



2022

Drought and Dry Year Actions Report



— BUREAU OF —
RECLAMATION

Mission Statements

U.S. Department of the Interior

The U.S. Department of the Interior conserves and manages the nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

U.S. Bureau of Reclamation

The mission of the U.S. Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

California Department of Water Resources

The mission of the California Department of Water Resources is to sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments.

2022

Drought and Dry Year Actions Report

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Acronyms and Abbreviations

CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CSTARS	Center for Remote Sensing and Spatial Technologies
CVO	Central Valley Office
CVP	Central Valley Project
DCC	Delta Cross Channel
DCP	State Water Project and Central Valley Project Drought Contingency Plan
Delta	Sacramento-San Joaquin Delta
DRY	drought relief year
DWR	California Department of Water Resources
EAV	emergent aquatic vegetation
EDSB	emergency drought salinity barrier
FAV	floating aquatic vegetation
FHAB	freshwater and estuarine harmful algal bloom
FOG	Feather Operations Group
FRFH	Feather River Fish Hatchery
GIS	geographic information system
HAB	harmful algal bloom
IEP	Interagency Ecological Program
ITP	incidental take permit
LFC	low-flow channel
LSNFH	Livingston Stone National Fish Hatchery

NMFS	National Marine Fisheries Service
Petitions	petitions for temporary transfer
Reclamation	U.S. Bureau of Reclamation
SAV	submerged aquatic vegetation
SFEI	San Francisco Estuary Institute
SRSC	Sacramento River Settlement Contractors
State Water Board	California State Water Resources Control Board
SWP	State Water Project
taf	thousand acre-feet
TAO	Thermalito Afterbay Outlet
TCCA	Tehama Colusa Canal Authority
TMP	Temperature Management Plan
TUCO	temporary change petition order
TUCP	temporary urgency change petition
UC	University of California
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WOMT	Water Operations Management Team
WY	Water Year
°F	degrees Fahrenheit

Purpose

This document provides information on the drought response actions implemented in Water Year (WY) 2022. The California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation) developed a drought contingency plan that provided an initial outline of areas of potential concern given the observed dry hydrology of WY 2022. Drought actions included in this report are from the *State Water Project and Central Valley Project Drought Contingency Plan* (DCP) (DWR and Reclamation 2022) and from the *Drought Toolkit* (Reclamation 2022).

Background

As detailed in the *Drought Toolkit*, the Drought Relief Year (DRY) Team can be activated by Water Operations Management Team (WOMT) in water years where hydrology or water storage and environmental conditions (e.g., drought) present challenging water management decisions that cannot be fully addressed by annual operations planning. In those years, and once activated, the DRY Team will coordinate and review potential actions meant to avoid or mitigate drought impacts.

The DRY Team is composed of staff from multiple agencies including Reclamation, DWR, United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Wildlife (CDFW), and California State Water Resources Control Board (State Water Board) (Table 1). The staff membership of the DRY team is considered and confirmed by each participating agency at the time of activation of the DRY team by WOMT. Technical staff provide information pertaining to the implementation and effectiveness of the actions disclosed in this annual report, which is then reviewed by the DRY Team.

Table 1 DRY Team Representatives (Updated 11/1/2022)

Agency	Representative
U.S. Bureau of Reclamation	Adam Nickels
U.S. Fish and Wildlife Service	Jana Affonso, Jim Earley, Kim Squires
National Marine Fisheries Service	Evan Sawyer
California Department of Water Resources	Kevin Clark, Chris Wilkinson
California Department of Fish and Wildlife	Crystal Rigby, Erica Meyers
State Water Resources Control Board	Craig Williams, Erin Foresman

WY 2022 was the second year that the DRY Team was activated. Specifically, the DRY Team was charged with refining the *Drought Toolkit*. The DRY Team completed a revised *Drought Toolkit* in November 2022.

The DCP provided an efficient way of communicating the interagency drought response such that it could be used to satisfy both the commitments made in Reclamation’s final biological assessment and the requirements of the NMFS biological opinion for the long-term operations of the State Water Project (SWP) and Central Valley Project (CVP), as well as the requirements of the incidental take permit (ITP) for the SWP. The multiple iterations of, and addendums to, the DCP have been used as a means of disclosing and communicating actions taken to address drought conditions in WY 2022.

Key to understanding and improving drought response actions is evaluation of those actions. This report, which satisfies the commitment made in Reclamation’s biological assessment to assess the effectiveness of drought response measures, also satisfies the similar reporting requirement of the ITP.

Discussion

Interim Operations Plan (IOP)

In WY 2022, the Central Valley was classified as critically dry according to both the [Sacramento Valley and the San Joaquin Valley Hydrologic Classification Indices](#), and consequently, Shasta Reservoir temperature management was limited by these dry conditions. WY 2022 followed a critically dry year in 2021 and a dry year in 2020. WY 2022 was also marked by the driest January through March period on record. Given the extremely dry conditions, the U.S. District Court ordered an IOP, on March 14, 2022, which identified priorities and planning efforts for Shasta Reservoir cold water pool management to meet operational priorities and species needs. This IOP included establishing a six-agency Shasta Planning Group to work iteratively with the technical groups to solicit operational guidance and risk assessments and provide policy guidance, as necessary. Additionally, because the IOP superseded a number of the operational commitments and requirements of the CVP and SWP, the IOP limited the type and number of drought actions that could be considered for implementation.

