the CVP and SWP and the 2020 Incidental Take Permit from CDFW for Long-Term Operation of the SWP would continue. 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 February–April 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) Long-term Operations (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 February–April under the TUCP and TUCP with DCC cases 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 (with a greater negative effect under the TUCP with DCC option because of the DCC assumed to be open for half of February and March). These impacts are trade-offs as a result of the benefits associated with the TUCP, specifically upstream cold-water pool preservation and additional water supplies for future years for releases (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 generally would be similar under the base case, TUCP, and TUCP with Collinsville X2 options; there may be a greater potential for migratory delay because of DCC operations in February and March under the TUCP with DCC option. Less San Joaquin River flow under the TUCP could result in greater straying potential for adult spring-run returning to the San Joaquin River basin, should similar mechanisms exist as observed for fall-run Chinook salmon in the fall.

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 and TUCP with DCC options have the potential to result in negative changes to delta smelt habitat relative to the base case, including less zooplankton prey in the low salinity zone, greater silverside abundance, and higher salinity leading to lower probability of occurrence in areas of typically high population density, such as Montezuma Slough. Preliminary analyses discussed in the 2015 biological review and more recent peer-reviewed analyses suggest the potential for negative effects to delta smelt recruitment from less spring outflow under the TUCP, TUCP with DCC, and TUCP with Collinsville X2 options.

Lower Delta outflow could have limited negative effects on longfin smelt prey. The reduction in February through April 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 already poor environmental conditions due to the drought and statistical analysis suggesting that the probability of a lower abundance index under the TUCP options 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 benefits associated with the TUCP, specifically upstream cold-water pool preservation and additional water supplies for future years for releases (which occur outside the geographic scope of the Delta), and 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 increasing the duration and likelihood of success of maintaining a cold water pool sufficient for 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. Storage conservation measures in the beginning of WY 2021 helped to meet D-1641 requirements through the winter and early spring. The 2021 TUCP allowed the Projects to manage upstream reservoir storage during June through August, 2021. 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, June through August 2021 TUCP, 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 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 Watershed Monitoring Workgroups to develop a robust drought monitoring program for long-term Project operations through completion of the 2022 Drought Contingency Plan, with updates to the Long-term Operation Agency Coordination Team. DWR and Reclamation shall provide the Water Board an updated harmful algal blooms (HABs) report by 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 FEBRUARY THROUGH APRIL 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 2022 Temporary Urgency Change Petition (2022 TUCP) that the State Water Resources Control Board (Water Board) change 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 February 1 through April 30, 2022, as summarized in Table Action1 and outlined below.

1) Modification of NDOI Requirement (February 1 through April 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.

Reclamation and DWR petition the Water Board to temporarily modify the Delta outflow standard during the months of February through April to allow an NDOI no less than 4,000 cfs monthly average (with a 7-day average no less than 3,000 cfs), the which is consistent with the unprecedentedly and persistently dry conditions facing California than the levels currently contained within D-1641 Table 3 and footnotes. Reclamation and DWR also request that if the Eight River Index for January is more than 650 TAF, that the State Water Board waive the “starting gate” salinity requirement as specified in footnote 10 of Table 3. This modification is necessary because of the extraordinarily dry conditions of the past several years in combination with the forecasts of limited future precipitation, low reservoir storage, and the competing demands on water supply of fish and wildlife protection, Delta salinity control, and critical water supply needs, and because the requirement imposes a substantial water cost to upstream reservoir storage in order to meet 2.64 millimhos per centimeter for at least one day at Collinsville between February 1 and February 14.

[1] D-1641 Table 3 Footnote 10

Table Action1: Summary of 2022 TUCP Operations Framework

Timeframe	Proposed D-1641 Action(s)	Modeled Operational Management Scenarios[5]		
		TUCP	TUCP w/DCC	TUCP w/X2
February 1 through April 30, 2022	**Modify Net Delta Outflow Index (NDOI) Requirement**[1] • NDOI no less than 4,000 CFS monthly average, with a 7-day average no less than 3,000 CFS − combined exports no more than 1,500 CFS **OR**	X		
	• NDOI no less than 7,100 CFS on a three-day average or when electrical conductivity (EC) at Collinsville is below 2.64 mmhos/cm on a daily or 14-day average (Spring X2 met through Collinsville only) − Chipps days not required (D1641 Table 4) − No water quality requirement for Feb 1st to 14th − Combined exports operate as needed to allow capture of unregulated flows subject to ESA and CESA and DCC gates closed			X
	Allow DCC Flexibility[2] • Open the DCC gates as needed to maintain water quality standards at interior Delta M&I locations		X	
	Modify Vernalis Requirement[3,4] • Vernalis baseflow no less than 710 CFS on a monthly average and 7-day average no less than 80 percent of baseflow (568 CFS), where the higher flow objective, based on Chipps days, is not required.	X	X	X

CESA = California Endangered Species Act
CFS = cubic feet per second
DCC = Delta Cross Channel
EC = Electrical conductivity
ESA: Endangered Species Act
mmhos/cm = millimhos per centimeter
M&I = municipal and industrial
NDOI = Net Delta Outflow Index
X2 = Delta Outflow Requirements

NOTES:
1. Delta Outflow from February to June in all year types is defined in D-1641 Table 3 Footnote 11
2. D-1641 requires the Delta Cross Channel Gates to be closed from February 1 to May 20 in all year types
3. River Flows- San Joaquin River at Airport Way, Vernalis in critical years from February to June will be 710 or 1,140 cfs
4. Stanislaus contribution will follow the Stepped Release Plan Daily Hydrograph flows which include a base flow of 200 cfs for critical, dry and below normal year types.
5. Modeled Operational Management Scenarios refers to the DSM2 simulated hydrologic scenarios that were completed to analyze conditions associated with the Proposed D-1641 actions.

a) Modification of Export Limits

Reclamation and DWR request that the maximum Export Limits included in Table 3 of D-1641 be modified as follows: During February through April, when footnote 11 of Table 3 of D-1641 is not being met, or when the DCC gates are open during a period inconsistent with footnote 23 of Table 3 of D-1641, the combined maximum SWP and CVP export rate at the Clifton Court Forebay Intake and C.W. “Bill” Jones Pumping Plant will be no greater than 1,500 cfs on a 3-day running average. However, when precipitation and runoff events occur that allow the DCC gates to be closed and footnote 10 of Table 3 of D-1641 to be met at Collinsville [3-day average Delta Outflow of 7,100 cfs, or electrical conductivity of 2.64 millimhos per centimeter on a daily or 14-day running average at the confluence of the Sacramento and the San Joaquin rivers (Collinsville station C2) if applicable], even when additional Delta Outflow requirements contained in Table 4 of D-1641 are not being met, Reclamation and DWR request that exports of natural and unregulated (e.g., precipitation-generated runoff) surface flows are permitted up to D-1641 Export Limits contained in Table 3, in compliance with applicable laws and regulations including federal Endangered Species Act (ESA) and California ESA (CESA). This maximum export assumes the DCC is closed.

2) Allow DCC Flexibility (February 1 through April 30, 2022)

D-1641 requires the closure of the DCC gates from February 1 through May 20. DWR and Reclamation request permission to open the DCC gates as needed between February 1 and April 30, 2022 for human health and safety supplies, based on conferring with the CDFW, USFWS, and NMFS. Opening of the DCC gates can help improve interior Delta salinity conditions. Normally, runoff, upstream releases, and the Delta inflow/outflow needed to meet the Delta Outflow requirement would assist in meeting salinity requirements in the Delta with the DCC gates closed. However, if dry hydrologic conditions occur, there may be a need to open the DCC gates to help achieve the salinity conditions in the interior and southern Delta needed for protection of municipal and industrial beneficial uses without expending water needed for later use.

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

D-1641 requires a San Joaquin River at Airport Way Bridge, Vernalis minimum monthly average flow. Reclamation and DWR petition the State Water Board to approve a San Joaquin River flow at Vernalis river flow requirement for February through April 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 – a monthly average of no less than 710 cfs and a 7-day average no less than 20% below the monthly objective – is necessary because of the extraordinarily dry conditions of the past several years in combination with the forecasts of 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.

As stated above, this petition is to modify certain terms of the Projects' water rights permits from what is currently provided in D-1641 from February 1 through April 30, 2022. These modifications are necessary because of the extraordinarily dry conditions of WY 2020 and WY 2021 in combination with potential limited future precipitation and low reservoir storage at the beginning of WY 2022. Additionally, there will be competing demands on water supply for fish and wildlife protection, Sacramento-San Joaquin Delta (Delta) salinity control, and critical water supply needs.

Agency Coordination

On October 21 and October 22, 2021, Reclamation and DWR met with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and the Water Board to develop the TUCP and associated Biological Review outline and identify methods to be used in the biological review. Information from those meetings was incorporated into the development of the TUCP Biological Review.

In addition, between February 1 and April 30, 2022, DWR and Reclamation will meet and confer weekly with the Water Board to coordinate management of water supplies during the course of the declared drought emergency. 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 Water Board, for this coordination effort. The WOMT meets weekly to provide hydrology and operations updates, 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 February through April 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.

Reclamation and DWR's operations of DCC will consider risk assessments based on Knights Landing Rotary Screw Trap, Delta Juvenile Fish Monitoring Program (e.g., Sacramento trawl, beach seines), as well as updated DSM2 modeling informed with recent hydrology, salinity, and tidal data, consistent with decision support processes associated with proposed DCC gate operations during drought conditions, described in the description of the proposed action for Long-term Operations of the CVP (Reclamation 2019). This information would be evaluated, in coordination with the Long-term Operation Agency Coordination Team, to determine timing and duration of the gate closure/opening associated with the TUCP.

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. The analysis for the 2022 TUCP incorporated operations described in the 2020 Record of Decision (ROD) implementing Alternative 1, which was consulted upon for the 2019 NMFS and USFWS Biological Opinions for the Re-initiation of Consultation (ROC) 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, as analyzed in the Final Environmental Impact Report certified by DWR on March 27, 2020.

II. Purpose of Biological Review

As described in the February through April 2022 TUCP, legal users of water will not be injured by the requested changes. In support of the February through April 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 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 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 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 February through April 2022 TUCP addresses Delta conditions. The 2020 ROD implementing the Proposed Action consulted upon in the NMFS 2019 Biological Opinion addresses 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.

While outside of the regional scope of the TUCP Biological Review, TUCP impacts are considered in light of the benefits associated with the TUCP, specifically upstream cold-water pool preservation and additional water supplies for future years for releases (some of which occur outside the geographic scope of the Delta). 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.

The Biological Review assesses the potential for biological impacts that could result from the February through April 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 February through April 2022 TUCP), its operation is included in the Delta Simulation Model II (DSM2) hydrodynamic modeling study to support the February through April 2022 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 February through April 2022 operational actions as part of the TUCP are considered in the context of conceptual models, current regulatory documents, 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); 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 four operational management scenarios: three TUCP option cases (all of which are possible outcomes of the TUCP requested changes), and a base case 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. Actual TUCP operations could be a combination of the modeled options, dependent on actual hydrology and other factors. Thus, the effects of the TUCP may be inferred based on the range of estimated effects of the three modeled options and the base case.

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 three sources:

- Up to the point where the forecast begins, observed historical data (through October 21, 2021) was used.
- From the end of available historical data through December 2021, forecasted data from DWR's Delta Coordinated Operations (DCO) model that determines allocations to SWP water supply contractors was used. Information that is fed

into the DCO includes hydrology data, contractor delivery requests, and legal restrictions on exports. The DCO allocation forecasts that were used for this analysis utilized 90% exceedance hydrology for reservoir inflows. This represents a forecast for a very dry year. Based on historical data, a 90% exceedance hydrology assumes that only one in ten years would be drier than this forecast.

- For January through April of 2022, another method was used to develop operational scenarios. The 90% historical exceedance boundary flows were assumed for all Delta inflows except for Sacramento River at Freeport and San Joaquin River at Vernalis. For each scenario, required Delta outflow was determined based on the required flow in D-1641, or the relaxed outflow requirements requested in each TUCP case. For the February through April X2 requirement, the 90% historical exceedance 8RI was used to determine the number of required Chipps days and required outflow was aggregated based on the Chipps and Collinsville requirements. The 90% historical exceedance was used for January, while the D-1641 required (for Critical WY) or TUCP relaxed baseflow was used to determine Vernalis flows from February through April. Freeport flows and combined Project exports were used to balance the system, in accordance with the requirements and needs of each scenario.

Note that modeling of all the scenarios focused on the Delta, rather than system-wide, DCO-based scenarios because the source of water used to meet compliance with D-1641 requirements does not need to be defined. This allows conceptually different alternatives, where the projects make use of the TUCP in different ways to be compared to a common baseline. Comparisons with different alternatives can make differing assumptions about the source of the water, allowing the analysis to be carried out looking at conceptual bookends. For example, in the TUCP case and TUCP with DCC case, it is assumed that the water used to comply with D-1641 in the base case comes from storage withdrawals. Thus, when comparing this case with the baseline, it can be assumed the difference in Freeport flow can be backed into reservoir storage. On the other hand, in the TUCP with Collinsville X2 case, the opposite is true, and it is assumed that water used to meet compliance with D-1641 requirements comes from unregulated flow that cannot be backed into upstream storage, thus water above the required Collinsville outflow is exported.

A detailed breakdown of operational assumptions in each case is provided below:

- **Base case**
    - Vernalis flows based on D-1641 base flows (Vernalis spring pulse flow not modeled)
    - NDOI based on meeting D-1641 Collinsville outflow, aggregated with the 90% historical exceedance number of Chipps days
    - South Delta exports to meet minimal M&I demand levels (1,500 cfs combined)

    - Freeport flow used to balance the system and meet outflow, source of water not defined (reservoir releases or unregulated flow)

- **TUCP case**
    - Vernalis baseflow relaxed to 763 for February, and 710 cfs from March through April, (February flow adjusted to meet salinity requirement at Vernalis based on historical salt loadings) (Vernalis spring pulse flow not modeled)
    - NDOI relaxed to 4,000 cfs from February through April
    - South Delta exports to meet minimal M&I demand levels (1500 cfs combined)
    - Freeport flow used to balance the system and meet outflow
    - Compared to the base case, assumes water used to meet D-1641 is withdrawn from storage and can be backed up into upstream storage under the TUCP

- **TUCP with DCC case**
    - Same as TUCP case but with the Delta Cross Channel open 50% of the time in February and March (approximately 4 weeks total)[2] to assist in maintenance of interior Delta water quality

- **TUCP with Collinsville X2**
    - Freeport flow identical to the base case
    - Outflow based on Collinsville requirement only, Chipps days requirement is relaxed
    - Vernalis baseflow relaxed to 763 for February, and 710 cfs March through April, (February flow adjusted to meet salinity requirement at Vernalis based on historical salt loadings) (Vernalis spring pulse flow not modeled)
    - Water in excess of that required for Collinsville flow requirements is exported from the south Delta; however, combined exports assumed to be limited to 1,500 cfs in April
    - Compared to the base case, this scenario assumes water used to meet D-1641 is unregulated flow that cannot be backed up into upstream storage under the TUCP; therefore, available water is exported at the south Delta facilities

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.

[2] For modeling purposes, the Delta Cross Channel gates were assumed to be open during the first half of February and the first half of March.

Non-hydrologic modeling assumptions are listed below; these assumptions are common to the baseline and all TUCP scenarios unless otherwise noted:

- Suisun Marsh Salinity Control gates are in tidal operation beginning September 1, 2021
- The False River temporary barrier will be notched for fish passage and boating access, but not fully removed, on January 10, 2022, and will be closed again on April 10, 2022
- The Delta Cross Channel Gates are closed in all of December, January, February, March and April in all cases except for the TUCP with DCC case, which assumes the gates are open for the first half of days in February and March
- The Old River at Tracy and Middle River barriers will be breached by November 2, 2021. Grant Line Canal Barrier will be breached by November 11, 2021.

Table Model1. Summary of Primary Modeling Assumptions by Case for February through April 2022.

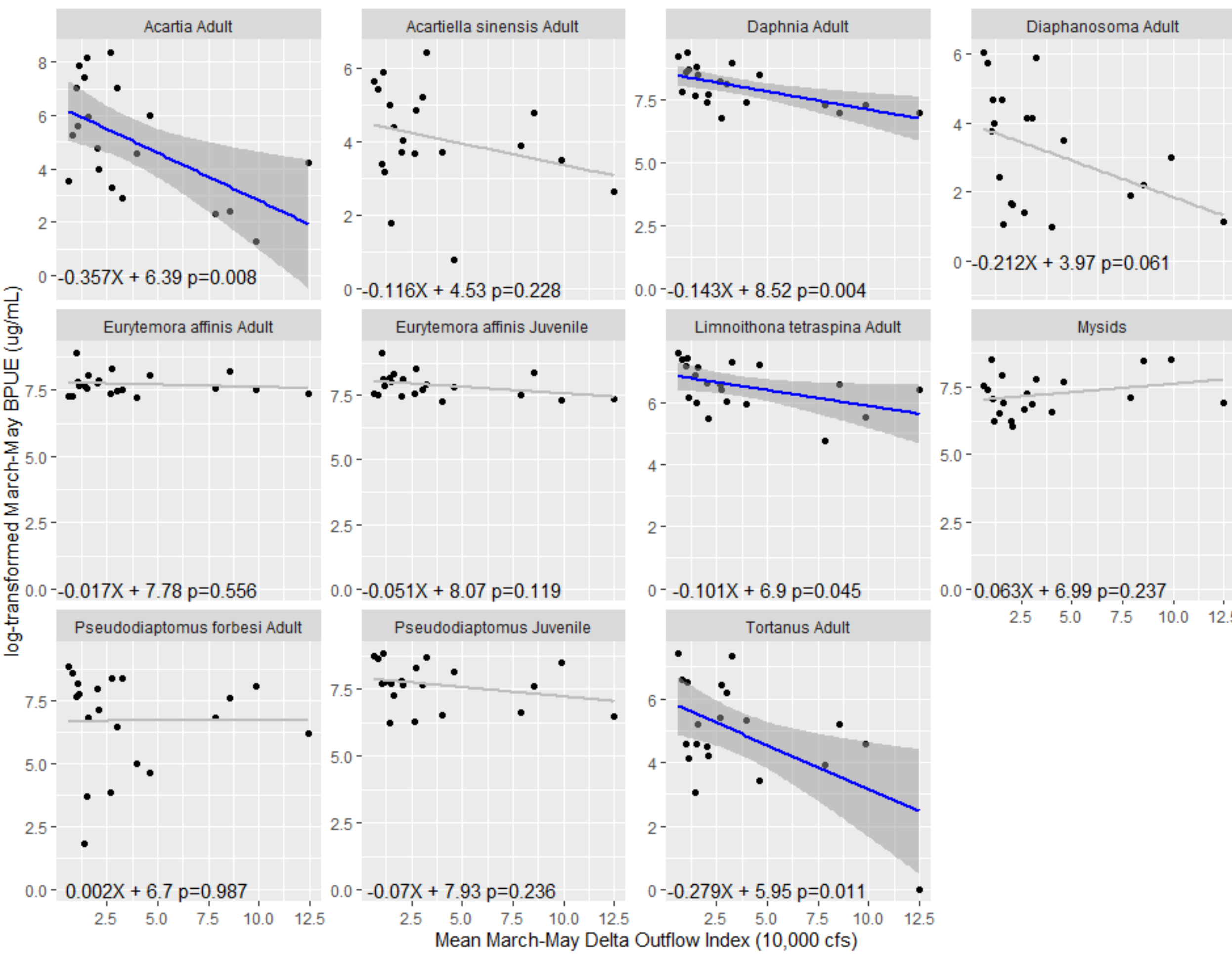
	Base (No TUCP)				TUCP / TUCP with DCC				TUCP with Collinsville X2			
	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports
Month	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
February	9,164	916	10,181	1,500	4,000	763	5,170	1,500	7,100	763	10,181	3,411
March	8,458	846	9,825	1,500	4,000	710	5,502	1,500	7,100	710	9,825	2,722
April	9,902	990	11,544	1,500	4,000	710	5,922	1,500	9,622	710	11,544	1,500

IV. Analysis of the Impacts of TUCP

Ecosystem Impacts

Impacts of the February through April 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 is correlated with flow, with 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).

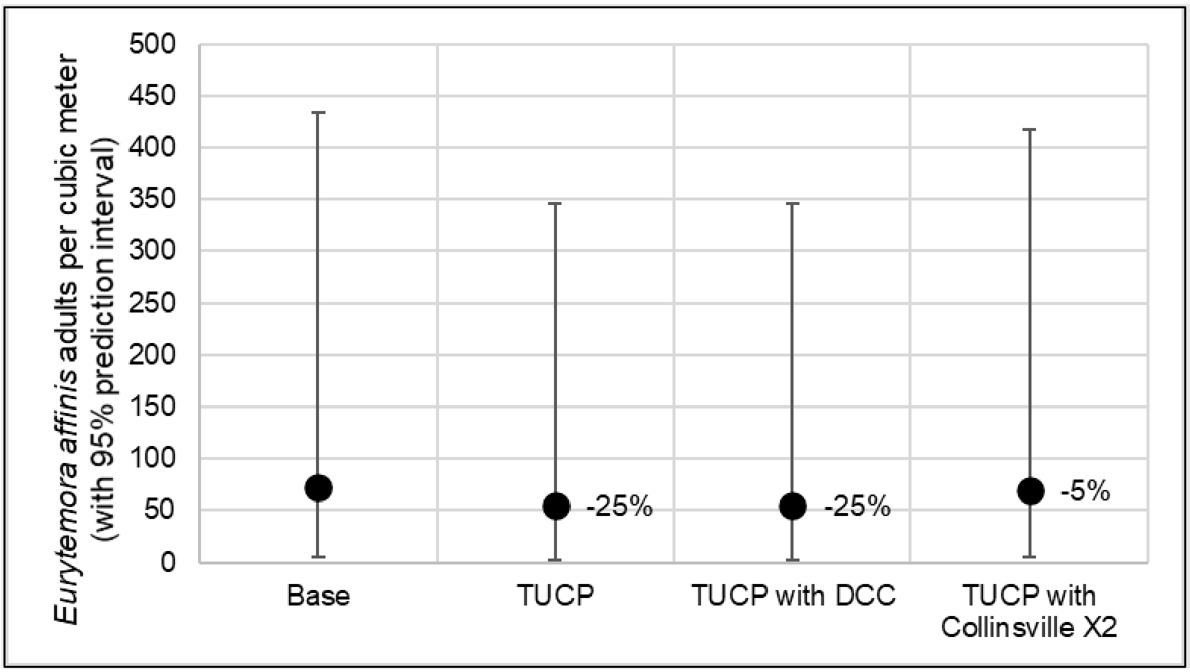
Figure ZOOP1. Regression Relationships of Various Zooplankton Taxa and Mean March through May Delta Outflow from Environmental Monitoring Program and 20-mm Survey Stations, 2000 through 2021.