2022 Urgent Actions to Protect Sacramento River Chinook Salmon

In addition to the actions described in the DCP and *Drought Toolkit* that were taken in 2022, an additional number of urgent actions were implemented specific to the protection of Sacramento River Chinook salmon. Although not discussed or coordinated with the DRY Team, these actions are identified in this report so as to provide reference to the additional measures taken in response to drought conditions, but not directly related to water operations or water right decision processes.

Specifically, in response to a third consecutive year of drought, NMFS, USFWS, and CDFW initiated conversations to identify urgent actions to protect winter-run and spring-run Chinook salmon in the Sacramento River. Ultimately NMFS, USFWS, and CDFW, identified four, additional, urgent actions to implement in 2022 that were intended to help mitigate the impacts of continued drought on winter-run and spring-run Chinook salmon.

1. Relocate a portion of adult winter-run Chinook salmon trapped at Coleman National Fish Hatchery and the Keswick Dam fish trap to Battle Creek, upstream of Eagle Canyon Dam.

2. Relocate spring-run Chinook salmon collected incidentally at the Keswick Dam fish trap to Clear Creek.
3. Initiate a secondary captive broodstock of winter-run Chinook salmon.
4. Incubate a portion of winter-run Chinook salmon eggs from Livingston Stone National Fish Hatchery (LSNFH) along the McCloud River.

Details regarding these actions, their implementation, their associated science and monitoring activities, and preliminary assessment have been shared at the [Sacramento River Science Partnership, Spring 2023 Annual Workshop](#). However, data describing the effectiveness of the actions are still being collected, and as such, the impact of each action will not be fully discernable until data collection ceases and associated analyses are subsequently completed.

Increased Hatchery Production at Central Valley Hatcheries in 2022

In addition to the actions described in the *Drought Toolkit* and discussed with the DRY Team, CDFW, DWR, and USBR funded and implemented increased fall-run Chinook salmon production at several Central Valley hatcheries to offset low in-river production associated with the drought. These actions included:

- Feather River Hatchery – Increased smolt production targets from 6 million to 8 million (± 10 percent) fish and targeted additional production of 1.5 million (± 10 percent) pre-smolts.
- Nimbus Fish Hatchery – Increased smolt production targets from 4 million to 4.5 million (± 10 percent) and targeted additional production of 2 million (± 10 percent) fry.
- Livingston Stone National Fish Hatchery – Increased winter-run Chinook salmon production is included in the *Drought Toolkit* under Action 18 and is described in more detail in the “Drought Action Evaluation” section, below.

Additional details regarding hatchery production will be available in annual hatchery reports. The DRY Team will discuss and consider including increased hatchery production in the *Drought Toolkit* in the future.

Drought Action Evaluation

The ITP February 1 deadline for evaluating the effectiveness of many drought actions, drawing conclusions, and making recommendations is too short for all but a superficial effort by the DRY Team. As such, each drought action was evaluated based on criteria identified in the *Drought Toolkit* by the staff leading the action. The action evaluations are brief summaries of more extensive evaluations that are currently in development. Many of these actions have limited data on which to base an evaluation and some of these actions are ongoing, and thus cannot yet be evaluated. Additionally, some action evaluations were not submitted to the DRY Team for review and are not included in this report. For those actions that could be evaluated, the action evaluations give an overall picture of which actions occurred in 2022, whether the actions were executed as planned, and whether the actions are worth including in future dry year plans.

Drought actions implemented in 2022 (Table 2) addressed a wide array of management problems that occur during dry years. Many of the actions addressed water supply and water quality for human use, and other actions addressed deteriorating environmental conditions to support fish and other ecosystem components. Many of the actions had multiple benefits and were focused on improving our understanding of the system through science and monitoring.

Table 2 List of Implemented Drought Actions for 2022

Implemented Drought Actions	Lead Agency
Water Transfers by SRSC	SRSC
SRSC Diversion and Operation Communication	SRSC
Request Modified Fall Diversion Schedule by SRSC	SRSC
Request Modified Spring Diversion Schedule by SRSC	SRSC
Release Water through River Outlets	SRSC
Temporary Urgency Change Petition	DWR
Emergency Drought Salinity Barrier	DWR
Water Right Curtailments in the Sacramento-San Joaquin Delta Watershed	State Water Resources Control Board
LSNFH Infrastructure Improvements	USFWS & Reclamation
Aquatic Vegetation Monitoring	DWR
Delta Ecosystem Monitoring and Synthesis	DWR
Increased Winter Run Chinook Salmon Production at LSNFH	USFWS & Reclamation
Drought Feather River Spring Flow Redistribution	California Department of Fish and Wildlife & DWR
Feather River Settlement Contractors Delivery Reduction	DWR
Harmful Algal Bloom Monitoring	DWR
Exchanges through the Consolidated Place of Use	DWR
Release of Water from Friant Dam for Contractual Demands in Mendota Pool	Reclamation
SRSC Delivery Reduction	Reclamation

Notes: DWR = California Department of Water Resources; LSNFH = Livingston Stone National Fish Hatchery; Reclamation = U.S. Bureau of Reclamation; SRSC = Sacramento River Settlement Contractors; USFWS = U.S. Fish and Wildlife Service

Drought Action Evaluations

Action Evaluation: Water Transfers by SRSC

Point of Contact

Anne Williams, MBK Engineers

Dates Implemented

Water was transferred from April 1, 2022, through October 31, 2022. Preliminary efforts associated with water transfers began occurring in December 2021.

Water Year

Very low (or no) water supply allocations to discretionary contracts. Shasta Reservoir operations planned to be limited by the IOP and the Temperature Management Plan (TMP).

Timeframe and Milestones

In December 2021, Sacramento River Settlement Contractors (SRSC) began signing Letters of Intent with potential buyers for 2022 water transfers, which would result in water being made available through groundwater substitution and crop idling/shifting. In January 2022, the SRSC began submitting Intent to Transfer Checklists to the State Water Board, followed by petitions for temporary transfer (Petitions).

The SRSC received letters in March 2022 from Reclamation alerting them of less water than previous Shasta Reservoir Critical years (75 percent contract supply), along with the potential for unreliable supplies during April. In early April, the SRSC withdrew their Petitions because Reclamation identified that capacity would be available at the CVP Jones Pumping Plant for the conveyance of transfer water allowing for use of Forbearance Agreements (as the transfers will occur under existing SRSC contracts and not under individual SRSC water rights) and knowing their contract supply would be limited.

Reclamation's draft TMP was submitted on April 6, 2022, and because of the IOP priorities and decision-making structure, included a summer release of 4,500 cubic feet per second (cfs) and a forecast for Shasta Reservoir storage of 1.252 million acre-feet at the end of September 2022. This operations plan would allow for delivery of only 18 percent of the water supplies provided under the SRSC contracts from Shasta Reservoir releases. With such limited supplies available, many of the SRSCs transferred their contract water because they would be unable grow crops internally with such a limited supply. The SRSC pursued only in-basin transfers under the SRSC contracts to neighboring entities, such as the City of Redding and surrounding urban areas, the Tehama Colusa Canal Authority, north of Sacramento-San Joaquin Delta (Delta) federal refuges, and Woodland Davis Clean Water Agency.

Intended Effect

Provide water to areas in need of water supplies and provide some income to the SRSC and landowners who otherwise had severely limited or no income in 2022 because of the reduced water supply.

Relation to Other Drought Actions

Action 3: SRSC Diversion and Operation Communication – This effort was expanded in 2022 to include entities purchasing the transfer water.

Action 4: Request Modified Fall Diversion Schedule by SRSC – This effort was expanded in 2022 to include entities purchasing the transfer water.

Action 5: Request Modified Spring Diversion Schedule by SRSC – This effort was expanded in 2022 to include entities purchasing the transfer water.

Data Used for Evaluation

Proposed transfer quantities and actions are submitted to Reclamation for approval in advance. Diversion quantities are measured by Reclamation at each point of diversion, which includes diversions of transfer water.

Reclamation conducted accounting of the transfer water by individual SRSC and diversion by the buyers. Because the transfers in 2022 were all to in-basin CVP buyers, this accounting was simple as compared to other years.

Other Considerations

N/A

Resources Needed/Used

Approximately 76 thousand acre-feet (taf) (or approximately 20 percent of the SRSC 18 percent contract supply) purchased by in-basin buyers.

Lessons Learned

Uncertainty early in the season related to hydrology and operations resulted in unnecessary effort and funds to prepare and submit Intent to Transfer Checklists and Petitions to the State Water Board.

Extremely low contract supplies for the SRSC resulted in lesser quantities available for transfer than in prior drought years, and there was an overall desire for water to remain in-basin.

Recommendations for Modifications

The SRSC continues to meet with the agencies (Reclamation, DWR, State Water Board) to improve the water transfer submittal and approval processes.

Figures/Tables

N/A

Action Evaluation: SRSC Diversion and Operation Communication

Point of Contact

Anne Williams, MBK Engineers

Dates Implemented

Coordination calls between the SRSC and Reclamation Central Valley Operations (CVO) occurred weekly from April 6, 2022, through November 2, 2022.

Water Year

Shasta Reservoir operations limited by the IOP and the TMP.

Timeframe and Milestones

In 2022, following another dry winter, Reclamation was ordered by the court to operate to the IOP, which prioritized operations at Shasta Reservoir for fishery needs and resulted in an extremely restricted release schedule through the irrigation season. As a result of this operations plan and the drought conditions, the SRSC received an 18 percent contract supply from Shasta Reservoir releases (as compared to a Shasta Reservoir Critical Year supply of 75 percent required under the settlement contracts) for the first time since the settlement contracts were issued.

In an effort to maximize the available water supply and better align with the severely restricted flows and timing of releases from Shasta Reservoir for temperature management, a group of many SRSCs voluntarily coordinated with CVO, the CVP refuges in the Sacramento Valley, and the Tehama Colusa Canal Authority (TCCA) weekly throughout the irrigation season to maintain target releases from Shasta Reservoir and target flows in the Sacramento River at Wilkins Slough (and thus avoiding impacts downstream to the overall CVP/SWP).

Weekly coordination calls between the SRSC and CVO began on April 6, 2022. These calls were held to exchange information and discuss current and future Sacramento River operations. During these calls, CVO provided updates relative to temperature management, overall CVP operations, and Delta conditions.

Outside of these calls, diversion projections were updated and maintained by the managers of individual settlement contractors, refuges, and TCCA regularly and in real time when needed. Updated diversion projections and actual diversion estimates were provided on an ongoing basis through the SCRC's online diversion portal. Data relative to operations and river conditions were pulled into the portal from California Data Exchange Center (CDEC), U.S. Geological Survey (USGS), and CVO's website on a regular basis. The compiled information was summarized through plots made available on the portal.