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* (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 *Eurytemora affinis*[3] (*E. affinis)*, 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 scenarios ranging from -5% (TUCP with Collinsville X2) to -25% (TUCP and TUCP with DCC operations), 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.

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* abundance indices declined considerably in the late 1990s and by far the most abundant mysids now are *Hyperacanthomysis*

[3] *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.

longirostris and *Neomysis kadiakensis* (Barros 2021). Neither *H. longirostris* nor *N. kadiakensis* have 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 would have very limited effects on mysids as a whole, although with some potential negative effects to *N. mercedis* based on the correlation observed by Hennessy and Burris (2017).

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 (Mahardja et al. 2016). Silverside abundance could increase as a result of the drought and minimal south Delta exports. Note the original study's lowest level of exports (~2,500 cfs) was greater than the 1,500-cfs exports level that would occur under the base, TUCP, and TUCP with DCC options. Somewhat greater spring south Delta exports under the TUCP with Collinsville X2 option (i.e., ~2,700 cfs in March; 1,500 cfs in other months) could give lower silverside abundance than the other TUCP options and the base case based on the nature of the statistical relationship. However, the very low outflow under all cases indicates considerable uncertainty in differences given that outflow is at or below the range of data modeled by Mahardja et al. (2016).

The February through April period of the TUCP occurs prior to the warmer seasons when potential flow-related effects from other ecosystem stressors occur (e.g., *Microcystis,* harmful algal blooms [Lehman et al. 2018], and invasive clams, *Potamocorbula amurensis* [Kimmerer et al. 2019]). Discussion of other relevant ecosystem impacts is provided in the species-specific analyses below.

Winter-Run Chinook Salmon

Presence and Life Stages of Winter-Run Chinook Salmon

Monitoring with rotary screw traps estimated that just over 500,000 juvenile winter-run Chinook salmon have passed Red Bluff Diversion Dam as of November 4, 2021[4]. The historical (past 18 years) mean total passage by this date is ~81%; therefore, the bulk of passage is likely to have occurred at this location, indicating that the overall juvenile abundance is of similar order of magnitude to prior years during or following droughts (e.g., brood years [BY] 2014–2017) and an order of magnitude less than BY 2018–2020. The Salmon Monitoring Team, which meets weekly, identified 10-19% of juvenile-winter-run Chinook salmon had entered the Delta as of the week of November 8, 2021. This suggests winter-run Chinook salmon are entering the Delta relatively earlier than observed in most previous years. Brood Year (BY) 2020 juveniles entered the lower Sacramento River and Delta and were present in the Delta during February through April 2021 (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 occur in the Delta in February through April (Table WR2).

[4] See https://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2021/Biweekly20211022-20211104.pdf

Figure WR1. Raw Catch of Juvenile Winter-Run Chinook Salmon from Brood Year 2020 from July 1, 2020 through May 6, 2021.

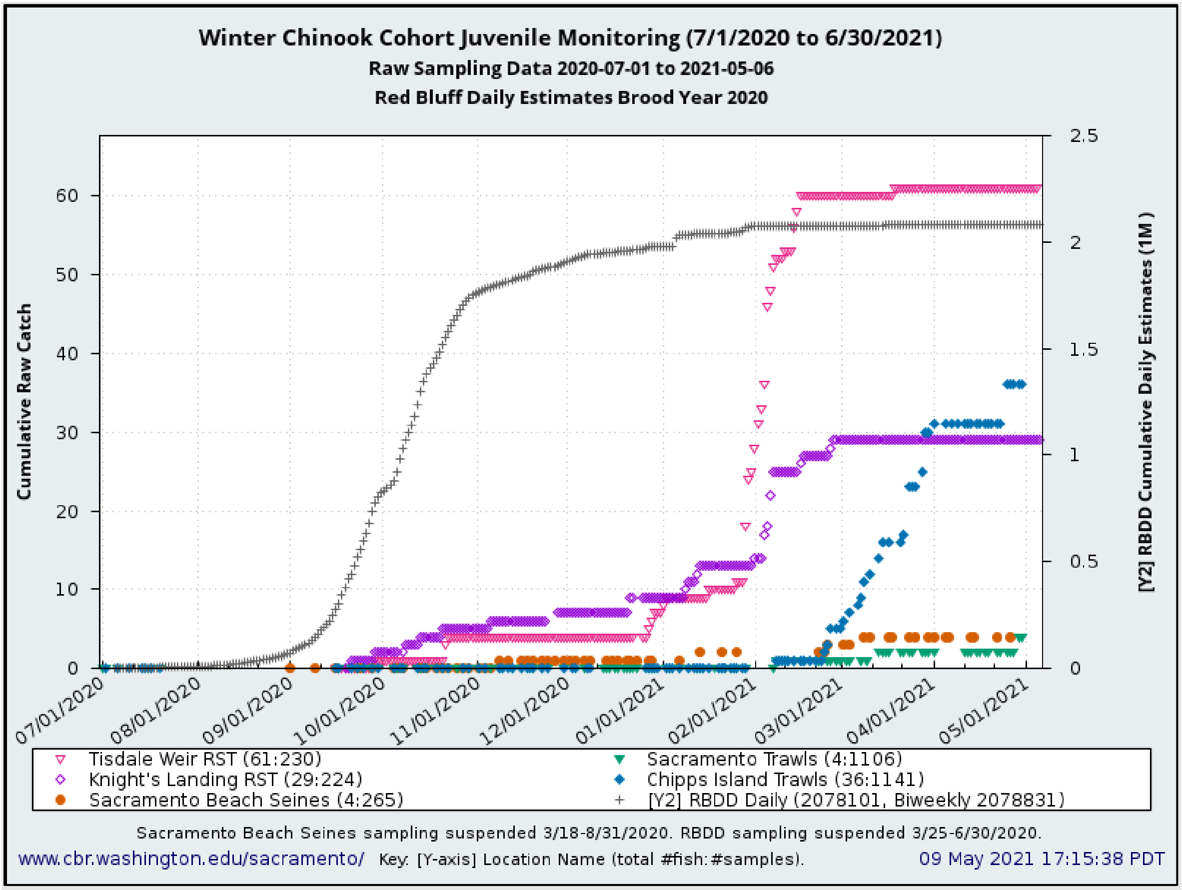


Table WR1. Temporal Occurrence of Sacramento River Winter-Run Chinook Salmon by Life Stage in the Sacramento River

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.

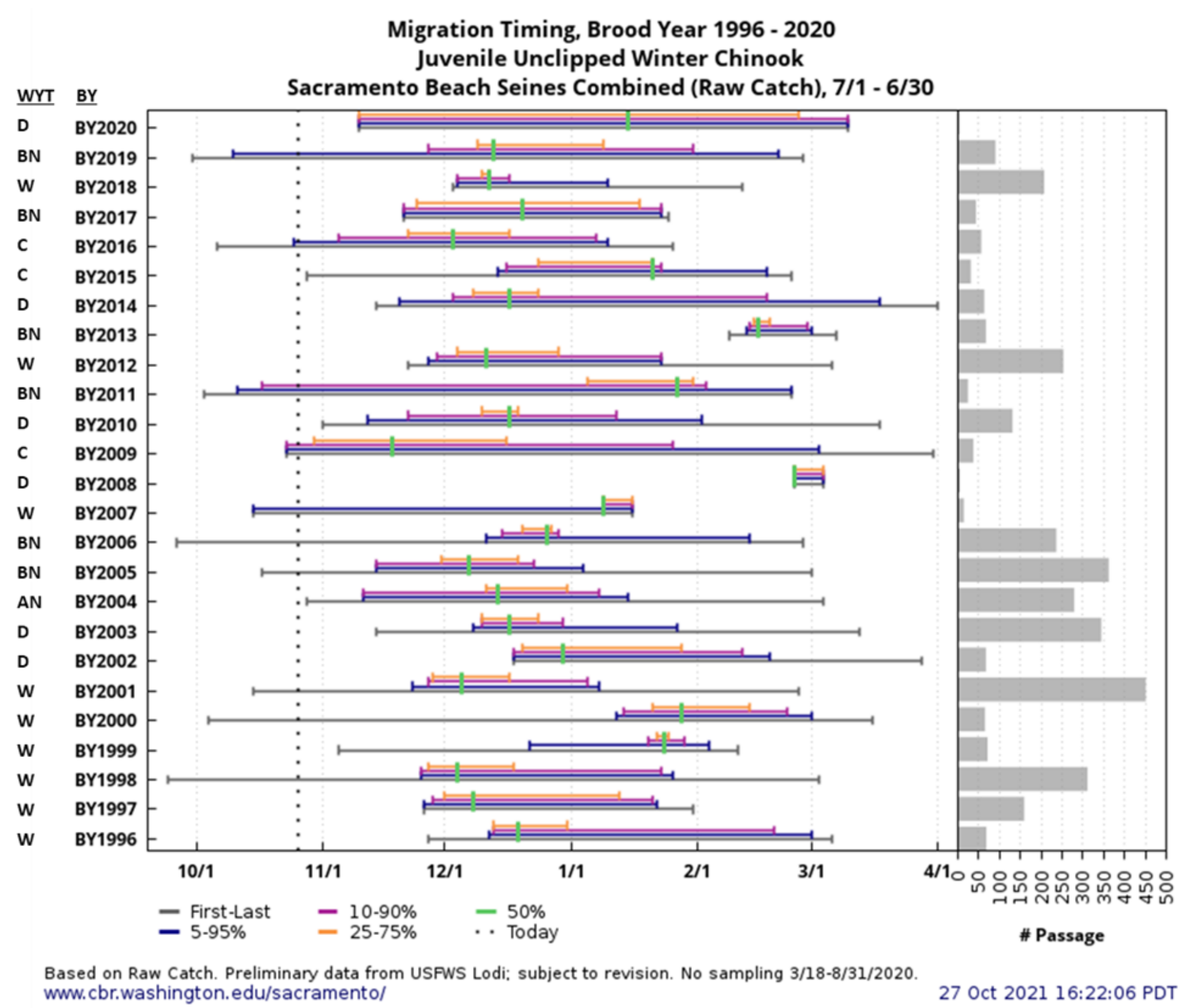


Figure WR3. Catch Index Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon in Sacramento Trawls at Sherwood Harbor, Brood Years 1996 through 2020.

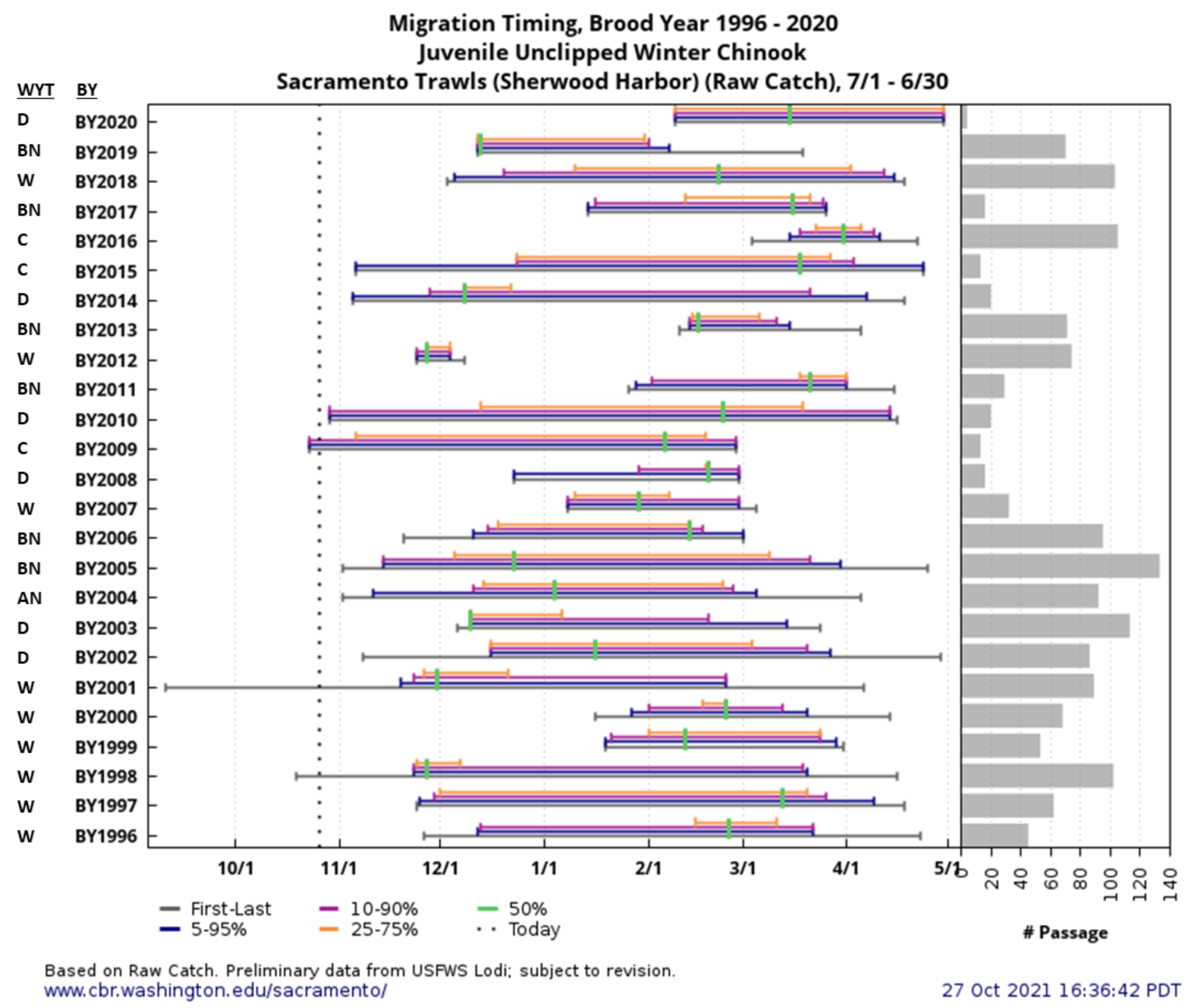


Figure WR4. Catch Index Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon in Chipps Island Trawls, Brood Years 1996 through 2020.

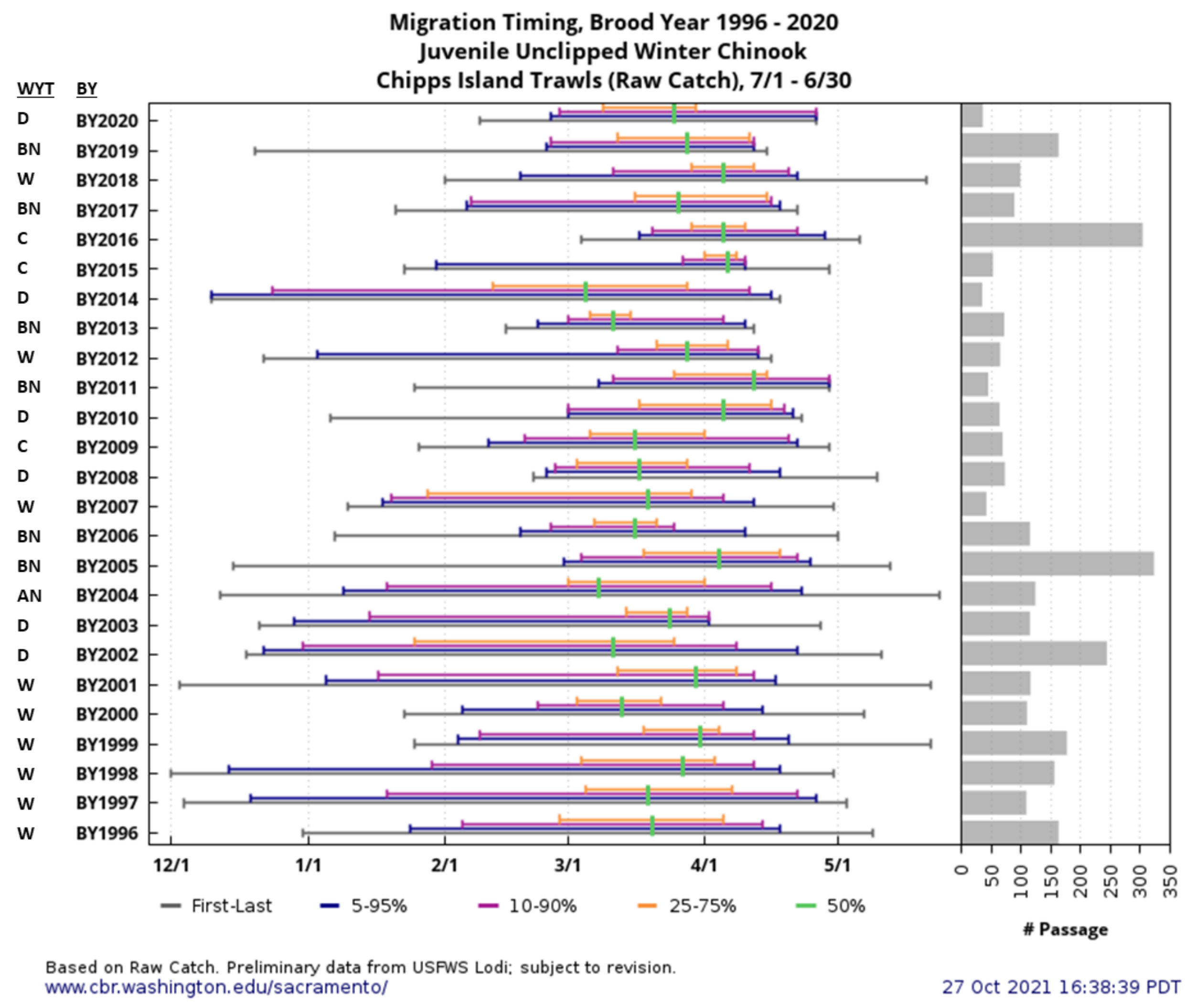
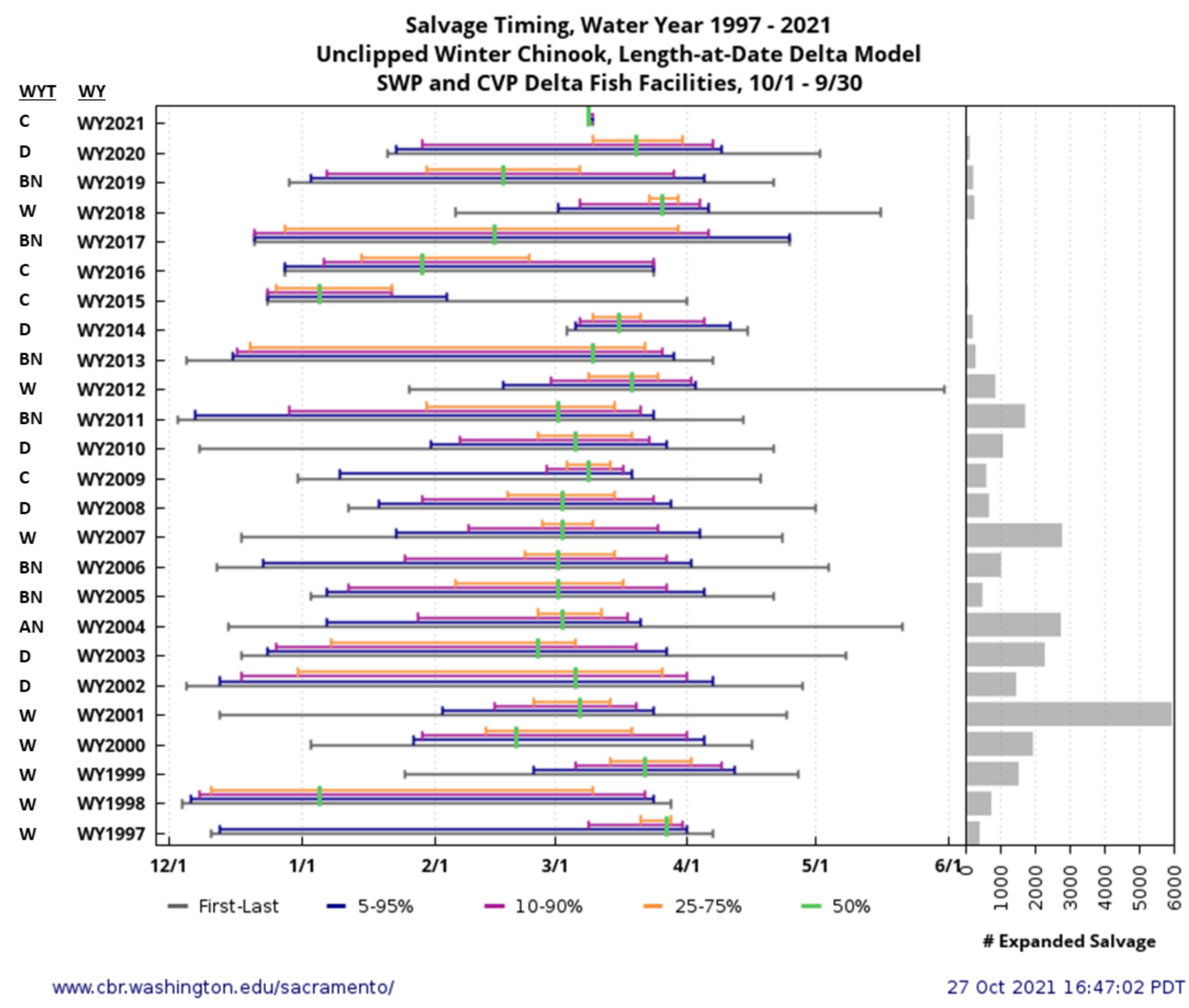


Figure WR5. Timing and Number of Unclipped Juvenile Winter-Run Chinook Salmon (Race Determined from Length at Date, LAD) at the SWP and CVP South Delta Fish Salvage Facilities, Water Years 1997 through 2021.



Impacts of TUCP on Winter-Run Chinook Salmon

Per the presence summary above, BY 2021 winter-run Chinook salmon juveniles will be in or entering the Delta during the February through April period when the TUCP would result in changes to Delta flows. Individuals migrating during this time could experience reduced through-Delta survival based on factors such as increasing 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) as a result of the TUCP and TUCP with DCC options, and thereby increasing predation risk relative to baseline conditions. DSM2 modeling results for the Sacramento River at Freeport and Delta Cross Channel gate opening status were used to estimate through-Delta survival based on the model of Perry et al. (2018).[5] Estimates of through-Delta survival from this model integrate flow impacts on north Delta hydrodynamics, including channel flow and proportion of flow entering distributaries such as Georgiana Slough. Note that this model does not include south Delta exports. 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 option than the base case (0.05–0.06 [i.e., 5–6% absolute difference], or 13–16% relative difference), with the TUCP with DCC option having greater differences (0.10–0.12, or 28–29% relative difference) in February and March as a result of the DCC being assumed to be 50% open in these months (Table WR3[6]). There is no difference in through-Delta survival between the base case and the TUCP with Collinsville X2 option because Freeport flow and DCC operations do not differ between these cases, although as noted above the model does not capture any differences in through-Delta survival that could result from greater south Delta exports under the TUCP with Collinsville X2 option (see additional discussion below with respect to south Delta entrainment). 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 (0.03–0.04, or 11–13% relative difference) under the TUCP option relative to base, with greater differences under the TUCP with DCC option in February and March

[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 February–April 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).

(0.09, or 33–35% relative difference) because of DCC opening in these months (Table WR4); these patterns are part of the through-Delta survival estimates.

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. Particles were released in the February through April 2022 modeled period in the Sacramento River at Freeport with particles that reach Chipps Island representing fish that survived through the Delta. The results from the ECO-PTM model were similar to the results from the spreadsheet model version of Perry et al. (2018; Table WR3): differences in February and March were less and differences in April were greater (Figures WR6, WR7, 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. In addition, the greater temporal overlap of particles released in April under the TUCP and TUCP with DCC options migrating through the Delta with subsequent opening of the Delta Cross Channel in May following the TUCP period may be driving the largest differences (Figure WR8).

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

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	0.39	0.33 (-15%)	0.27 (-29%)	0.39 (0%)
March	0.38	0.33 (-13%)	0.28 (-28%)	0.38 (0%)
April	0.40	0.34 (-16%)	0.34 (-16%)	0.40 (0%)

Note: Percentage difference in parentheses represents TUCP options minus base.

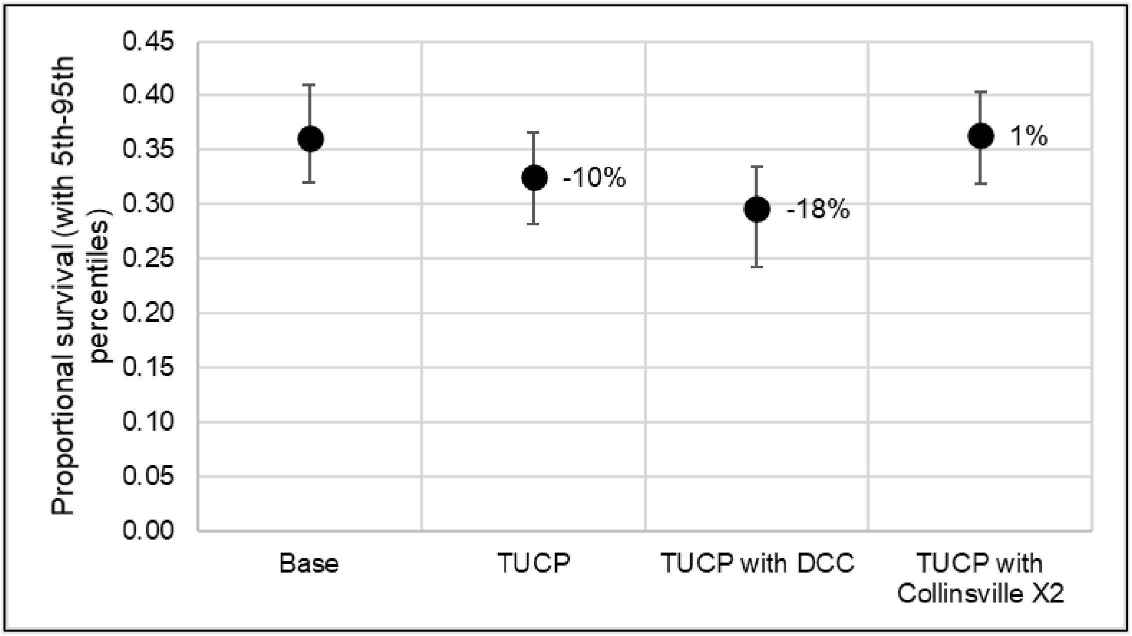
Table WR4. Mean Monthly Probability of Juvenile Chinook Salmon Entering the Interior Delta Through Georgiana Slough and the Delta Cross Channel Based on Freeport Flow and Delta Cross Channel Position from the Model of Perry et al. (2018).

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	0.27	0.31 (13%)	0.36 (35%)	0.27 (0%)
March	0.27	0.30 (11%)	0.36 (33%)	0.27 (0%)
April	0.26	0.30 (14%)	0.30 (14%)	0.26 (0%)

Note: Percentage difference in parentheses represents TUCP options minus base.

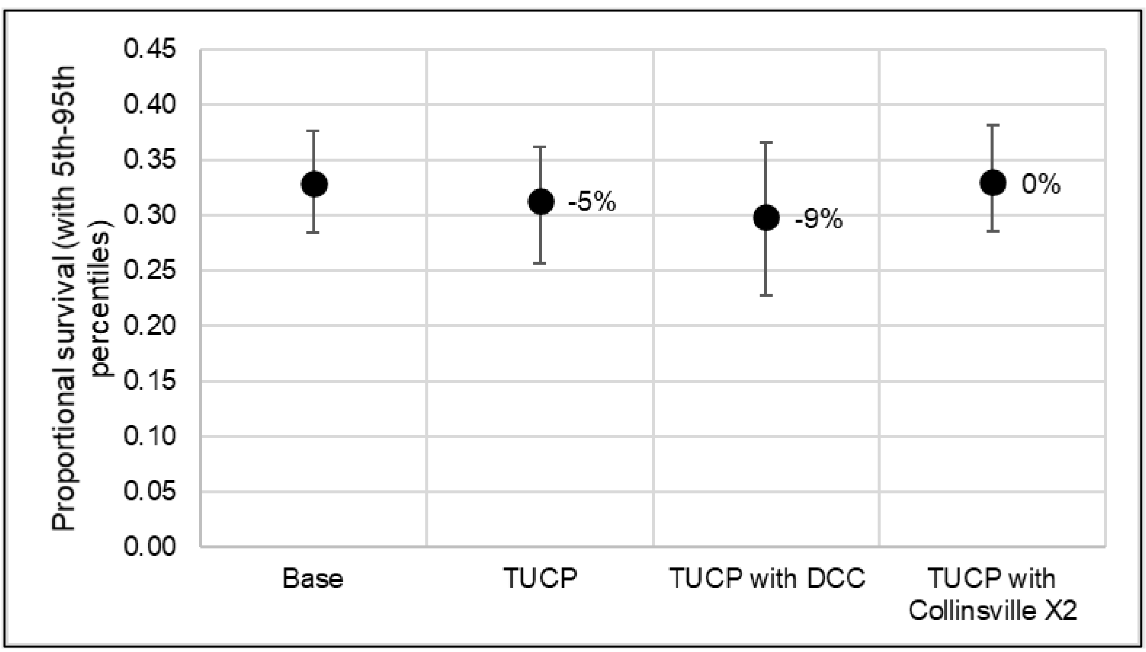
[7] The ECO-PTM model does not include consideration of south Delta entrainment (Wang 2019).

Figure WR6. February - Juvenile Chinook Salmon Through-Delta Survival, Based on the ECO-PTM Model.



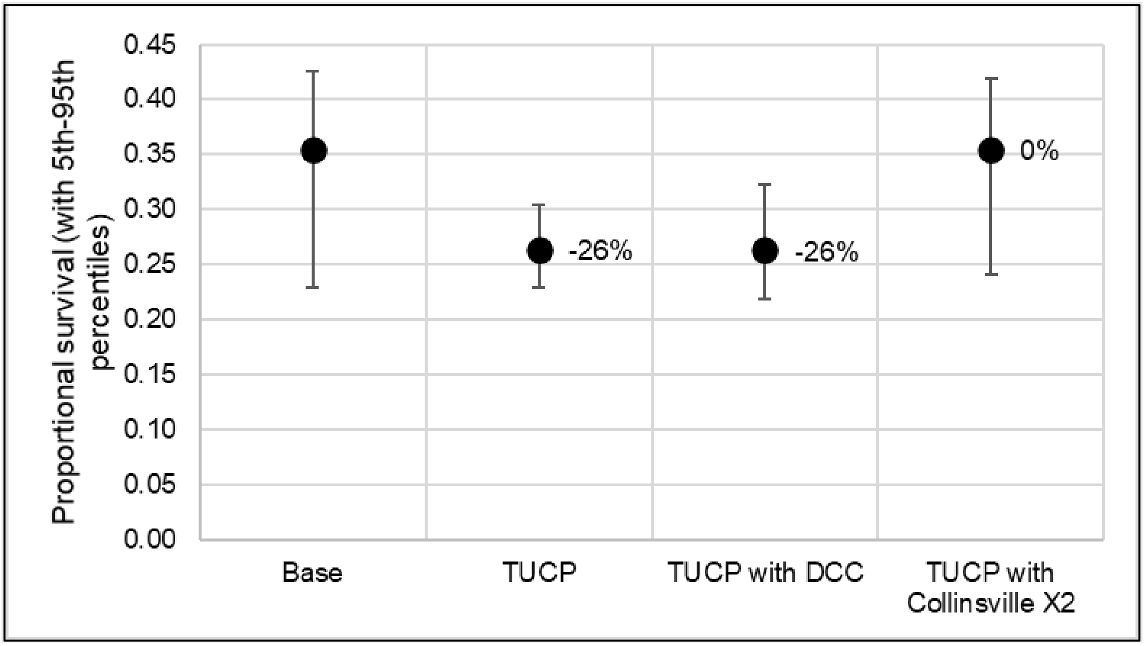
Note: Circles represent mean estimate, with percentage labels indicating relative difference of mean estimates of TUCP cases compared to the base case. Error bars represent the 5th–95th percentiles of daily estimates. The summary is for particles released in February; migration may extend later than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

Figure WR7. March - Juvenile 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 March; migration may extend later than March depending on the simulated movement patterns.

Figure WR8. April - Juvenile 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.

As noted in the 2015 TUCP biological reviews, at low outflow (i.e., decreased 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. The 2015 TUCP biological reviews hypothesized that 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.

The base case and TUCP and TUCP with DCC options would have the same level of minimal south Delta exports (1,500 cfs) and therefore relatively similar Old and Middle River flows (Table WR5) that would be expected to limit juvenile (and adult) winter-run Chinook salmon entrainment 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 salvage loss thresholds (NMFS 2019: 478–479). Although the TUCP with Collinsville X2 option has the potential for greater south Delta exports in February (~3,400 cfs) and March (~2,700 cfs), resulting in more negative Old and Middle River flows, exports and Old and Middle River flows would still 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 weekly risk assessment is required by the CDFW (2020) SWP ITP in order to determine south Delta operational adjustments; this would continue under the base case and all TUCP options, limiting entrainment to low levels.

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

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	-1,144	-1,216	-1,216	-2,957
March	-1,274	-1,338	-1,338	-2,452
April	-1,336	-1,468	-1,468	-1,468

Based on timing information in Table WR2 above, the February through April TUCP period would coincide with the highest relative abundance of adult winter-run Chinook salmon migrating through the Delta. Delta Cross Channel operations would not differ between the base case and the TUCP and TUCP with Collinsville X2 options, thus there would not be any difference between these cases in delay of adult winter-run Chinook salmon that may move upstream via the Mokelumne River when the Delta Cross Channel is open. There may be greater potential for migratory delay under the TUCP with DCC option because of DCC operations in February and March, with the gates assumed to be closed for half of each of these months. In the context of delays by the DCC gates when opened for water quality purposes during the winter-run Chinook salmon migration period, NMFS (2019: 434) suggested: “Since adult Chinook salmon have been observed to make several movements upstream and downstream in the Delta waterways before finally moving upstream towards their spawning grounds, the temporary delay [from DCC closure] should not cause any permanent physiological impairment.” This suggests limited effects of migratory delay, although this is uncertain. 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), although the available information for hatchery-origin fall-run Chinook salmon released north of the Delta indicates straying 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 TUCP options and the base case for winter-run Chinook salmon adults returning during the TUCP February through April period.

<u>Conclusions for Winter Run Chinook Salmon</u>

In the Delta, a large portion of BY 2021 juvenile winter-run Chinook salmon may be in or migrating through the Delta during the February through April 2022 TUCP, although entry into the Delta had already begun in appreciable numbers during

October/November 2021[8]. These juvenile winter-run Chinook salmon in the Delta would not experience risk of high levels of entrainment at the south Delta export facilities in February through April 2022, because of very 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 salvage loss thresholds, and continued implementation of entrainment risk assessment and operations adjustments. Through-Delta survival of juveniles migrating during February through April under the TUCP and TUCP with DCC options 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 (with a greater negative effect under the TUCP with DCC option because of the Delta Cross Channel being assumed to be open for half of February and March). Migration conditions for adult winter-run Chinook salmon adults generally would be similar under the base case and TUCP and TUCP with Collinsville X2 options; there may be a greater potential for migratory delay because of Delta Cross Channel operations in February and March under the TUCP with DCC option.

Spring-Run Chinook Salmon

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

During the February through April 2021 period, young-of-the-year juveniles from BY 2020 spawning by spring-run Chinook salmon adults had likely entered and were present in the Delta (Figure SR1), which may be representative of conditions that could occur in the TUCP period of February through April 2022. Historical migration timing data also suggest that most young-of-the-year juveniles are present in the Delta in the February through April period (Tables SR1 and SR2; Figures SR3, SR4, and SR5). 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 February through April period than for young-of-the-year juveniles. Adult presence in the Delta also occurs during the February through April period, extending into June (Table SR2).

[8] A previously noted, as of November 8, 2021, it was estimated that 10–19% of juvenile winter-run Chinook salmon had entered the Delta. Further early-season storm pulses in addition to the pulse that occurred in October 2021 could result in most juvenile winter-run entering the Delta prior to the TUCP period.

Figure SR1. Raw Catch of Juvenile Spring-Run Chinook Salmon from Brood Year 2020 to September 30, 2021.

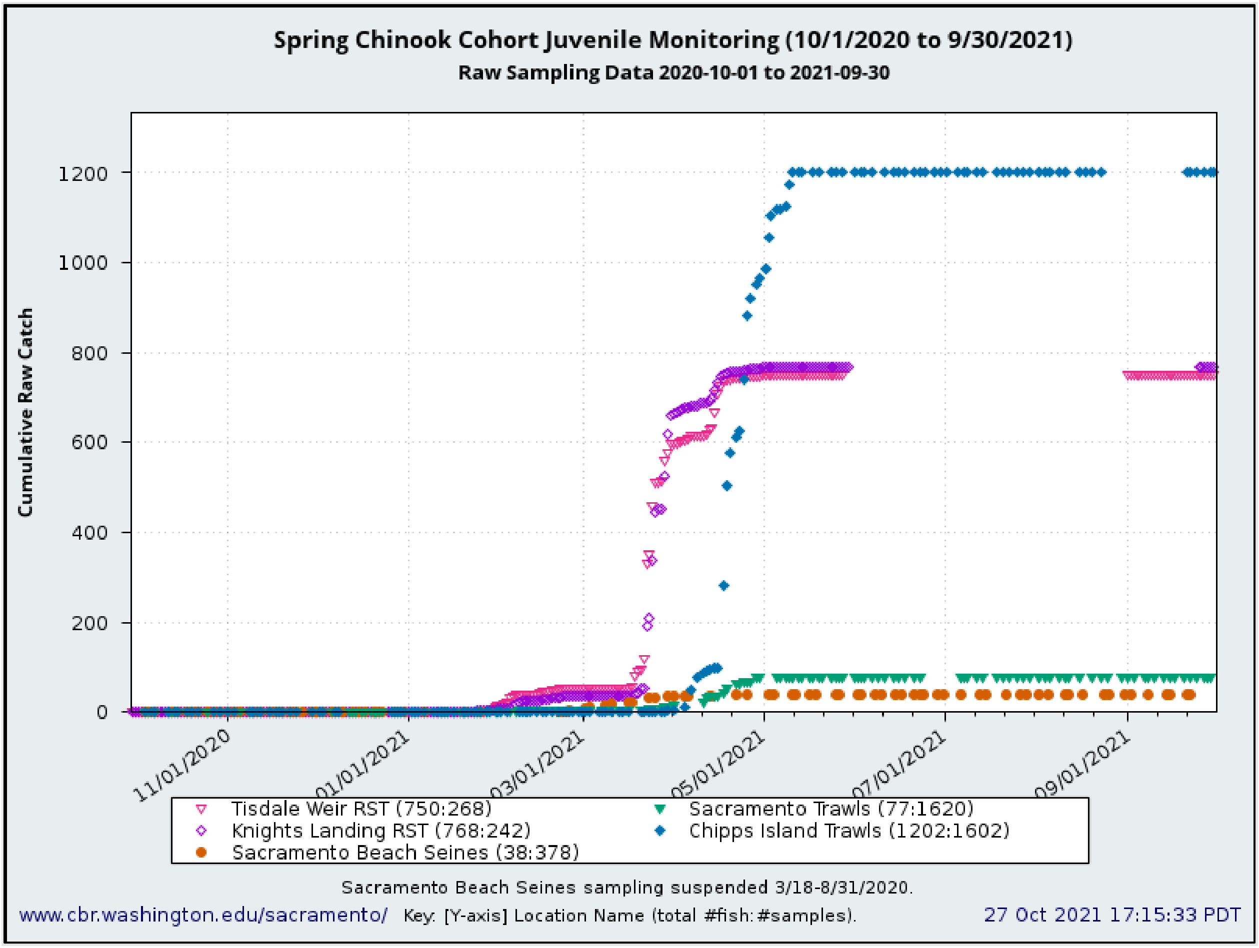


Table SR1. Temporal Occurrence of Central Valley Spring-Run Chinook Salmon by Life Stage in the Sacramento River

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.

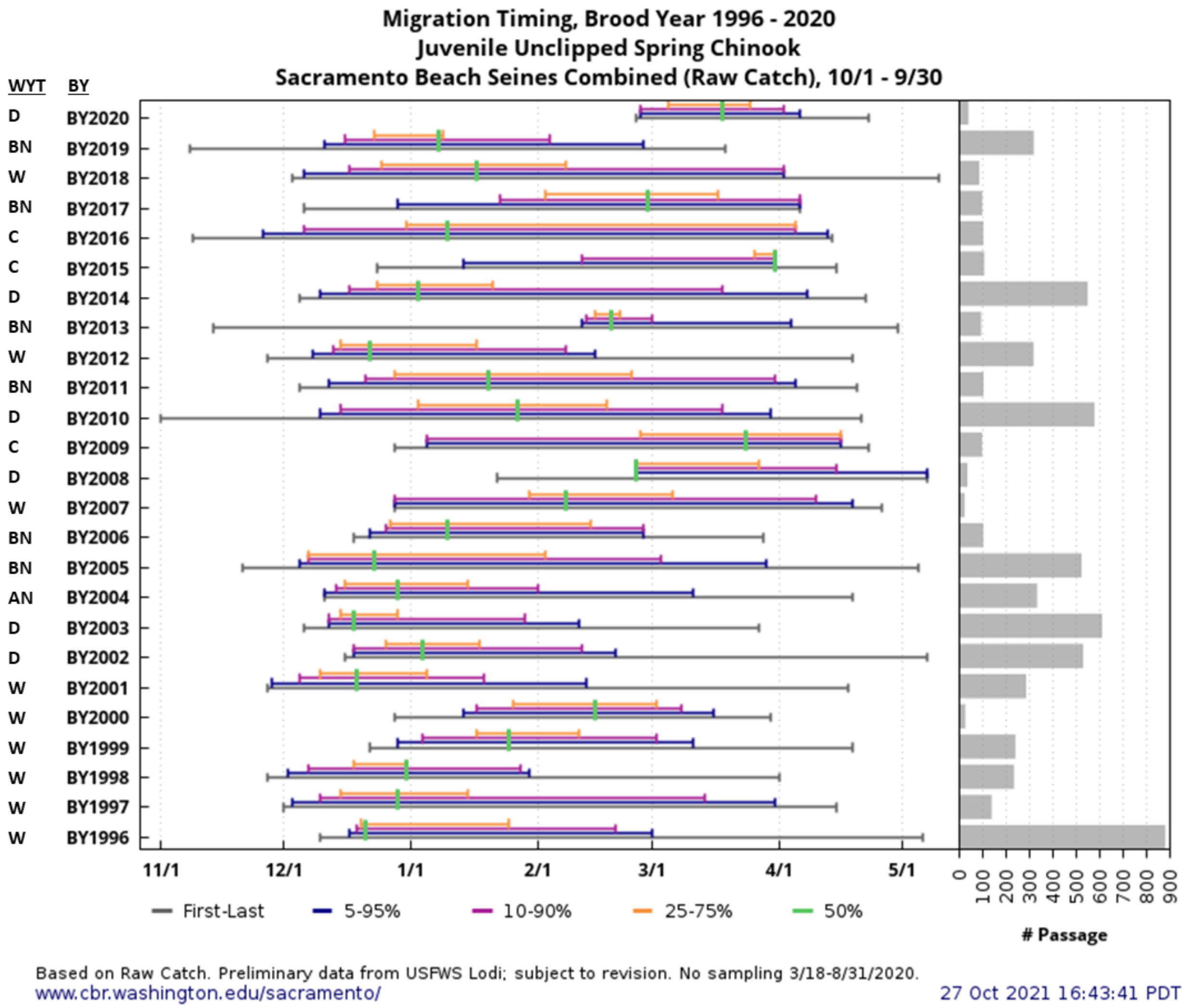


Figure SR3. Catch Index Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon in Sacramento Trawls at Sherwood Harbor, Brood Years 1996 through 2020.