In the late spring, precipitation events and cooperation by the SRSC resulted in Shasta Reservoir releases being able to remain at minimum levels until May 10, and at levels lower than those identified in the TMP until July, which conserved an additional volume of approximately 100 taf of water in storage.

During the summer months of July and August during peak demand, Reclamation maintained releases from Keswick Reservoir at 4,500 cfs and the SRSC (through coordination with the CVP refuges and the TCCA) actively managed diversions along approximately 200 river miles to maintain a Wilkins Slough flow target of 3,200 cfs. A request for additional releases in these months to meet peak crop demands from the water conserved by the SRSC in the springtime was denied through the Shasta Planning Group.

During September, the tight coordination continued, and targets were met for the first half of the month. In mid-September, however, Reclamation identified that instead of continuing to reduce flows to meet the TMP target, it was going to maintain a higher release because of concern over redd dewatering (a decision made by the NMFS).

In early October, Reclamation informed the SRSC that after the redd emergence, releases would remain elevated because of the need for additional flow into the Delta to meet Delta standards.

The occurrence of the weekly coordination calls concluded on November 2, 2022, as the irrigation season came to an end.

Intended Effect

Improve communication between the SRSC and CVO to optimize diversion and operation decisions.

Relation to Other Drought Actions

Action 2: Water Transfers by SRSC – This effort was discussed during weekly coordination calls between the SRSC and CVO in 2022, and active participation by TCCA to physically divert the transferred water.

Action 4: Request Modified Fall Diversion Schedule by SRSC – This effort was discussed and coordinated during weekly coordination calls between the SRSC and CVO in 2022.

Action 5: Request Modified Spring Diversion Schedule by SRSC – This effort was discussed during weekly coordination calls between the SRSC and CVO in 2022.

Data Used for Evaluation

Diversion quantities are measured at each point of diversion and provided in water accounting records by Reclamation. Anticipated diversion schedules are input into an online portal by individual SRSCs, and actual daily diversions are tracked against the schedules. Accretion/depletion estimates are used to help inform the release and diversion schedules. Tributary gage data (downstream of Keswick Reservoir) are analyzed and used to help inform the release and diversion schedules.

Other Considerations

N/A

Resources Needed/Used

The SRSC diverted approximately 300 taf of their contract amounts during the irrigation season, with an additional diversion of approximately 76 taf of SRSC contract amounts by other in-basin users through water transfers.

The SRSC maintains an online portal, which is estimated to cost approximately \$5,000 per year.

Lessons Learned

Storm events and tributary flows (downstream of Keswick Reservoir) may provide flexibility in spring operations at Shasta Reservoir to reduce releases.

Such a low water supply resulted in significant fallowing within the Sacramento Valley during 2022, particularly of rice ground. Consequently, the pattern of diversion by the SRSC over the irrigation season was different than prior years.

Recommendations for Modifications

The SRSC become a part of the Shasta Planning Group to participate in decision-making around river operations.

Figures/Tables

N/A

Action Evaluation: Temporary Urgency Change Petition

Point of Contact

Janice Wu, DWR

Dates Implemented

April 4 through June 30, 2022.

Water Year

The Delta watershed experienced extreme dry hydrologic conditions, with January through March 2022 being among the driest on record following record dry conditions in 2021. Large storms early in WY 2022 resulted in above average snow water content, but these reserves have steadily dwindled in the months since. With the significant decrease in expected inflow, these reservoirs could no longer support Delta outflows under State Water Board Decision 1641, and there was not adequate storage in other CVP/SWP reservoirs to meet critical water supply needs without a temporary urgency change petition (TUCP) in place.

Timeframe and Milestones

DWR and Reclamation submitted the TUCP to the State Water Board State Water Board on March 18, 2022. On April 4, the State Water Board approved, subject to conditions, the requested changes for the period from April 4 through June 30, 2022.

Intended Effect

- Reduced impact on the SWP and CVP operations.
- Conserved cold-water pools in upstream reservoirs.
- Protected future cold-water needs for natural resources.

Relation to Other Drought Actions

The TUCP is coordinated with development of the DCP and implementation of the West False River emergency drought salinity barrier (EDSB).

Data Used for Evaluation

Monitoring and reporting is ongoing in accordance with the temporary

urgency change order issued by the State Water Board on April 4, 2022. Submittals by DWR and Reclamation are posted on the State Water Board's [State Water Project and Central Valley Project Temporary Urgency Change Petition](#) webpage.

Other Considerations

N/A

Resources Needed/Used

N/A

Lessons Learned

N/A

Recommendations for Modifications

N/A

Figures/Tables

N/A

Action Evaluation: Emergency Drought Salinity Barrier

Point of Contact

Robert Trang, DWR

Dates Implemented

June 3, 2021 – Barrier construction initiated.

November 23, 2022 – Barrier removal completed.

Water Year

WY 2022 was the third consecutive dry year in the state.

Timeframe and Milestones

- June 3, 2021 – Barrier construction initiated.
- June 24, 2021 – Barrier construction completed.
- January 4, 2022 – Notch construction initiated.
- January 18, 2022 – Notch construction completed.
- April 1, 2022 – Notch filling initiated.
- April 13, 2022 – Notch filling closed.
- October 15, 2022 – Barrier removal initiated.
- November 23, 2022 – Barrier removal completed.