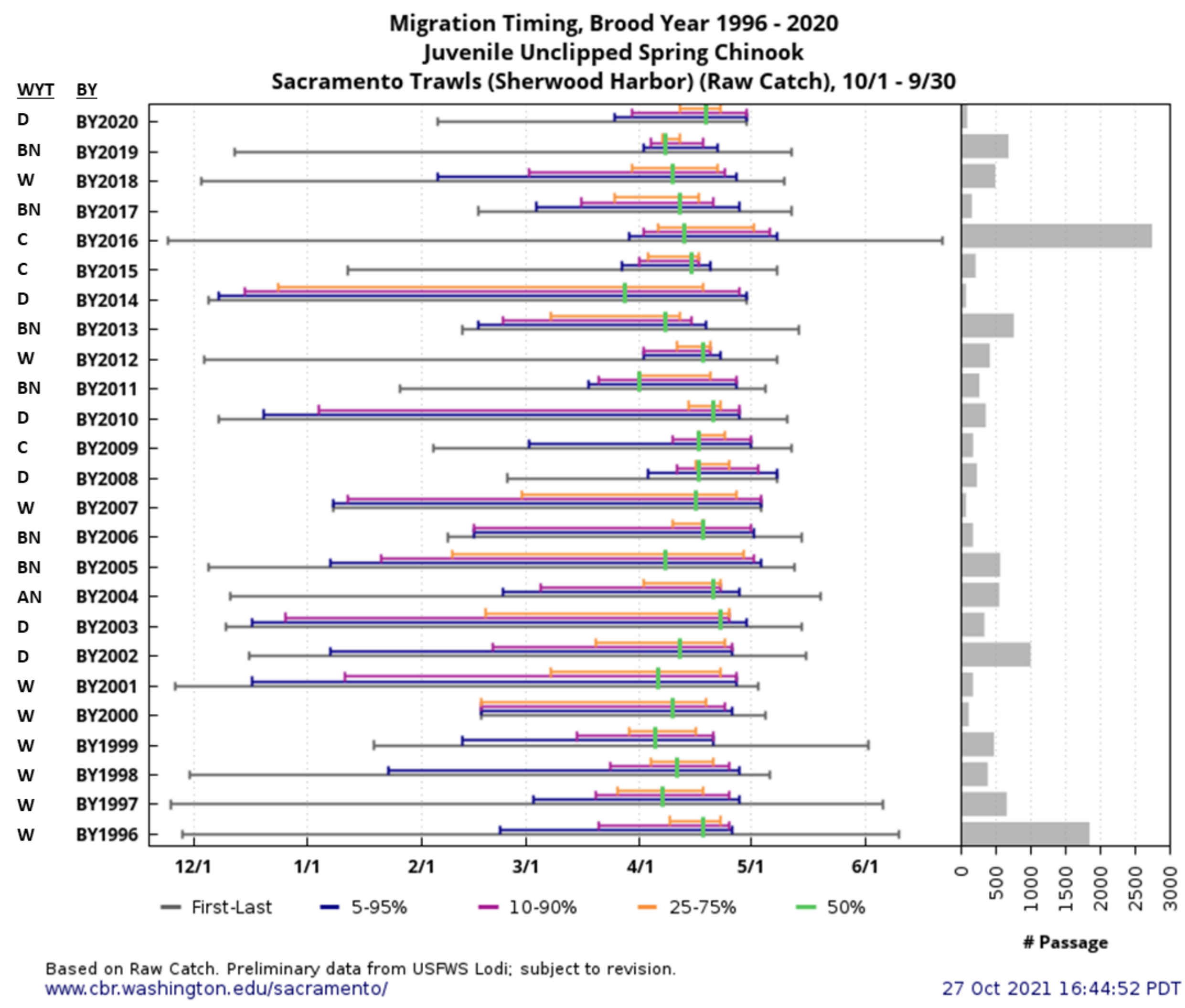


Figure SR4. Catch Index Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon in Chipps Island Trawls, Brood Years 1996 through 2020.

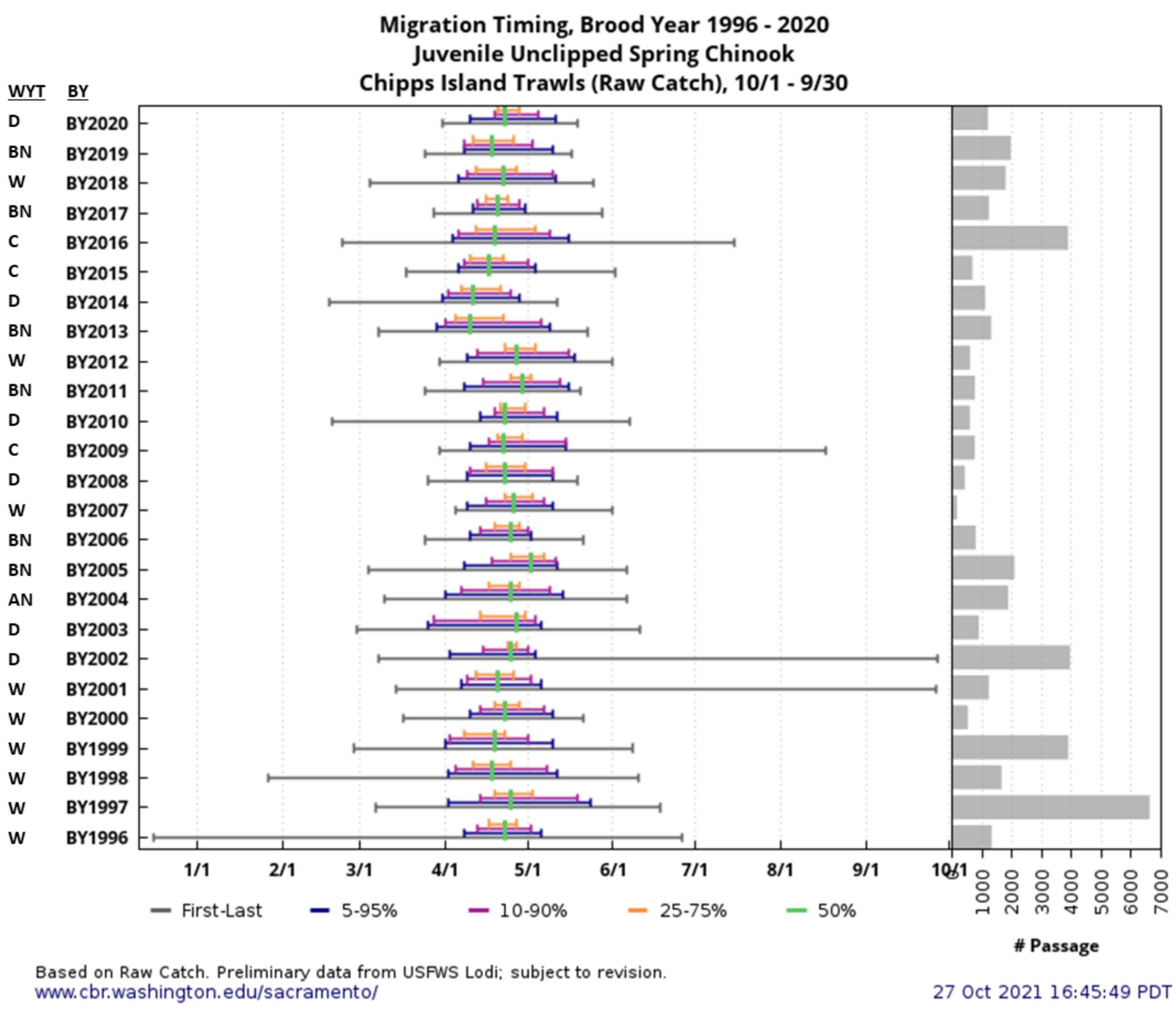
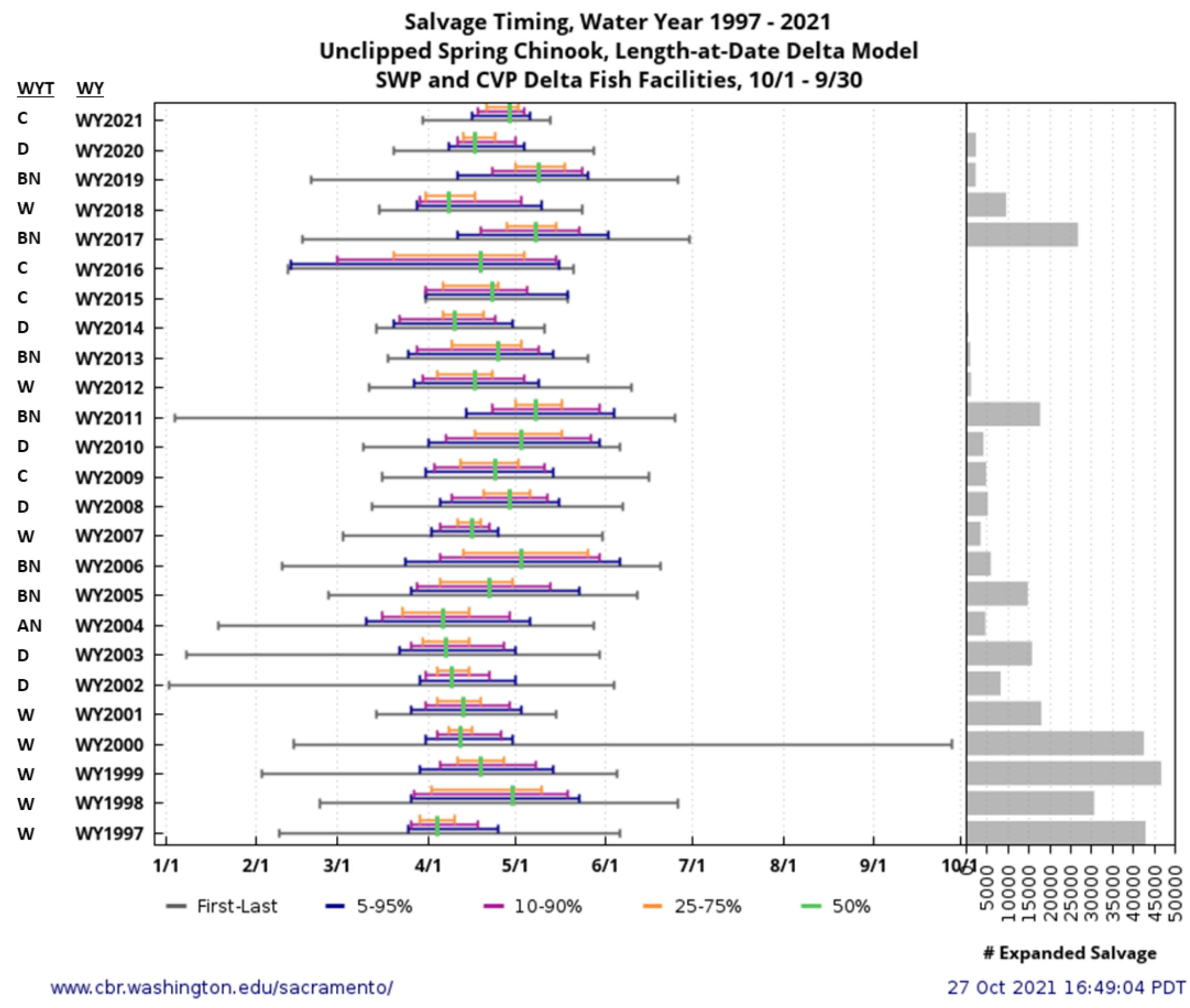


Figure SR5. Timing and Number of Unclipped Juvenile Spring-Run Chinook Salmon (Race Determined from Length at Date) at the State Water Project and Central Valley Project South Delta Fish Salvage Facilities, Water Years 1997 through 2021.



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. The footnote for Table SR1 indicates that yearling spring-run Chinook salmon downstream emigration generally occurs in fall and winter, although monitoring outside of tributaries does not sample yearlings consistently. In the November 9, 2021 Weekly Assessment, the Salmon Monitoring Team noted older juvenile salmon had been observed in Delta fish monitoring, which may be indicative of yearling spring-run Chinook salmon outmigrating through the Delta during fall 2021. The Salmon Monitoring Team also noted that recent environmental conditions in October and November were conducive in spring-run tributaries with yearling downstream migration. This timing is earlier than what was reported in water year 2021 for which weekly risk assessments from the Salmon Monitoring Team[9] noted in January and early February that flows consistent with yearling downstream migration began in Mill Creek on 10/21/2020 and in Deer Creek on 12/26/2020, with monitoring in Butte Creek indicating that yearling migration had also begun. The Salmon Monitoring Team noted south Delta entrainment risk of yearling spring-run Chinook salmon until the 2/9/2021 risk assessment, without specific mention thereafter. Hatchery-origin surrogate yearling spring-run were released from the Coleman National Fish Hatchery into Battle Creek on 1/8/2021, 1/22/2021, and 1/29/2021, with a cumulative total of 189,076 fish. Based on this information, as well as the information so far from water year 2022, yearling spring-run Chinook salmon migration are unlikely to overlap the February through April TUCP period.

The peak of young-of-year spring-run Chinook salmon abundance in the Delta occurs in April, coinciding with the last month of the TUCP (Table SR2). Entrainment of any migrating spring-run Chinook salmon at the south Delta export facilities during the February through April 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 and TUCP with DCC options (Table WR3 and Figure 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. Potential impacts of the TUCP were assessed with the Structured Decision Model Routing Application (see California Department of Water Resources 2020, Appendix E, Section E.4.6 *Structured Decision Model (Chinook Salmon Routing Application)* for method description). The results from this model suggested that through-Delta migration survival of juvenile spring-run Chinook salmon from the San Joaquin River basin would be minimal under the base case and all of the TUCP options (Table SR3), consistent with recent drought-year results from acoustic telemetry studies (Buchanan et al. 2018). There were small differences in estimates of

[9] See https://wildlife.ca.gov/Conservation/Watersheds/Water-Operations.

through-Delta survival between the base case and the TUCP and TUCP with DCC options, with slightly greater survival than the base case under the TUCP with Collinsville X2 option in February and March reflecting the positive relationship between south Delta exports and survival represented in the model. Overall, however, any differences between scenarios would be minimal relative to the very low survival that is estimated based on the drought hydrology.

Based on timing information in Table SR2 above, the highest relative abundance of adult spring-run Chinook salmon would be migrating through the Delta during the February through April TUCP period. As discussed for winter-run Chinook salmon, Delta Cross Channel operations would not differ between the base case and the TUCP and TUCP with Collinsville X2 options, 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 may be greater potential for migratory delay under the TUCP with DCC option because of DCC operations in February and March; see discussion for winter-run Chinook salmon. 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), although the 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 TUCP options and the base case for spring-run Chinook salmon adults returning during the TUCP February through April 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 ~150–400 cfs under the TUCP relative to the base case may have given the overall drought hydrology. However, if similar mechanisms apply as for fall-run Chinook salmon (Marston et al. 2012), there may be greater potential for straying under the TUCP.

Table SR3. Mean Monthly Probability of Through-Delta Survival of Juvenile Chinook Salmon from the San Joaquin River Basin Based on the Structured Decision Model Routing Application.

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	0.0042	0.0042 (0%)	0.0042 (0%)	0.0042 (0%)
March	0.0042	0.0041 (-1%)	0.0041 (-1%)	0.0051 (24%)
April	0.0041	0.0041 (-1%)	0.0041 (-1%)	0.0047 (14%)

Note: Percentage difference in parentheses represents TUCP options minus base.

Conclusions for Spring-run Chinook Salmon

In the Delta, a large portion of BY 2021 juvenile spring-run Chinook salmon may be in or migrating through the Delta during the February through April 2022 TUCP. The Salmon Monitoring Team has reported that BY 2020 yearlings have been outmigrating through the Delta in October and November, and thus they will have outmigrated prior to the TUCP period. Juvenile spring-run Chinook salmon in the Delta would not experience risk of high levels of south Delta entrainment in February through April 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 February through April under the TUCP and TUCP with DCC options 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 (with a greater negative effect under the TUCP with DCC option because of the Delta Cross Channel assumed to be open for half of February and March); the TUCP with Collinsville X2 option would have the same Freeport flow as the base case and therefore similar north Delta effects, with south Delta entrainment being kept at low levels by entrainment management as noted above. Through-Delta survival for juveniles emigrating from the San Joaquin River basin would be very low with or without the TUCP options because of the drought conditions. Migration conditions for adult spring-run Chinook salmon adults generally would be similar under the base case and TUCP and TUCP with Collinsville X2 options; there may be a greater potential for migratory delay because of Delta Cross Channel operations in February and March under the TUCP with DCC option. Less San Joaquin River flow under the TUCP 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 February through April period of the TUCP.

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											
Sac River (<river mile 391)	☒ ☒	☒ ☒	# #	# #	# #	# ☒	☒ ☒	☒ ▼	▼ ▼	▼ ▼	▼ ▼	▼ #
(e) Sub-Adults and Non-spawning adults	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac-SJ-SF Estuary	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	▼ ▼	▼ ▼	▼ ▼	▼ ▼	▼ ▼	▼ ▼	☒ ☒
Pacific Coast	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒
Coastal Bays & Estuaries	☒ ☒	☒ ☒	☒ ☒	☒ ☒	☒ ☒	▼ ▼	▼ ▼	▼ ▼	▼ (cell extends into Oct)	▼ ▼	▼ ▼	▼ ☒ ☒

[1] Sexually mature adults (≥4.8 feet TL females, ≥ 3.9 feet TL males including pre- and post- spawning individuals)

Sources: (a) (Heublein et al. 2009); (DuBois and Danos 2018; Klimley et al. 2015a; Mora et al. 2018; Poytress et al. 2015); (b) (Heublein et al. 2017; Poytress et al. 2015); (c) (Heublein et al. 2017; Poytress et al. 2015); (d) (California Department of Fish and Game 2002; Heublein et al. 2017; Poytress et al. 2015; Radtke 1966); (e) (DuBois and Danos 2018; Erickson and Webb 2007; Huff et al. 2011; Lindley et al. 2011; Lindley et al. 2008; Moser and Lindley 2007). Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bay).

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 as part of their critical habitat are expected to be minimally affected by the TUCP options' February through April 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 February through April 2021 in all cases and recent years have seen minimal salvage of green sturgeon, indicating that very low or zero salvage would be expected under the TUCP options.

The NMFS'sDPS 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); if drought conditions continue in 2022 then it would be uncertain the extent to which the difference in drought-year-flows between TUCP options 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 under the base case and all TUCP options, supporting the conclusion that very little recruitment may occur under any of the cases.

Adult green sturgeon will be potentially present in the Delta throughout the TUCP 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 increase straying and travel time of green sturgeon in this region during February through April, although this is uncertain.

<u>Conclusions for sDPS Green Sturgeon</u>

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 there is some uncertainty in the conclusion given the general lack of information on the species. There would be expected to continue to be little to no salvage of sDPS green sturgeon at the south Delta export facilities, consistent with recent years with greater levels of exports than the TUCP.

Central Valley Steelhead

<u>Presence and Life Stages of Central Valley Steelhead</u>

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 February through April 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 July through March with peak occurrence from September and October (Table SH2).

<u>Impacts of TUCP on Central Valley Steelhead</u>

Given the species' timing in the Delta (Table SH2), juvenile steelhead migrating through the Delta from the Sacramento River basin in February through April 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 0.02–0.05 (13–23%) less than the base case (Table SH3).

As shown in Table SH2, adult steelhead may occur in the Delta during February through April in medium numbers. 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, although there is potential for migratory delay under the TUCP with DCC option because of Delta Cross Channel operations. 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 ~150–400 cfs under the TUCP 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.

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.

[10] The equation used for this assessment was based on 2016 results because that year included flows generally covering the range assumed for February–April 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 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.

Table WR3. Mean Monthly Probability of Through-Delta Survival of Juvenile Steelhead Based on Buchanan et al. (2021).

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	0.23	0.20 (-13%)	0.20 (-13%)	0.20 (-13%)
March	0.21	0.19 (-13%)	0.19 (-13%)	0.19 (-13%)
April	0.24	0.19 (-23%)	0.19 (-23%)	0.19 (-23%)

Note: Percentage difference in parentheses represents TUCP options minus base.

<u>Conclusions for Steelhead</u>

The February through April 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 February through April 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 February through April, survival under the TUCP and TUCP with DCC options 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 (with a greater negative effect under the TUCP with DCC option because of the Delta Cross Channel assumed to be open for half of February and March). As noted for juvenile Chinook salmon, the TUCP with Collinsville X2 option would have the same Freeport flow as the base case and therefore similar north Delta effects, with south Delta entrainment being kept at low levels by entrainment management as noted above. Through-Delta survival for juveniles emigrating from the San Joaquin River basin would likely be lower under all TUCP options relative to the TUCP than the base case. Migration conditions for adult steelhead generally would be similar under the base case and TUCP and TUCP with Collinsville X2 options; there may be a greater potential for migratory delay because of Delta Cross Channel operations in February and March under the TUCP with DCC option. Less San Joaquin River flow under the TUCP could result in greater straying potential for adult spring-run 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 2020 CDFW Fall Midwater Trawl abundance index of delta smelt was zero for the third year in a row. Very few delta smelt are currently being collected in sampling: none were collected during the five Spring Kodiak Trawl surveys during January through May 2021; only a single individual was caught during the March through June 20-mm Survey; one delta smelt was captured in 16 weeks of Phase 1 Enhanced Delta Smelt Monitoring (EDSM; approximately 40–140 trawl samples per week), five delta smelt were captured in 12 weeks of Phase 2 EDSM (approximately 20–80 trawl samples per week), and only one delta smelt was captured in 17 weeks of Phase 3 EDSM (approximately 140 trawl samples per week).[11] The February through April TUCP period would overlap the spring portion of the adult spawning, and egg and larval/early juvenile periods. No delta smelt were salvaged by the CVP/SWP south Delta export facilities during WY 2021. Risk assessments[12] for delta smelt entrainment, undertaken as part of CDFW (2020) ITP implementation, concluded that based on distribution patterns over the past decade and rare detections in WY 2021, 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 in both the Sacramento River/confluence and central Delta areas.