Intended Effect

The 2021–2022 EDSB at West False River reduced the salinity of water entering the Central Delta and Old/Middle River corridor in 2021 and 2022. This salinity reduction was achieved by altering tidal dispersion patterns so that less saline water was pumped through Franks Tract into the South Delta and more saline water was pushed farther into the Sacramento River.

Relation to Other Drought Actions

The barrier's effectiveness at conserving water was realized only when paired with the TUCP.

Data Used for Evaluation

The drought barrier contributes to water savings in two ways: indirectly by facilitating safe implementation of the TUCP and directly by reducing the amount of water used to manage Central Delta water quality. A preliminary report on the effectiveness of the barrier in 2021 is available [online](#), and a final report on the effectiveness of the barrier over both years of installation is forthcoming.

Other Considerations

N/A

Resources Needed/Used

Proposition 50 and General Funds were used for the planning and construction of the emergency barrier. Final project cost is in process of being realized and is currently estimated to be \$20 million.

Lessons Learned

Operations of the Delta Cross Channel (DCC) gates could have been better coordinated to achieve the maximum benefit of the barrier.

This is the second time in the past seven years that drought conditions have required an emergency barrier in this location. With this in mind, planning for installation of a drought barrier on a non-emergency basis would be beneficial to water management in the region. These plans are underway.

Recommendations for Modifications

An amendment was obtained to leave the drought barrier in place through November 2022 because of continued drought conditions. Thus, a notch was constructed through the barrier for January through March 2022 to allow for fish and boat passage through West False River. High velocities were observed through the notch which resulted in scour at the channel bottom adjacent to barrier. For future barrier installation, notching should not be recommended because of the potential for additional scour.

Figures/Tables

N/A

Action Evaluation: Water Right Curtailments in the Delta Watershed

Point of Contact

Conny Mitterhofer, State Water Board

Dates Implemented

August 20, 2021, through WY 2022 to present.

Water Year

Governor Newsom's May 10, 2021, executive order (reinforced by subsequent orders) declaring a drought emergency directed the State Water Board to consider a number of actions to protect water needed for health, safety, and the environment in the Delta watershed. The Governor's direction included curtailment of water diversions when water is not available at water right holders' or claimants' priority of right to protect previously stored releases of water from DWR's SWP and the Reclamation's CVP (collectively Project or Projects) reservoirs needed for minimum human health and safety, salinity control in the Delta, and some ecosystem protection.

Timeframe and Milestones

- During the spring 2021, an initial curtailment methodology for the Delta watershed was developed and released for public comment.
- Based on the initial curtailment methodology, notices of water unavailability were issued to post-1914 appropriative water right holders in June 2021. The notices were extended to senior claims of right (pre-1914 appropriative and riparian) in July 2021.
- On August 3, 2021, the State Water Board adopted emergency regulations authorizing the issuance of formal curtailment and reporting orders to water right holders and claimants in the Delta watershed.
- Following approval by the Office of Administrative Law on August 19, 2021, initial curtailment and reporting orders were issued to all right holders and claimants in the watershed requiring them to comply with regularly updated notifications of water unavailability and requiring the largest diverters to provide more detailed and frequent reporting of water use and demand.

- Since development, the methodology underlying the water unavailability analysis has been updated regularly to reflect improvements in the methodology, including based on public comments.
- The emergency regulation was readopted because of ongoing drought conditions on July 20, 2022, and became effective on August 12, 2022, and will remain in place for up to a year, and may be readopted after that time as appropriate.
- Curtailment updates continue to be issued weekly or more often as conditions warrant.

Intended Effect

Curtailments are intended to facilitate the administration of the State's water right priority system by providing an enforceable mechanism for notifying water right holders and claimants when water is not available at their priority of right. This includes preventing diversions of previously stored water by water right holders and claimants that do not have the right to that water so that those supplies can meet their intended purpose (e.g., providing for Delta outflows).

Relation to Other Drought Actions

Curtailments help to protect Project storage supplies, including supplies needed for: flow, temperature, salinity, and other requirements; water supply contract deliveries; and carryover storage going into the following year. The State Water Board approved TUCPs submitted by the Projects in WYs 2021 and 2022. The TUCPs reduced the Projects' obligations to provide water to meet flow and water quality requirements. Like curtailments, the TUCPs reduced the demand on limited water supplies. Curtailments may reduce the need for TUCPs and may improve temperature management by allowing more water to be retained in storage.

Data Used for Evaluation

The efficacy of curtailments can be evaluated through a number of factors, including storage and streamflow data, the volume of supplemental Project water released to meet water quality objectives, complaints from water users or members of the public, public water system diversion and use data, enhanced and annual reporting by water users, and State Water Board enforcement investigations of compliance with curtailment and reporting requirements.

Other Considerations

Although short-term emergency regulations and associated curtailments have significant utility, there are many complexities involved in curtailments that can be better addressed in longer term processes, including improvements in water right demand information and reporting, improved accretion and depletion data (including return flows, groundwater and other losses and gains, etc.), and other issues. The current curtailments also provide for the allocation of all natural and abandoned flows and do not provide for curtailment to meet water quality and instream flow needs. Curtailments also do not address water unavailability issues associated with contractual allocations of water and similar agreements.

Resources Needed/Used

The initial and ongoing development and implementation of curtailments requires significant State Water Board technical, management, executive, and legal staff resources, as well as cooperation and data from the approximately 17,000 water right holders and claimants in the Delta watershed. Evaluation, compliance, and enforcement activities associated with curtailments also require significant resources.

Lessons Learned

The extensive public processes to develop and implement curtailments has been instructive in refining curtailment tools and supporting data and identifying legal and policy issues, including identifying longer term improvements in curtailment methods that are under development. The State Water Board intends to continue to engage with the public and other agencies to continue to improve its curtailment methods.

Recommendations for Modifications

The State Water Board will continue to make improvements to its curtailment methods for use in current and future dry conditions as appropriate, including prioritizing efforts to improve data sources used for curtailment decisions.

Figures/Tables

N/A

Action Evaluation: Livingston Stone National Fish Hatchery Infrastructure Improvements

Point of Contact

Derek Rupert, Reclamation
Brett Galyean, USFWS

Dates Implemented

Water chiller rentals and operations for LSNFH occurred from July through mid-December 2022.

The LSNFH Infrastructure Review and Alternatives Analysis project is ongoing.

Water Year

Several projects were implemented under this action during WY 2022 and WY 2023. Additional projects will be required in WY 2023 and beyond.

Timeframe and Milestones

Reclamation awarded a contract for the chiller rental on May 27, 2022. The contractor mobilized and delivered on the chillers by July 17, 2022. The first chiller became operational on August 11, 2022, with remaining the chillers and generators on site and ready when needed (Figure 1). The chillers shut down on December 14, 2022, and demobilization started late in the month. It is likely that some components of the chiller package (e.g., pipes and heat exchanges) will remain in place as a contingency for WY 2023 operations.

Reclamation awarded a contract for a LNSFH Infrastructure Review and Alternatives Analysis on August 10, 2022. This contract's period of performance will end March 2023. Reclamation assembled a multi-agency technical team (with representatives from DWR, CDFW, NMFS, and USFWS) to follow along with this project and complete document reviews. The final deliverable will be a report on the status of the current infrastructure and alternatives for improvements.

Intended Effect

The intended effect of this project is to improve LSNFH's infrastructure for operational resiliency during drought years (e.g., provide adequate water quality for aquaculture) and to allow for increased fish production potential (e.g., increase the facility's current carrying capacity). In the short term, these objectives were achieved by installing temporary large water chillers to cool and stabilize the hatchery's water supply. In the long term, this will require renovations and additions to the facility's systems (e.g., upgraded water intake, permanent water chillers, replacing plumbing, providing overhead cover, duplicate charcoal filters, larger adult salmon collection facilities, increased number of rearing raceways/ponds) to increase aquaculture capacity and improve facility resilience.

Relation to Other Drought Actions

This toolkit item is related to the increased winter-run Chinook salmon production at LSNFH, as that project is highly reliant of water chillers to keep water temperatures within acceptable levels.

Data Used for Evaluation

Data used to evaluate this toolkit item include incoming water temperatures from Shasta Dam penstocks, water temperatures of the chilled water entering the hatchery, and overall water quality for aquaculture within the hatchery. Because of increased production at LSNFH, cool and stable temperatures are a necessity to be successful in salmon aquaculture under high density conditions.

The water temperatures stemming from the Shasta Dam penstock #4 generally increased across the summer and fall 2022 (Figure 2). Large daily water temperatures fluctuations occurred, often fluctuating more than 10 degrees Fahrenheit (°F) in a 24-hour period. The elevated temperatures and high daily temperature swings are poor for salmon aquaculture, particularly when fish densities are high and production infrastructure is fully utilized.

The water chiller system was able to cool and stabilized the water supply for LSNFH (Figure 3). The hatchery water supply did not exceed 55 °F during the operational period of the chillers. The chiller system's redundancies and generator backups were able to withstand several power outages and mechanical breakdowns, with no significant increase in water temperatures.

Winter-run adults, eggs, and juveniles generally remained healthy (i.e., with normal ranges) throughout the timeframe of water chiller implementation.

Resources Needed/Used

In 2022, 2,500 tons of chilling capacity was on hand to chill LNSFH water supply. This included seven Chillers and 12 diesel generators. This equipment rental was funded by Reclamation, at a considerable cost (approximately \$9.2 million). The diesel fuel required to run the generators was an additional cost, also funded by Reclamation (up to approximately \$2 million).

Lessons Learned

WY 2022 marked the fourth time water chillers were needed for LSNFH operations (previously chiller implemented in 2014, 2015, and 2021). These chiller rentals are expensive and temporary solutions. Reclamation is pursuing an alternative water supply location from Shasta Dam (i.e., 750-foot elevation release point) for the hatchery's water supply. This relocation could potentially pull water from a low elevation point in the reservoir, which would circumvent the temperature control device and penstocks. Transitioning to a separate water supply point could drastically reduce the need for chilling capacity in most years. Reclamation is currently working to implement this change in water delivery to LSNFH.

Figures/Tables

See next page.