Experimental releases of captive-reared Delta Smelt will occur for the first time in December 2021 through February 2022. Current plans are for releases of up to 45,000 fish in the lower Sacramento River. However, 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 February through April TUCP period would be low because south Delta exports would be at minimal levels (1,500 cfs) under the base case and TUCP and TUCP with DCC options, resulting in low negative levels of Old and Middle River flows (Table WR5) and low positive QWEST (which represents net flow in the lower San Joaquin River; Table DS1), both indicators of low south Delta entrainment risk. Although greater south Delta exports may occur under the TUCP with Collinsville X2 option February (~3,400 cfs in February and ~2,700 cfs in March, resulting in negative QWEST of a few hundred cfs), there will be continued risk assessment and, as necessary, operational adjustments as part of USFWS (2019)

[11] See https://www.fws.gov/lodi/juvenile_fish_monitoring_program/edsm/Enhanced%20Delta%20 Smelt%20Monitoring%20Report%20%28Weekly%20Summary%29/Archive/EDSM_report_ 211_2021_03_26.pdf, https://www.fws.gov/lodi/juvenile_fish_monitoring_program/edsm/ Enhanced%20Delta%20Smelt%20Monitoring%20Report%20%28Weekly%20Summary%29/Archive/ EDSM_report_212_2021_07_07.pdf, and Enhanced Delta Smelt Monitoring 2021 Phase 3 Sampling Preliminary Analysis 5pt DRAFT (fws.gov)

[12] See, for example, SMT Risk Assessment 22 June 2021 (ca.gov)

Biological Opinion and CDFW (2020) ITP implementation to limit entrainment risk until the end of June, when the management period ends because entrainment risk ends. See also Appendix A for Particle Tracking Modeling Analysis [Smelt Entrainment]).

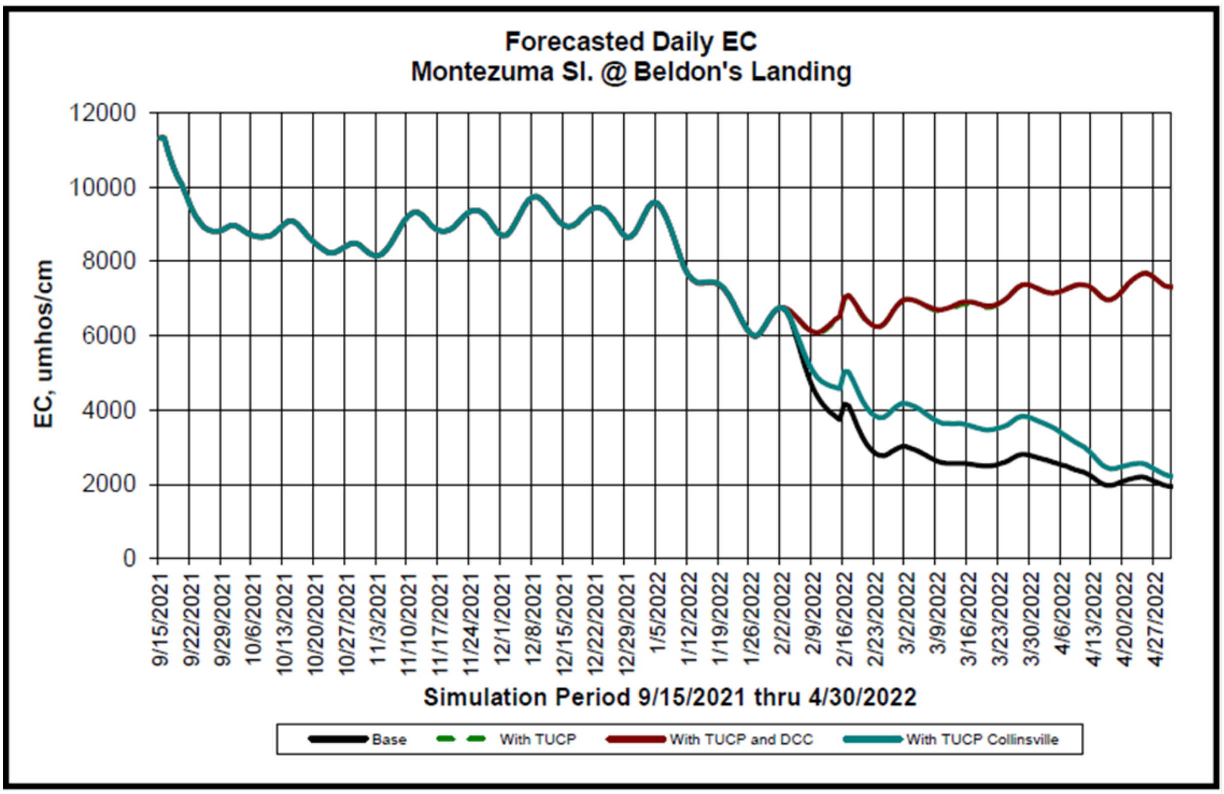
Table DS1. Mean Monthly QWEST (cfs) During the February through April TUCP Period.

Month	Base	TUCP	TUCP with DCC	TUCP with Collinsville X2
February	1,340	520	1,577	-724
March	1,056	345	1,428	-302
April	1,101	73	73	821

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 *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 and the TUCP with DCC options giving mean estimates of 25% lower density than the base case, and the TUCP with Collinsville X2 giving 5% 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. (2020) 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.

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 in January through May, including (among other areas) the waterways surrounding Grizzly Island such as Montezuma Slough. This area is relevant to consideration of potential TUCP effects because salinity could be affected and modeling information is available, whereas other hotspots are farther upstream and therefore unlikely to have negative salinity effects. DSM2 modeling suggests that conductivity in Montezuma Slough near Belden’s Landing would be around 6,000 µmhos/cm at the start of the TUCP period in February 2022 (Figure DS1). Conductivity under the TUCP and TUCP with DCC options would be in the range from 6,000 µmhos/cm to nearly 8,000 µmhos/cm until the end of April 2022, compared to 2,000–4,000 µmhos/cm under the base case, and the TUCP with Collinsville X2 option (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. However, Hamilton and Murphy's (2020) analysis examining habitat affinity as the difference between habitat availability and use found that for pre-spawning adult delta smelt in February a conductivity range of 350–6,100 µmhos/cm is suitable and a range of 350–10,000 µmhos/cm is adequate[13]. Based on this classification, the TUCP would not cause less than adequate habitat for pre-spawning delta smelt in Montezuma Slough at Belden's Landing. Hamilton and Murphy (2020) also found that for spawning adult delta smelt in March and April conductivity >1,630 µmhos/cm is unsuitable and conductivity >5,900 µmhos/cm is uninhabitable. Thus habitat for spawning adult delta smelt would be unsuitable under the base case and TUCP with Collinsville X2 options, with the TUCP and TUCP options resulting in uninhabitable conditions based on the classification. Larval/early juvenile delta smelt probability of occurrence in the 20-mm Survey is greatest at ~1,000–2,000 µmhos/cm and decreases as conductivity increases (Sommer and Mejia 2013). Thus, the TUCP may reduce the probability of occurrence of larval/early juvenile delta smelt in Montezuma Slough based on higher conductivity (Figure DS1).

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



Note: TUCP case (green broken line) is the same as the TUCP with DCC case (brown line).

[13] 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).

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) and therefore the potential for greater silverside abundance under the TUCP and TUCP with DCC cases, although with considerable uncertainty in differences given that outflow is at or below the range of data modeled by 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.

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 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 the TUCP could result in negative effects to delta smelt, based on higher March through May X2 under the TUCP and TUCP with DCC options (~88.3 km) and TUCP with Collinsville X2 option (~82.3 km) relative to the base case (~81.1 km).

<u>Conclusions for Delta Smelt</u>

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

The TUCP and TUCP with DCC options have the potential to result in negative changes to delta smelt habitat relative to the base case, including less zooplankton prey in the low salinity zone, greater silverside abundance, and higher salinity leading to lower probability of occurrence in areas of typically high population density, such as Montezuma Slough. Preliminary analyses discussed in the 2015 biological review and more recent peer-reviewed analyses suggest the potential for negative effects to delta smelt recruitment from less spring outflow under the TUCP, TUCP with DCC, and TUCP with Collinsville X2 options.

Longfin Smelt

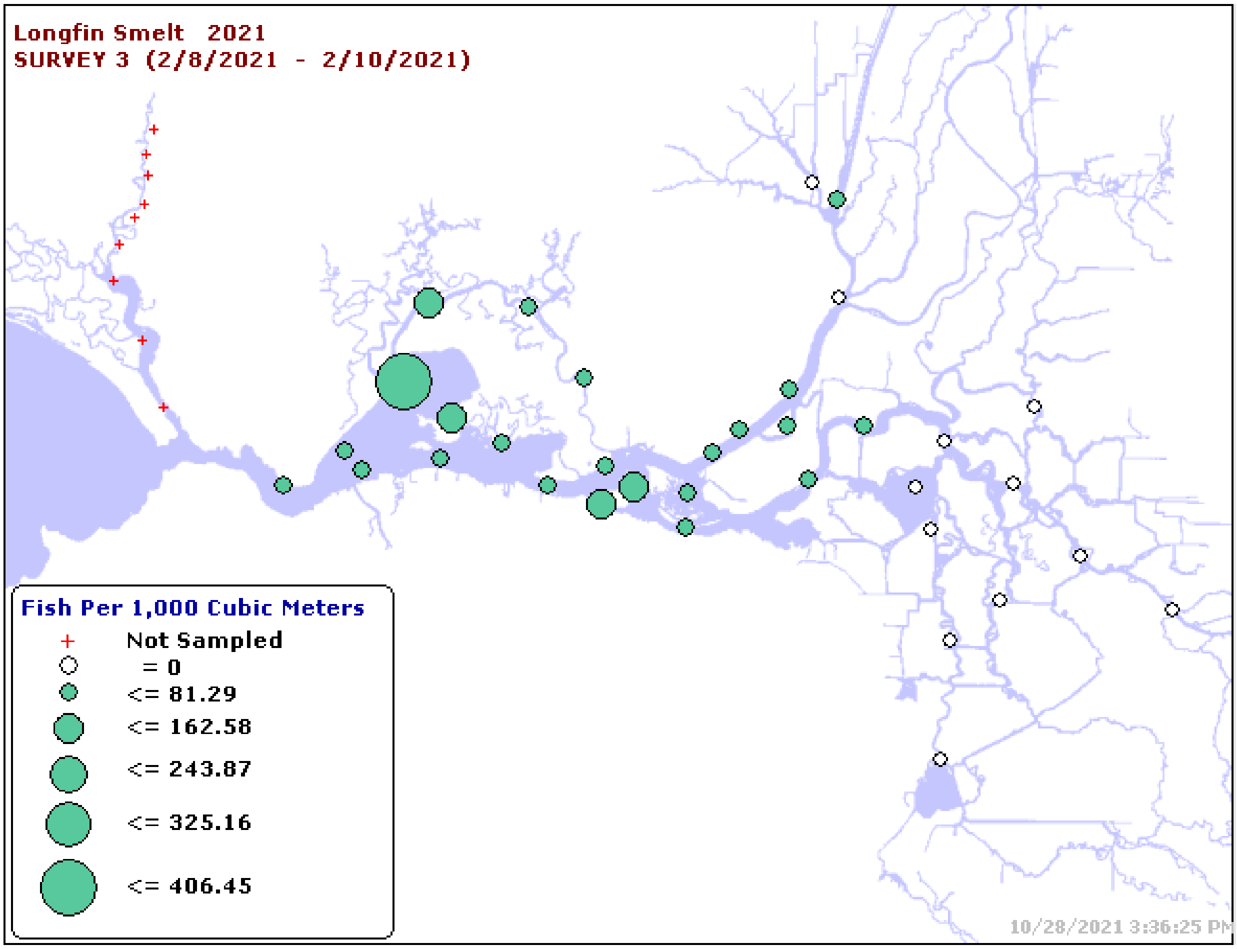
Presence and Life Stages of Longfin Smelt

The 2020 CDFW Fall Midwater Trawl abundance index for longfin smelt was 28, the lowest since the drought years of 2014–2016, and considerably less than the full survey period (1967–2020) mean of 6,571 and the 2000–2020 mean (406). During February through March 2021, within areas sampled by the Smelt Larva Survey,[14] larval and early juvenile longfin smelt occurred in highest density in or near Suisun Bay and at the confluence of the Sacramento and San Joaquin Rivers (Figures LFS1, LFS2, LFS3, LFS4). During March through April 2021, larval/early juvenile longfin smelt density in 20-mm Survey sampling was greatest in the lower Sacramento River (Figures LFS5, LFS6, LFS7). Although both the Smelt Larva Survey and 20-mm Survey indicated presence of longfin smelt larvae/early juveniles in or near the south Delta, density was very low relative to other areas (Figures LFS1, LFS2, LFS3, LFS3, LFS5, LFS6, LFS7). The number of longfin smelt juveniles salvaged was 0 in February 2021, 78 in March 2021, and 483 in April 2021, during a period of minimal south Delta exports.[15]

[14] 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.

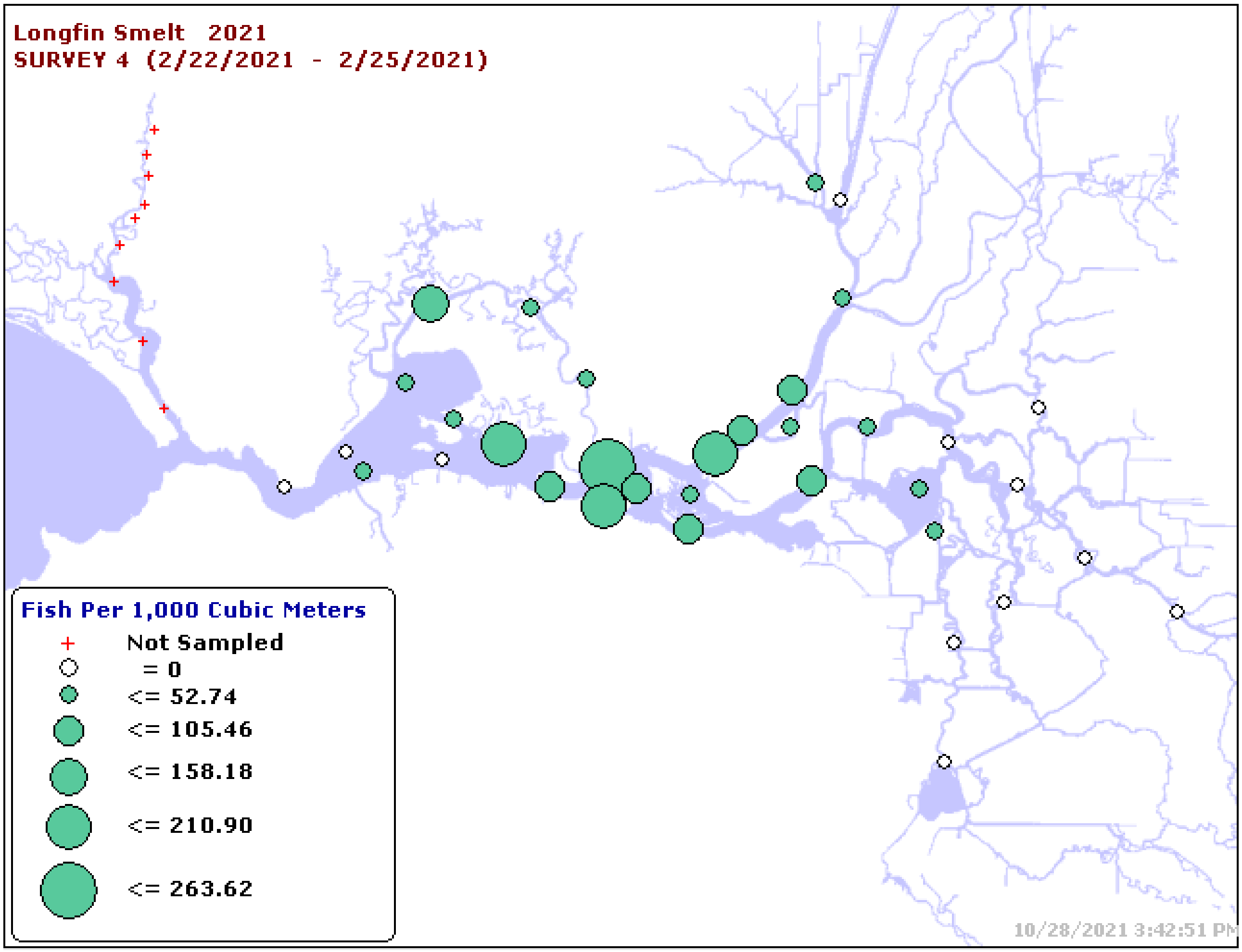
[15] Data from https://apps.wildlife.ca.gov/Salvage/Chart/AcrefeetSalvage?Adipose=All&SampMethod=Both&orgCode=25&orgDes=Longfin%20Smelt&endDate=09%2F30%2F2021%2000%3A00%3A00&StartDate=10%2F01%2F2020%2000%3A00%3A00&ShowValue=False.

Figure LFS1. Distribution of Longfin Smelt Larvae from Smelt Larva Survey 3, February 8–10, 2021.



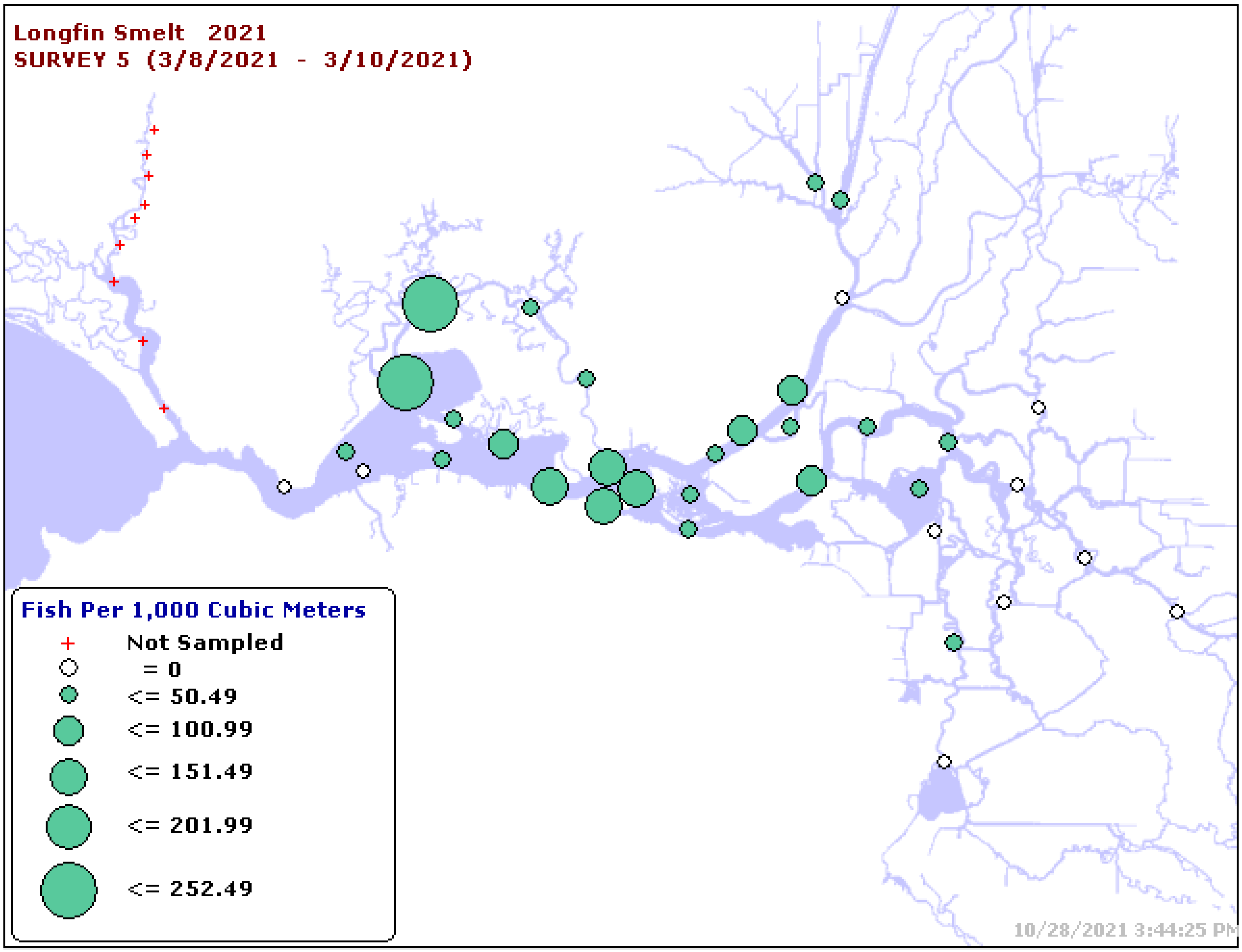
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

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



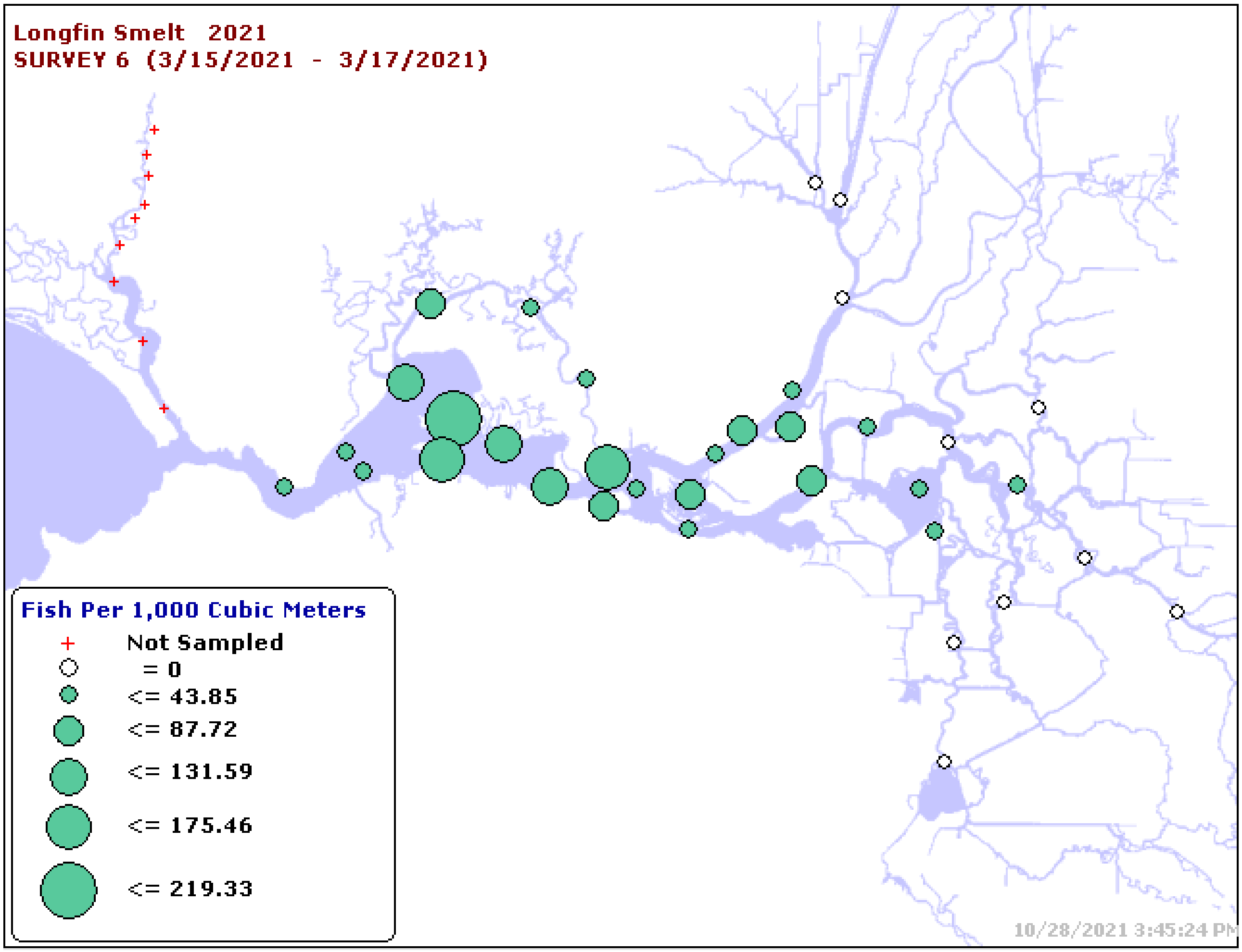
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

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



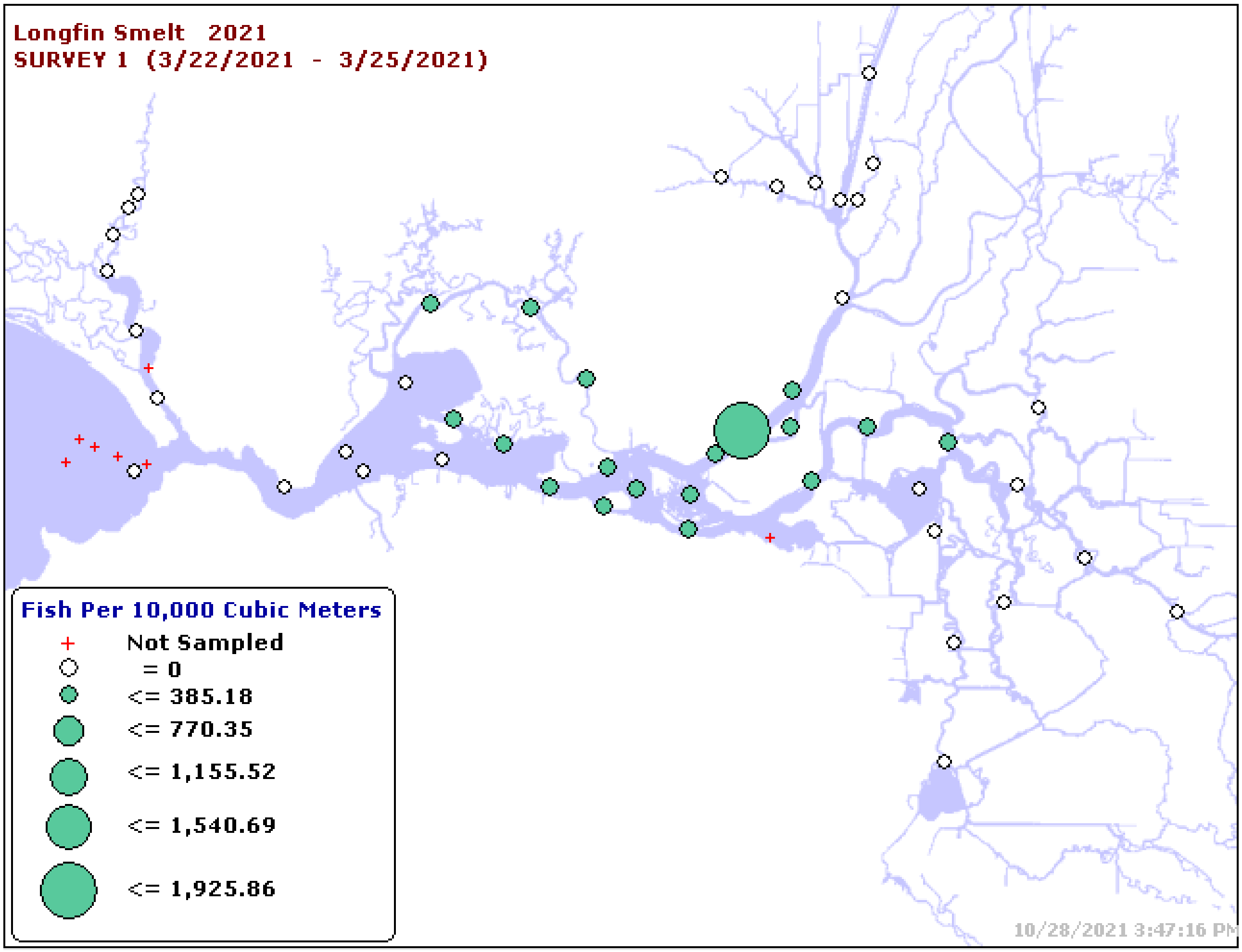
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

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



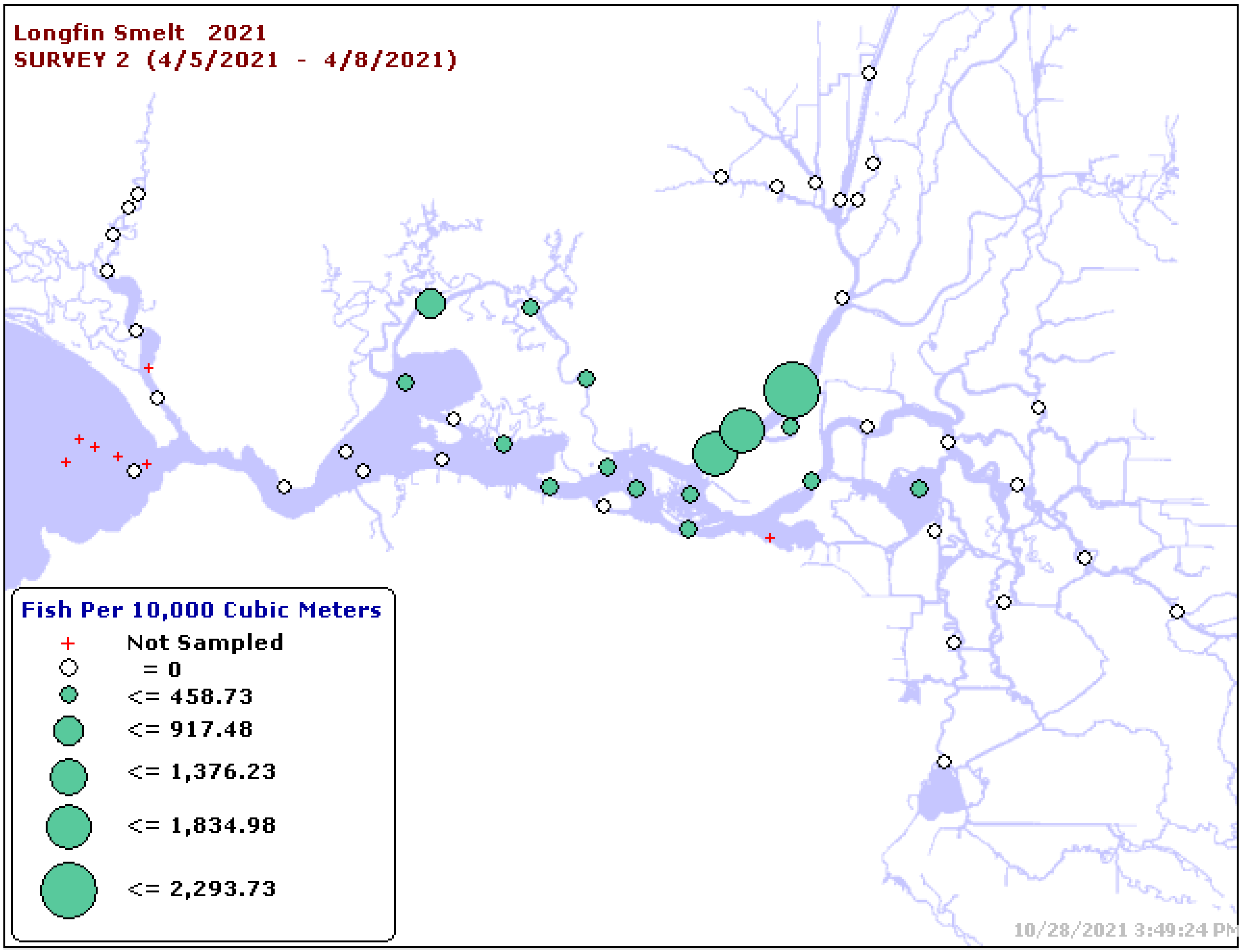
Source: https://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

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



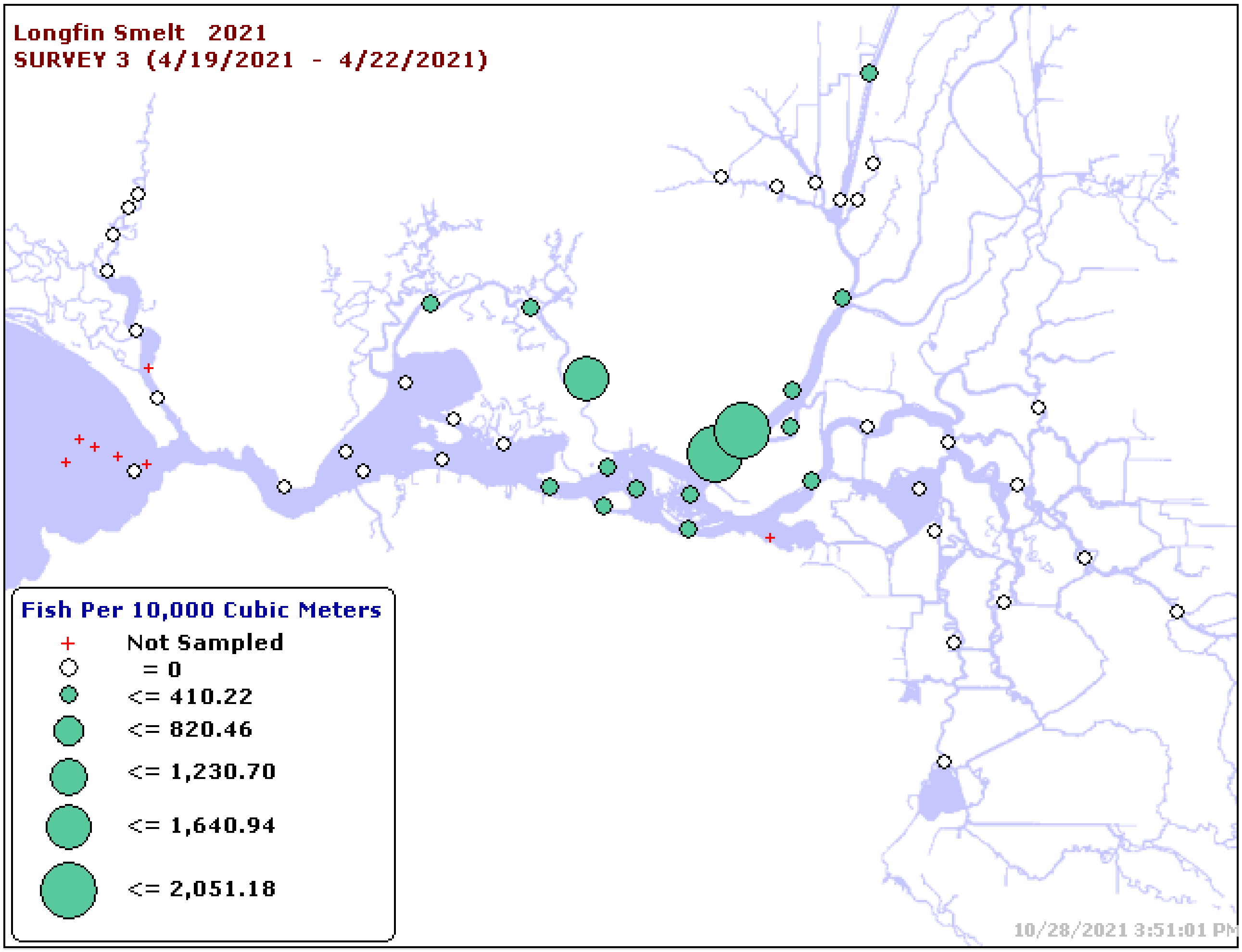
Source: https://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

Figure LFS6. Distribution of Longfin Smelt Larvae 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 Larvae from 20-mm Survey 3, April 19–22, 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). During the February through April 2022 TUCP period, south Delta exports would be at minimal levels (1,500 cfs) under the base case and TUCP and TUCP with DCC options, resulting in low negative levels of Old and Middle River flows and low positive QWEST (net flow in the lower San Joaquin River), both indicators of low south Delta entrainment risk. Although greater south Delta exports may occur under the TUCP with

Collinsville X2 option February (~3,400 cfs in February and ~2,700 cfs in March), 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. See also Appendix A for Particle Tracking Modeling Analysis [Smelt Entrainment]).

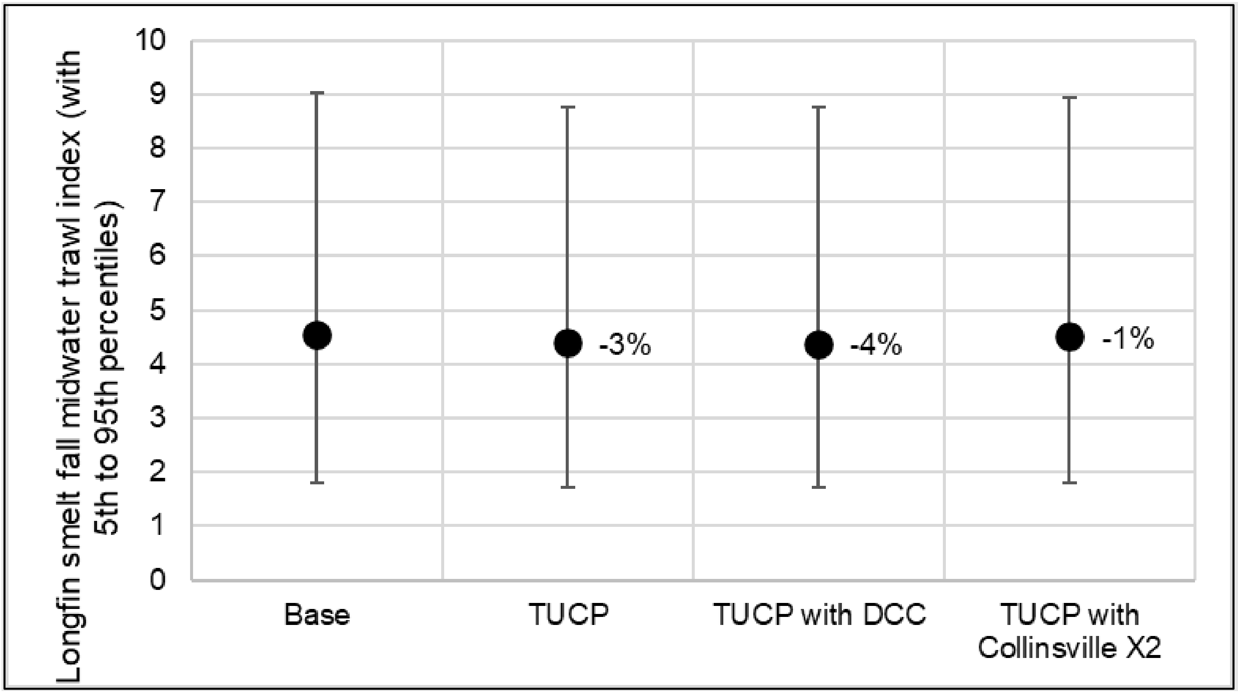
The TUCP will reduce Delta outflow from February to April relative to the base case. There are statistically significant relationships between longfin smelt abundance indices and winter-spring Delta outflow or X2 (e.g., Kimmerer et al. 2009; Thomson et al. 2010; Nobriga and Rosenfield 2016). The potential 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 the Appendix B). 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 would be small (1–4%; Figure LFS8). Based on the statistical model, the probability of longfin smelt Fall Midwater Trawl index under the TUCP and TUCP with DCC options being less than the base case is 0.52, i.e., 2% greater than a 50%:50% (equal) chance of the abundance index being greater or less than the base case. This relatively even probability is because of the variability in the model that is not related to Delta outflow. For the TUCP with Collinsville X2 option, there was an approximately even chance of the longfin smelt abundance index being greater or less than the base case. Any differences between the TUCP and the base case in longfin smelt abundance would 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 smelt 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 with Delta outflow (Figure ZOOP1) and so the TUCP would have very limited effects on mysids as a whole.

<u>Conclusions for Longfin Smelt</u>

Based on historical observations and drought hydrology that may continue during winter-spring 2022, longfin smelt are likely to experience relatively poor recruitment of juveniles in 2022. Lower Delta outflow could have limited negative effects on longfin smelt prey. The reduction in February through April 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 already poor environmental conditions due to the drought and statistical analysis suggesting that the probability of a lower abundance index under the TUCP options 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 February through April 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.

Figure LFS8. 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.

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.

<u>Impacts of TUCP on Other Native Species</u>

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. Entrainment at the south Delta export facilities would be expected to be low under the TUCP because of restrictions on south Delta exports. Adult fall-run Chinook salmon would not be expected to migrate through the Delta during the February through April 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 options may be limited primarily because the largest sturgeon recruitment occurs in wetter years (Fish 2010); as previously noted for green sturgeon, 2021 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 TUCP options 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 all TUCP options, supporting the conclusion that very little recruitment may occur under any of the cases.

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, which overlaps the TUCP February through April period. Application of the regression coefficients from Kimmerer et al. (2009) gives differences in bay shrimp mean abundance index of 17% less than the base case for the TUCP and TUCP with DCC options and 2% less than base case for the TUCP with Collinsville X2 option. A similar analysis for starry flounder gives a difference in mean abundance index of 33% less than the base case for TUCP and TUCP with DCC options and 6% less than the base case for the TUCP with Collinsville X2 option. 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 the Delta inflow would be appreciably greater during February through April under the base case than the TUCP and TUCP with DCC options, 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 24% less than the base case for TUCP and TUCP with DCC options and 5% less than the base case for the TUCP with Collinsville X2 option, and mean estimates for the fall midwater trawl survey that were 18% less than the base case for TUCP and TUCP with DCC options and 4% less than the base case for the TUCP with Collinsville X2 option. 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 12–27% less than the base case for TUCP and TUCP with DCC options and 1–3% less than the base case for the TUCP with Collinsville X2 option.

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. 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 TUCP, DWR and Reclamation will coordinate with the 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 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 2021 Drought Contingency Plan (DWR and Reclamation 2021) was prepared by DWR and Reclamation in an effort to provide updated information about areas of potential concern given the current dry hydrology of 2021. The Drought Contingency Plan was submitted by DWR 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 the LTO Implementation Agency Coordination meetings.

Over the past year, as part of implementing the action included in the 2019 Biological Opinions and ITP, DWR and Reclamation have worked with CDFW, NMFS USFWS, and the Water Board to identify actions that could potentially be implemented during a drought (not specifically for WY 2021) to manage the State's limited water supplies and protect species. These actions (known as the Drought Toolkit) 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 Water Board as any actions from that Toolkit are being considered for implementation in WY 2022.

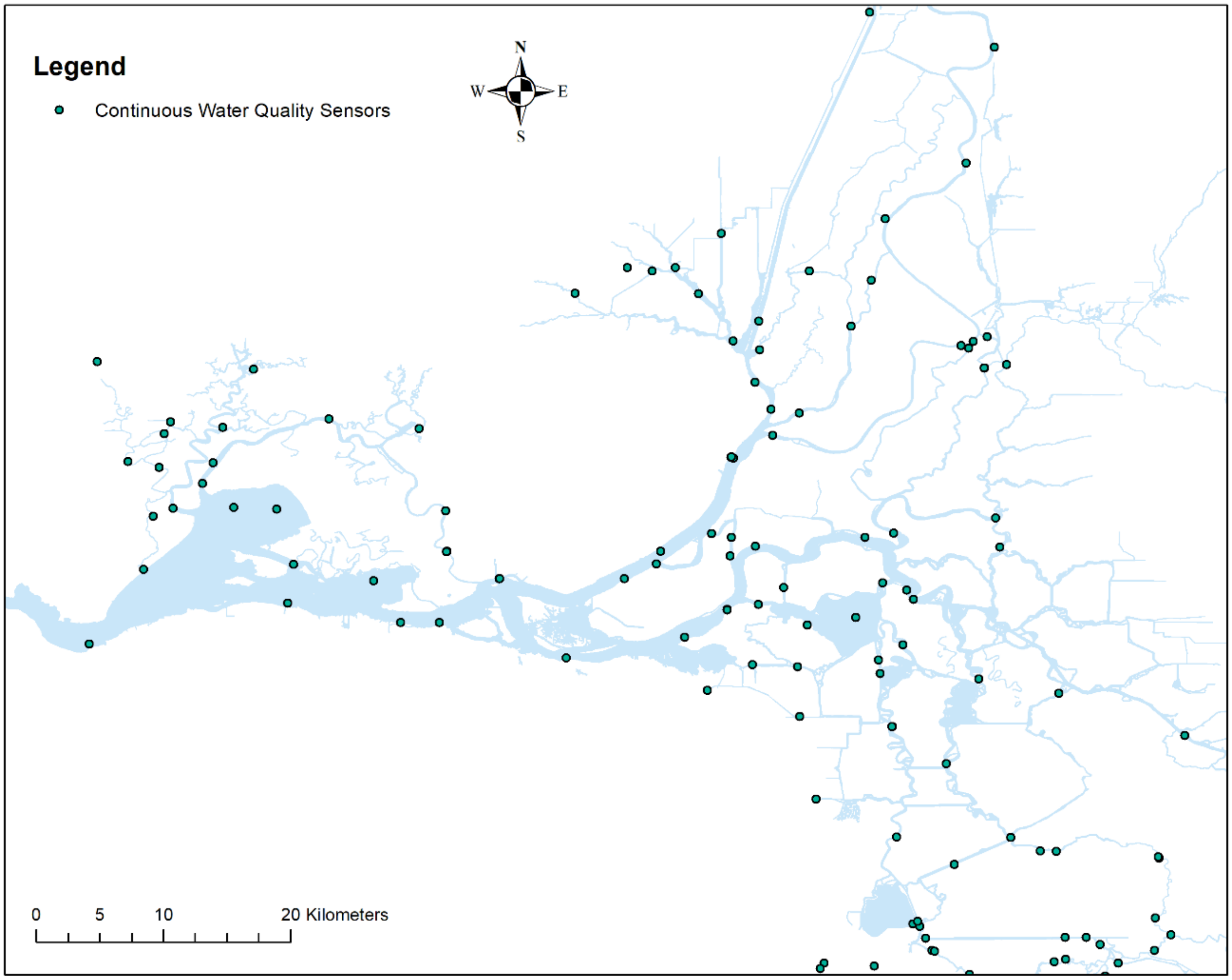
Prior to this petition, DWR and Reclamation provided weekly hydrology and condition updates through WOMT. DWR and Reclamation have met with the Water Board staff and with representatives of CDFW, NMFS and USFWS, to discuss the elements of this petition, and will continue to provide updates and to seek 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 through completion of the 2022 Drought Contingency Plan through the Long-Term Operations Agency Coordination Team. DWR shall also provide the Water Board an updated harmful algal blooms (HABs) report in March 2023.