Figure 1 WY 2022 Water Chiller System at Livingston Stone National Fish Hatchery

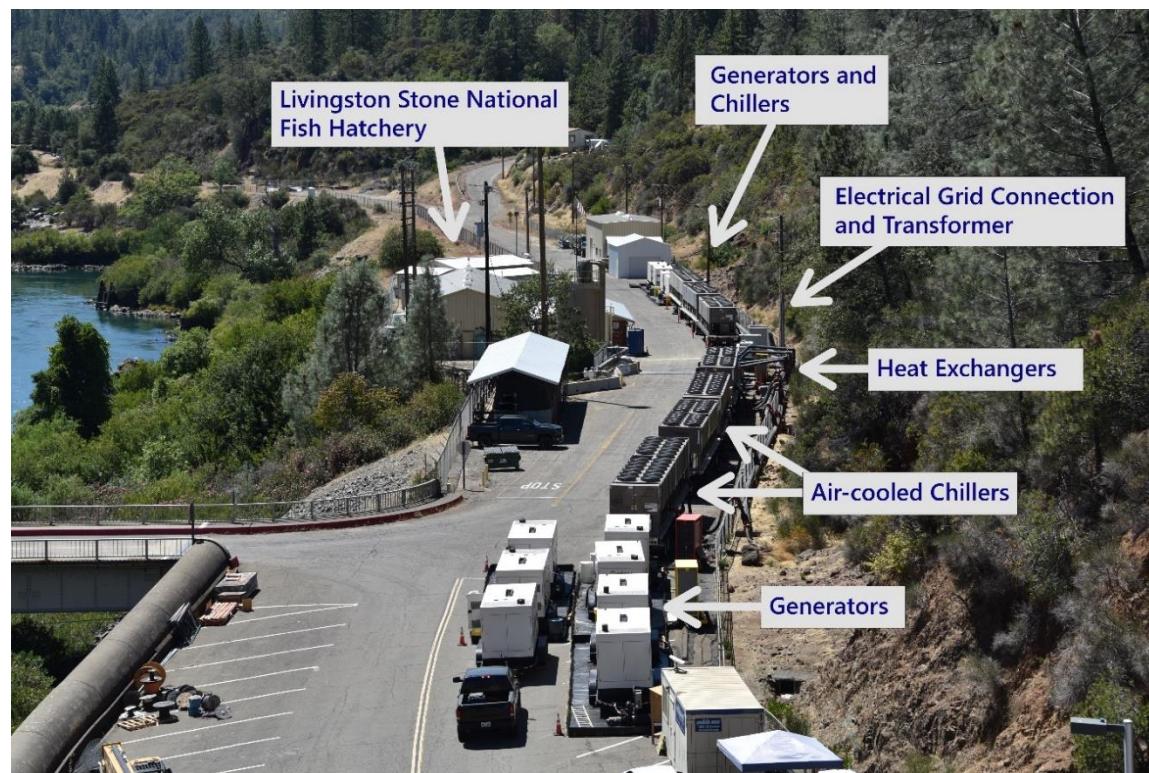
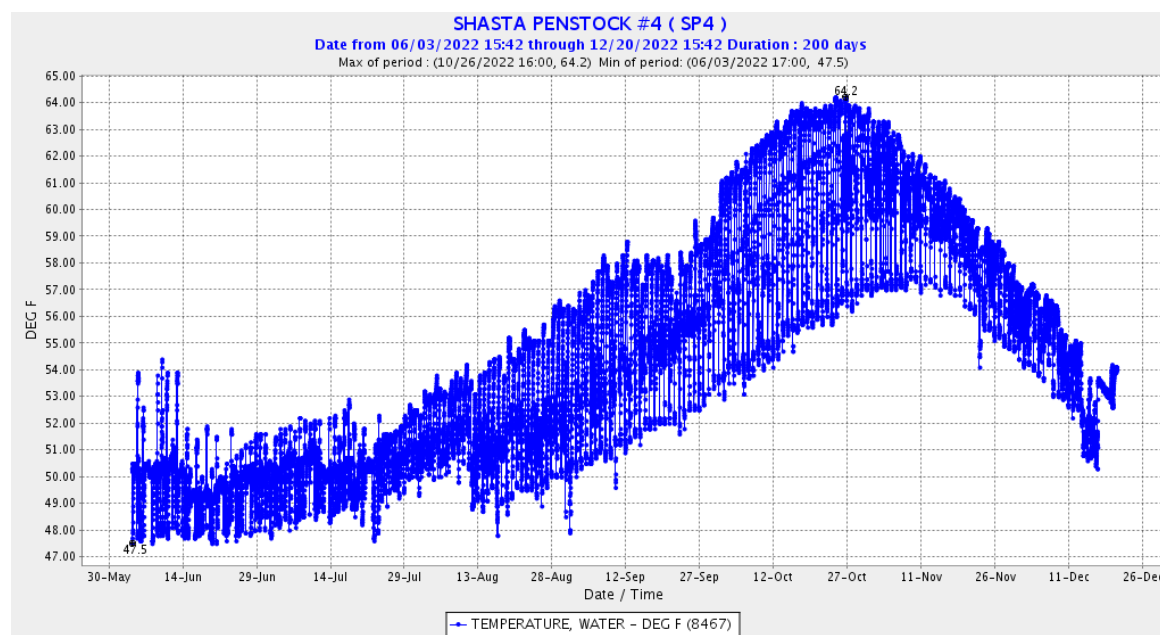
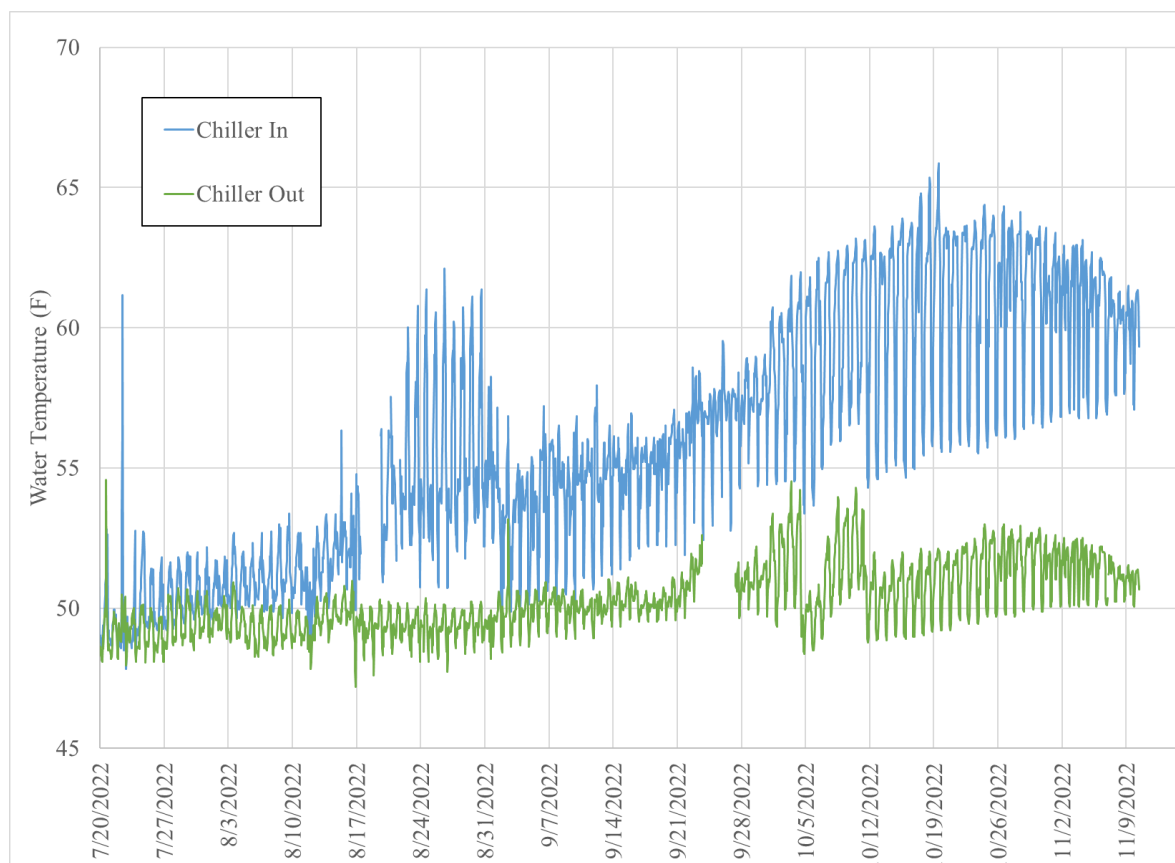