Drought Ecosystem Monitoring and Synthesis Plan

The 2021 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.

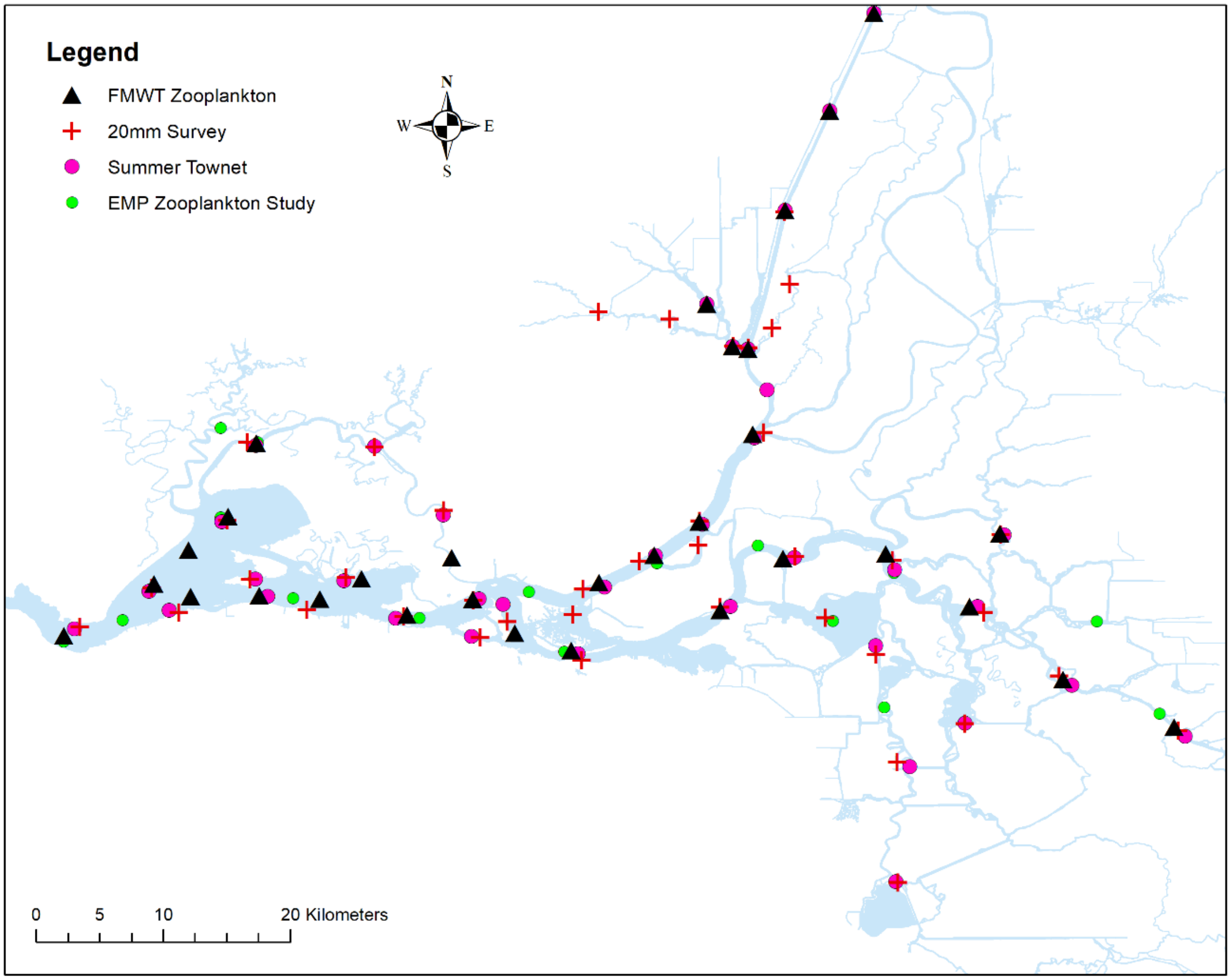
Monitoring covers the legal Delta and Suisun Marsh (Figures MON1 through MON4). In some cases, it will include limited data collection outside these areas where necessary to describe habitat for anadromous species.

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



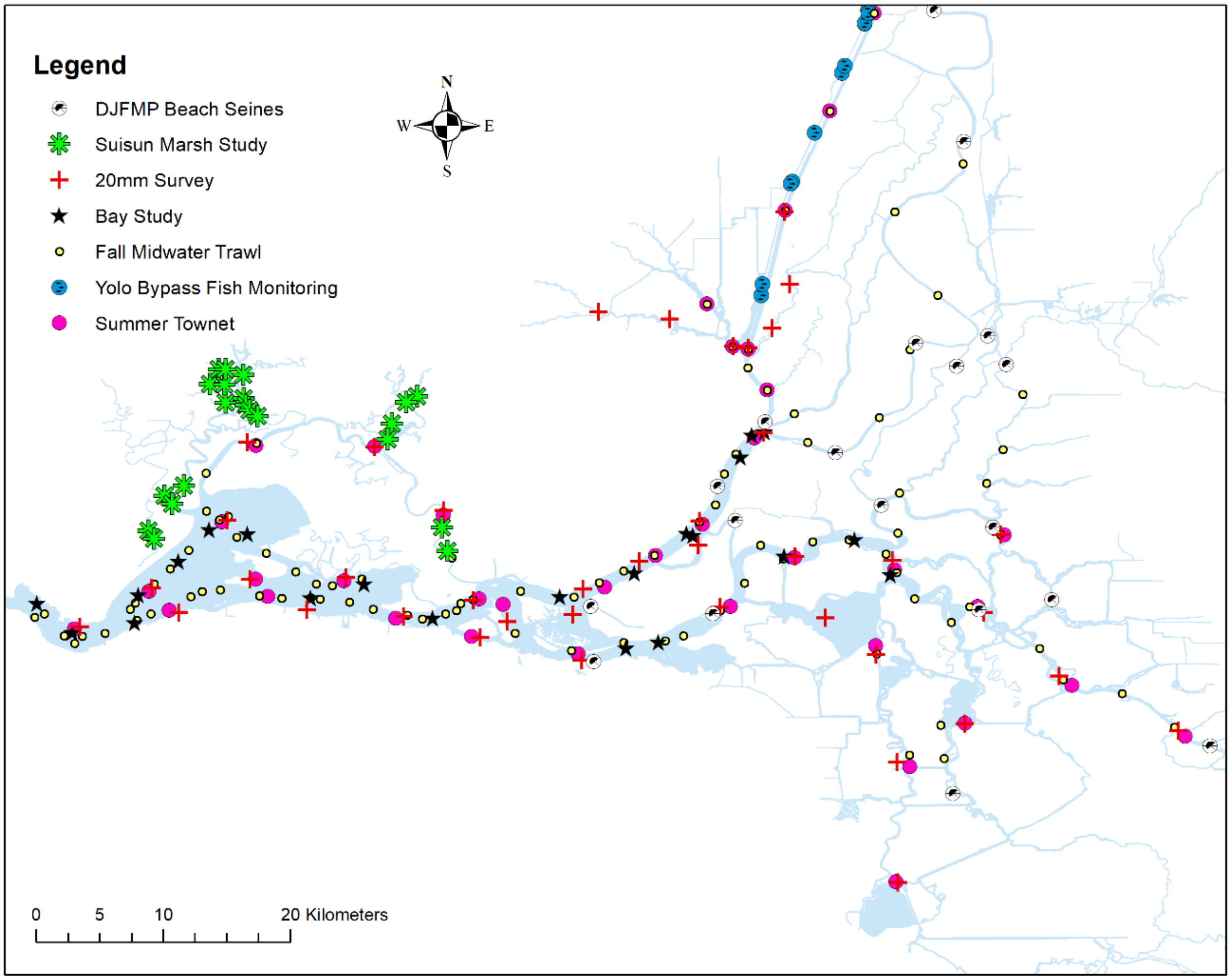
Source: DWR and IEP 2021.

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.



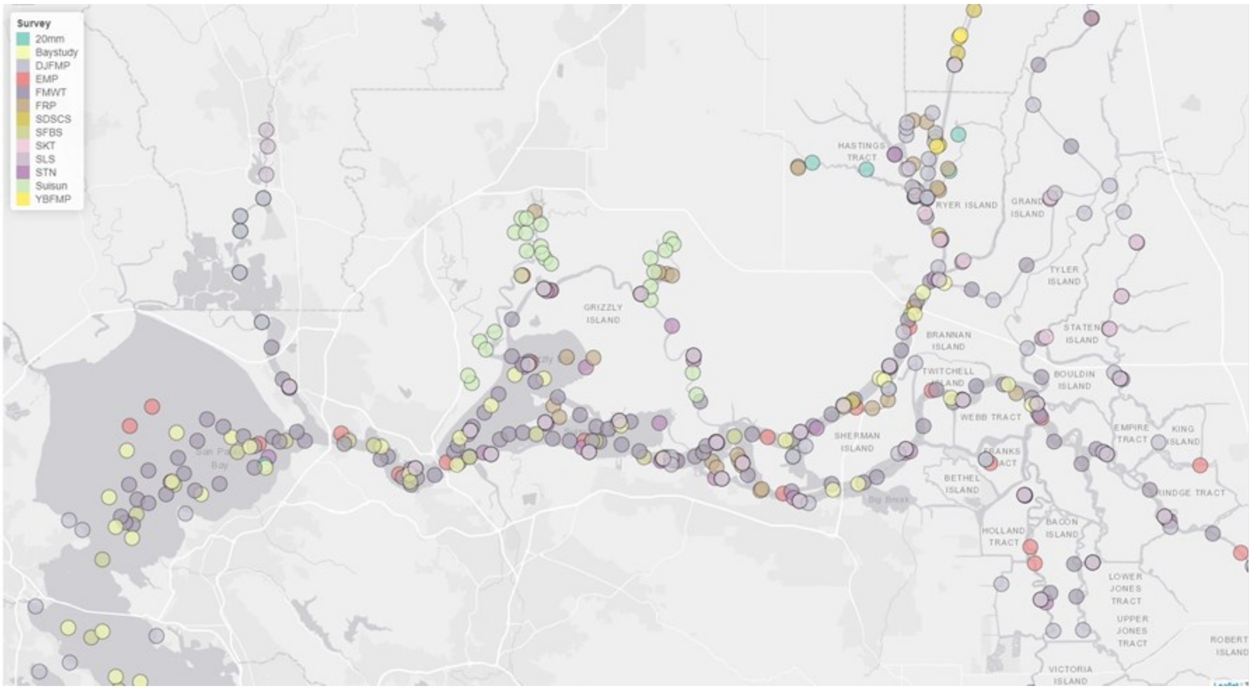
Source: DWR and IEP 2021.

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/.

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APPENDIX A: PARTICLE TRACKING MODELING ANALYSIS (SMELT ENTRAINMENT)

Methods

DSM2 particle tracking modeling (PTM) was used to assess hydrodynamic differences between scenarios to provide information regarding potential larval 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 delta smelt (DWR 2020: Appendix E, p.E-1) and longfin smelt (DWR 2020: Appendix E, p.E-13). The present analysis used PTM modeling for the base case, TUCP, TUCP with DCC, and TUCP with Collinsville X2. For delta smelt, the analysis focused on 60-day outputs for neutrally buoyant particles released at the beginning of March 2022 and April 2022[1]; for longfin smelt, the analysis focused on 90-day outputs for surface-oriented particles released at the beginning of December 2021, January 2022, February 2022, March 2022, and April 2022.

Delta Smelt

The PTM weighted by delta smelt distribution for the base case resulted in entrainment of ~14% of particles in March and ~10% of particles in April (Figure PTM_DS1). Under the TUCP options, entrainment was ~15–22% in March and ~11–19% April, a relative increase over the base case of 12–88% (Figure PTM_DS1). Note that under the TUCP and TUCP with DCC cases, 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. Although the TUCP with Collinsville X2 case has assumed Old and Middle River flows in February (-2,957 cfs) and March (-2,452 cfs) that are more negative than -2,000 cfs and are reflected in the DSM2 modeling results, Old and Middle River flow management as required under the USFWS (2019: 395) biological opinion would be implemented in order to ensure the incidental take limit is not exceeded. This management involves adjusting south Delta exports based on turbidity at the Bacon Island monitoring station (USFWS 2019: 395).

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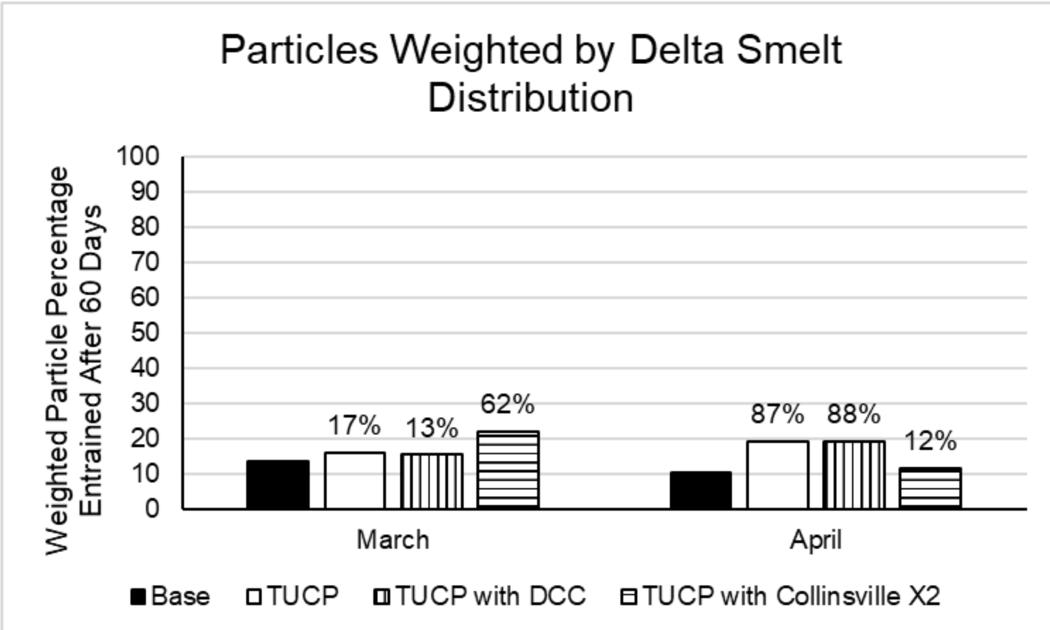
[1] DSM2 hydrodynamic data were not available to simulate particles released in May and June, which is also part of the delta smelt larval period, although the 60-day tracking period for particles released in April provides information.

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

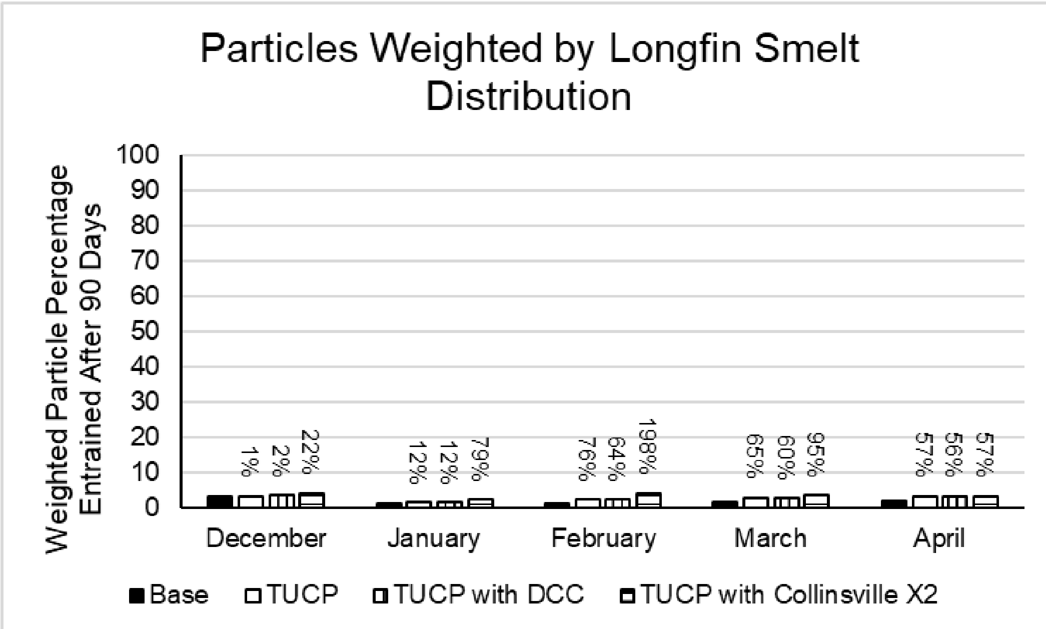


Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Longfin Smelt

The PTM weighted by longfin smelt distribution for the base case resulted in entrainment of ~1.3–3.4% of particles in December–April (Figure PTM_LFS1). Under the TUCP options, weighted particle entrainment was ~1.5–4.1%, a relative increase over the base case of ~1–200% (Figure PTM_LFS1).

Figure PTM_LFS1. Percentage of Particles Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant Weighted by Longfin Smelt Distribution.

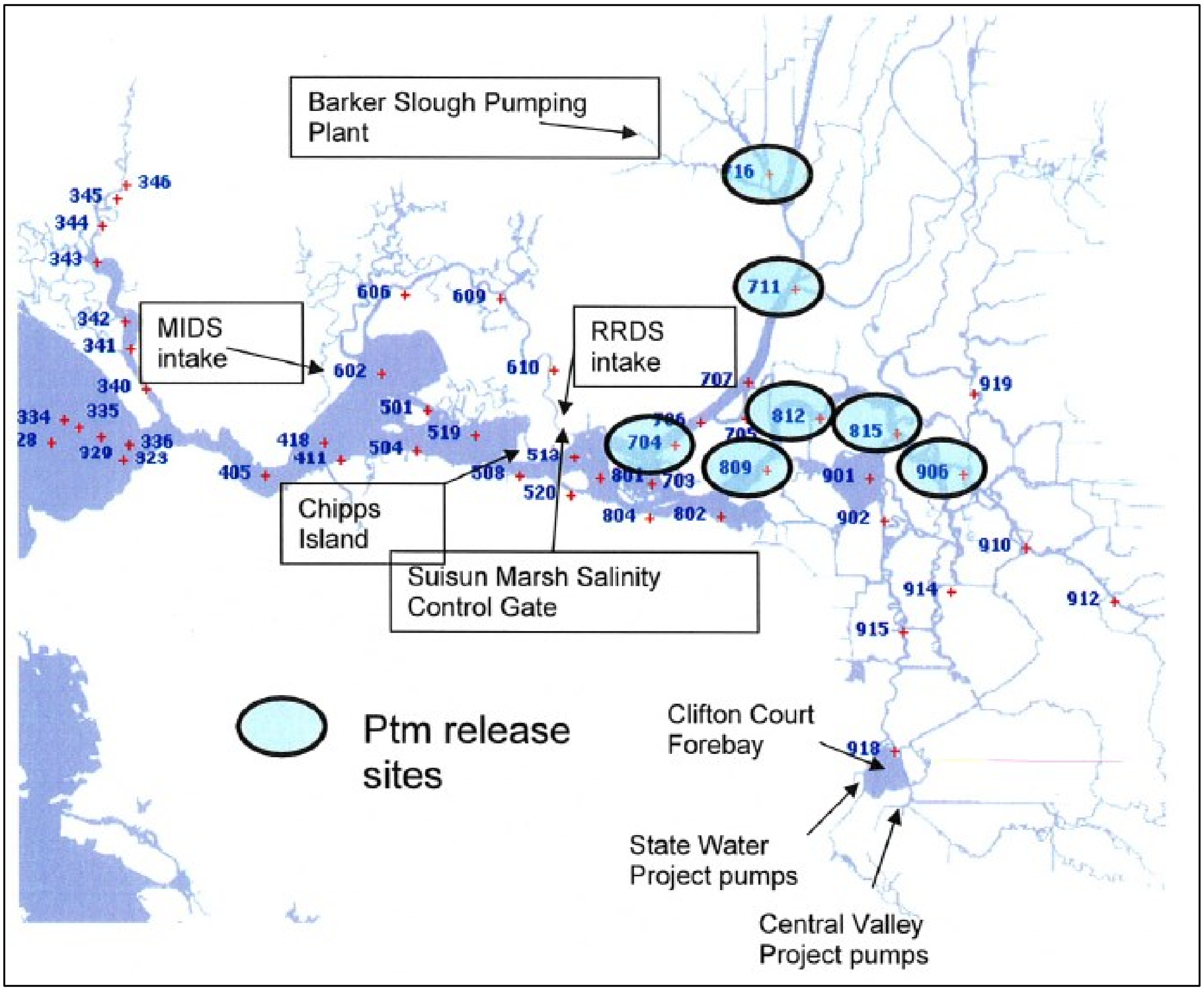


Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Additional perspective is provided through consideration of the subset of PTM stations highlighted by California Department of Fish and Game (2009; Figure PTM_LFS2). The results included relatively low absolute levels of particle entrainment at stations 704 (Figure PTM_LFS3), 711 (Figure PTM_LFS4), 716 (Figure PTM_LFS5), and 809 (Figure PTM_LFS6), with greater absolute levels of particle entrainment at stations 812 (Figure PTM_LFS7), 815 (Figure PTM_LFS8), and 906 (Figure PTM_LFS9). In general, the TUCP with Collinsville X2 case had the largest relative difference in particle entrainment compared to the base case.

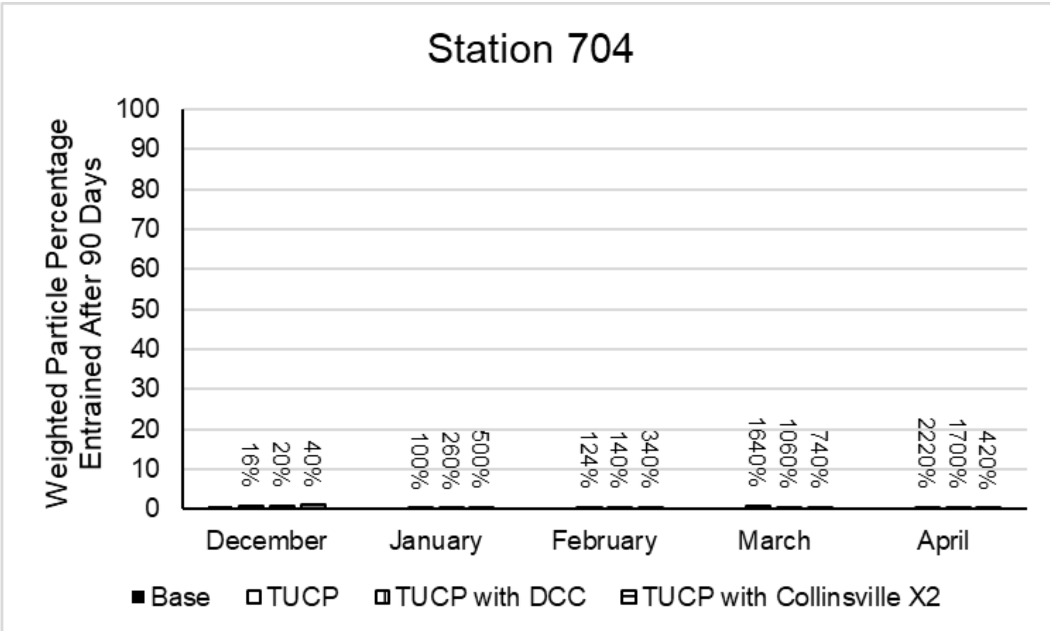
Note that during February–April Old and Middle River flows were modeled to be -1,468 cfs to -1,216 cfs for the TUCP and TUCP with DCC cases, which is near or above the upper end of the -1,250 cfs to -5,000 cfs range required for January–June larval and juvenile longfin smelt entrainment protection under the California Department of Fish and Wildlife (2020) ITP. Although February–April Old and Middle River flow for the TUCP with Collinsville X2 case was modeled to be -2,957 cfs to -1,468 cfs, real-time risk assessment under the California Department of Fish and Wildlife (2020) ITP may recommend lower exports (i.e., higher [less negative] Old and Middle River flow) if these assumed levels of Old and Middle River flow were assessed not to be protective of larval and juvenile longfin smelt.

Figure PTM_LFS2. Particle Tracking Injection (Release) Locations Used by California Department of Fish and Game (2009)



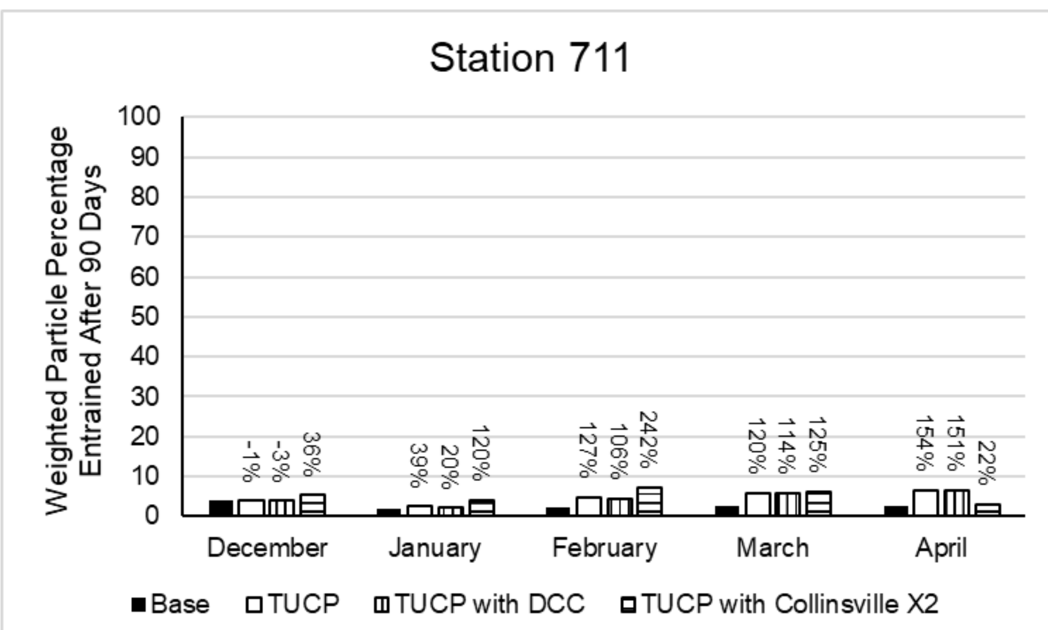
Source: California Department of Fish and Game (2009).

Figure PTM_LFS3. Percentage of Particles Released at Station 704 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



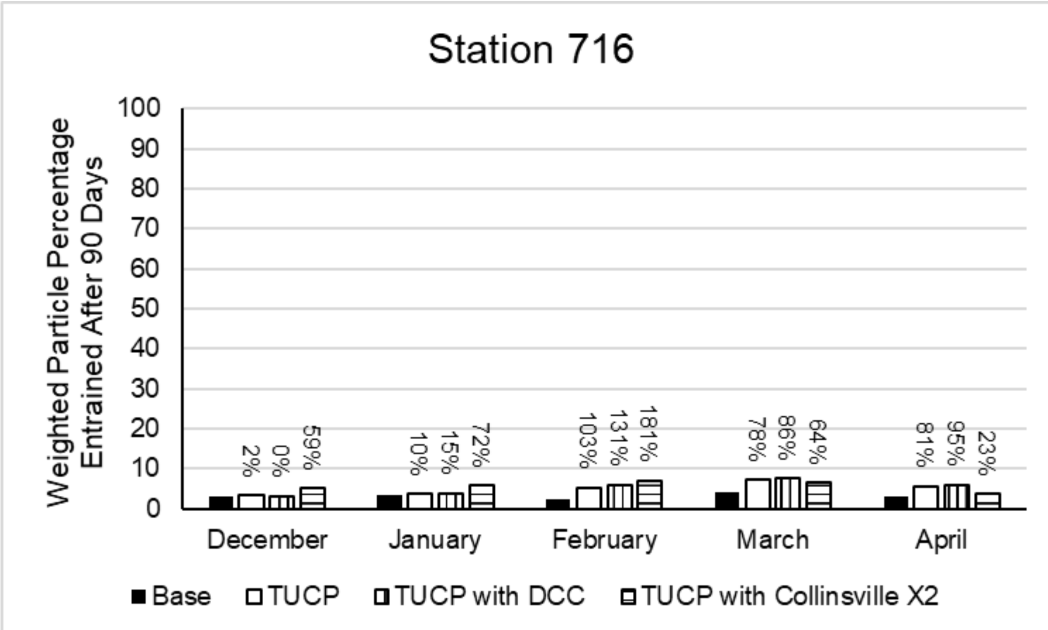
Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Figure PTM_LFS4. Percentage of Particles Released at Station 711 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



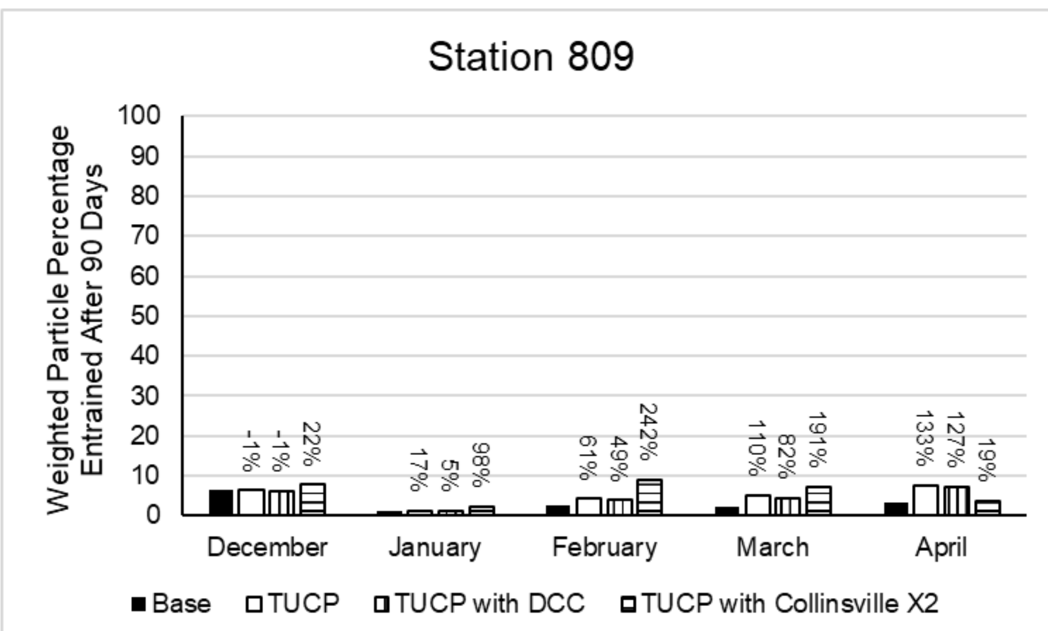
Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Figure PTM_LFS5. Percentage of Particles Released at Station 716 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



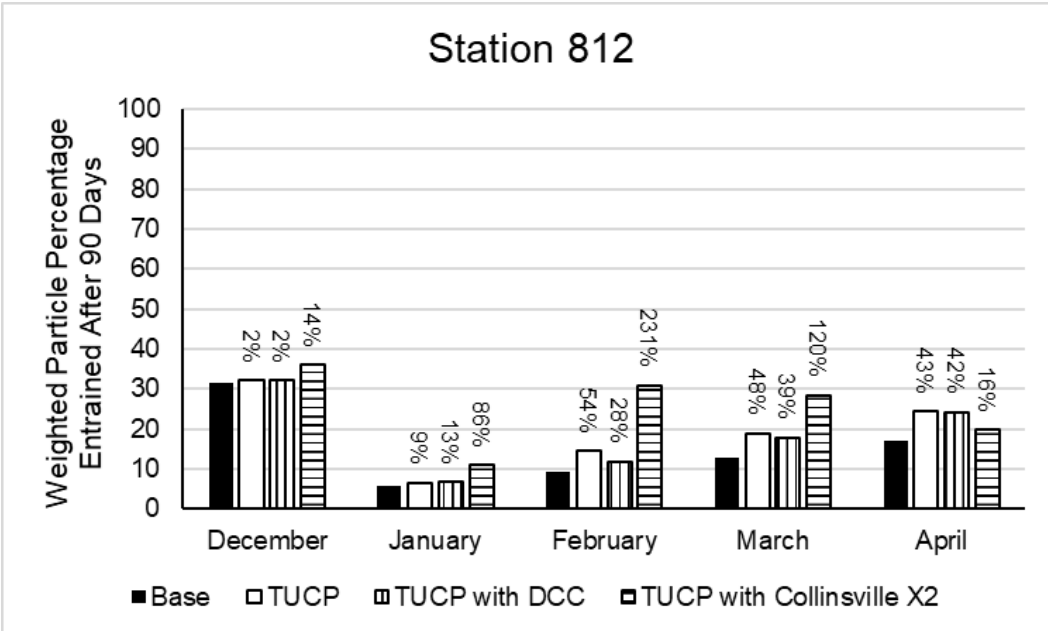
Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Figure PTM_LFS6. Percentage of Particles Released at Station 809 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



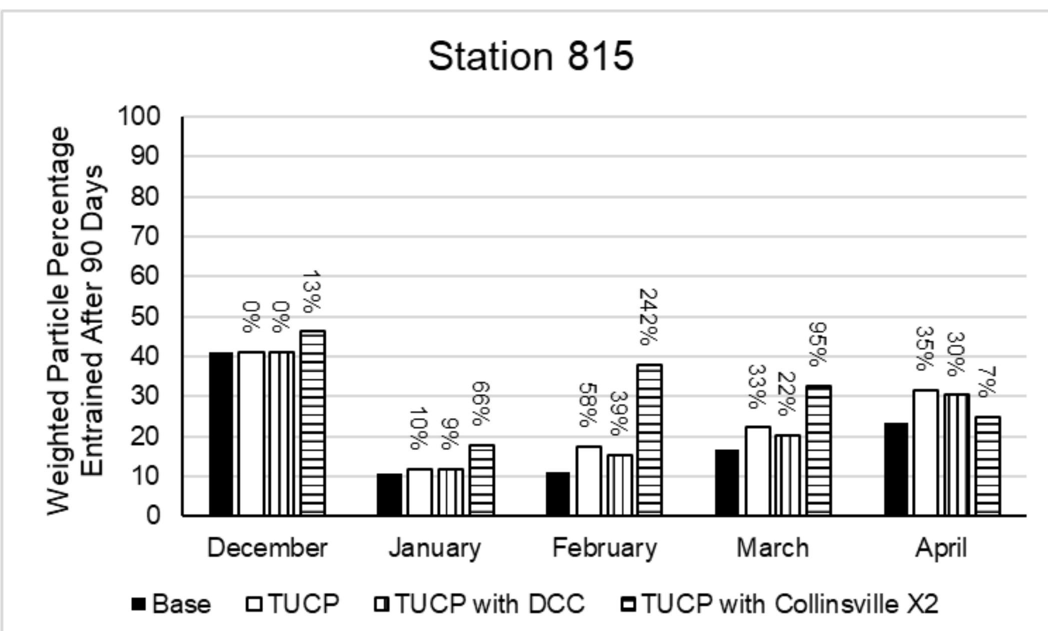
Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Figure PTM_LFS7. Percentage of Particles Released at Station 812 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



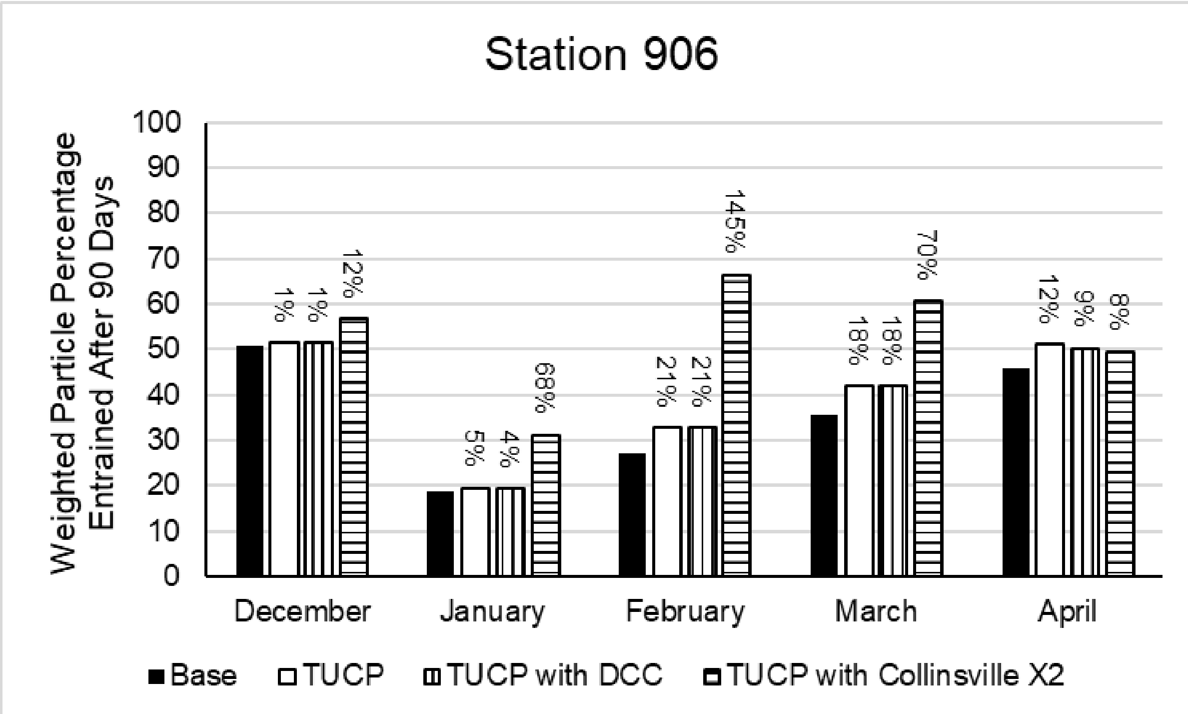
Note: Percentages above bars indicate relative difference between TUCP cases and the base case.

Figure PTM_LFS8. Percentage of Particles Released at Station 815 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



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

Figure PTM_LFS9. Percentage of Particles Released at Station 906 Entrained at the South Delta Export Facilities and Barker Slough Pumping Plant.



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

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APPENDIX B: LONGFIN SMELT DELTA OUTFLOW–ABUNDANCE INDEX ANALYSIS

Development of Statistical Relationship

The potential effect of the TUCP options 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 $\hat{R}$ <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

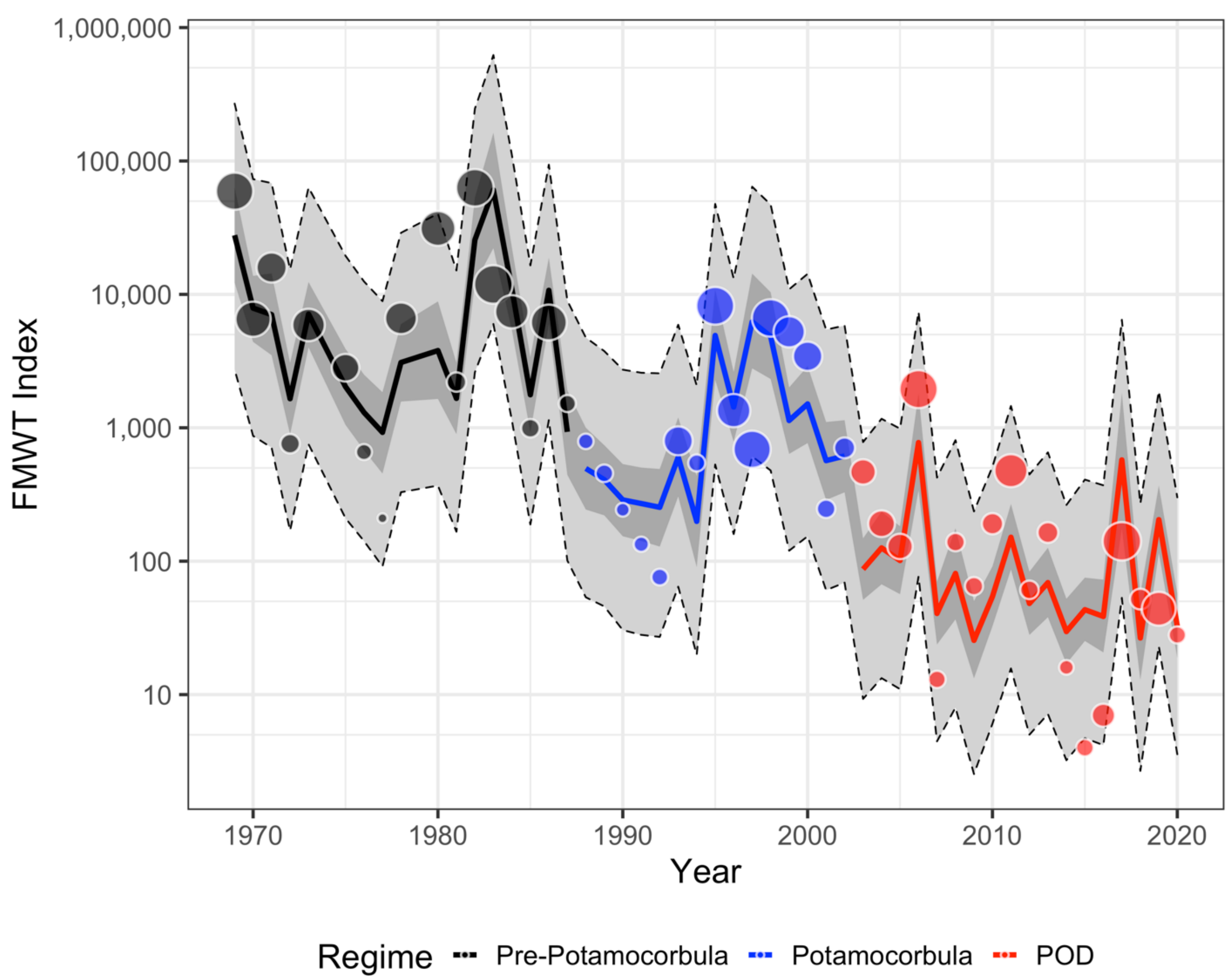
Note: AIC_c = Akaike's Information Criterion adjusted for small sample sizes; Δ AIC_c = difference in AIC_c from given model and best model; Wt(AIC_c) = AIC_c weight; K = number of estimated parameters (including the residual variance); LL = log likelihood of the model fits given the assumption of log-normally 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, TUCP, TUCP with DCC, and TUCP with Collinsville X2 were generated from the Bayesian posterior distributions from the best model, which can be written:

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

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

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 2021 under the different cases (base case: 2,651,640 acre-feet; TUCP and TUCP with DCC cases: 1,697,062 acre-feet; TUCP with Collinsville X2 case: 2,423,983 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 options were then calculated as

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[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.

the mean, 5th percentile, and 95th percentile of posterior predictive distributions for each case. The probability of the 2022 fall midwater trawl index being less than the base case was calculated for each TUCP option as the percentage of the posterior predictive distribution that was less than the base case.

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Attachment 3:

Summary of Primary Modeling Assumptions for February through April 2022

	Base (No TUCP)				TUCP / TUCP with DCC				TUCP with Collinsville X2			
	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports	NDOI	SJR at Vernalis	Sac R at Freeport	Combined Exports
Month	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
February	9,164	916	10,181	1,500	4,000	763	5,170	1,500	7,100	763	10,181	3,411
March	8,458	846	9,825	1,500	4,000	710	5,502	1,500	7,100	710	9,825	2,722
April	9,902	990	11,544	1,500	4,000	710	5,922	1,500	9,622	710	11,544	1,500