Figure 2 Water Temperatures within Shasta Dam Penstock #4 from July through December 2022



Note: Data from the California Data Exchange Center ([CDEC Link to SP4](#)).

Figure 3 Water Temperatures entering (“Chiller In”) Water Chillers Heat Exchanges compared to Water Temperatures leaving (“Chiller Out”) Heat Exchanges (i.e., entering the hatchery)



Action Evaluation: Aquatic Vegetation Monitoring

Point of Contact

Rosemary Hartman, DWR

Dates Implemented

July 12 through August 19, 2022

Water Year

Action implemented during WY 2022.

Timeframe and Milestones

DWR executed a task order through a Master Services Agreement with [SpecTIR](#) on May 12, 2022, to collect hyperspectral imagery over the Delta and Suisun Marsh. Imagery was collected from July 12–19, 2022. DWR executed a contract with the University of California, Davis, [Center for Remote Sensing and Spatial Technologies](#) (CSTARS) to collect field data for ground truthing the hyperspectral imagery and to analyze the imagery to create landscape-scale distribution maps of aquatic vegetation. The CSTARS staff collected ground-truthing field data by surveying the community composition of submerged (SAV), emergent (EAV), and floating (FAV) forms of aquatic vegetation at over a thousand locations across the Delta and Suisun Marsh from July 13 to August 19, 2022. In September 2022, CSTARS geographic information systems (GIS) specialists began analyzing imagery by using ground-truthing data in a random forest classification to categorize the pixels in the imagery as covered by open water, SAV, EAV, or FAV. The data analysis is ongoing.

Intended Effect

Track any expansion of weeds resulting from decreased flow, prioritize areas for weed treatment/control, assess impacts of other drought response actions, and evaluate effectiveness of restoration sites.

Assess the impact of drought actions, including TUCP and barriers, on distribution of weeds within the Delta.

Effects/Outcomes

The data from the 2021 aquatic weed mapping action was used in the report completed in October 2022 and posted [online](#).

Data from 2022 for the entire Delta and Suisun Marsh has been collected. Data processing is ongoing.

Relation to other Drought Actions: Data collected by this action will be used in a special study on the impact of the 2022 TUCP and emergency barrier on aquatic weeds and harmful algal blooms (HABs).

Data Used for Evaluation

This data contributes to a long-term data set that includes 11 years of weed data from the Delta collected between 2004 and 2021, which has been [published](#) on the KNB data repository.

Resources Needed/Used

- Amount of Water: 0
- Funding: DWR SWP funds, up to \$268,000

Recommendations for Modifications

Future contracts should require data to be produced faster (within six months of imagery collection).

Lessons Learned

N/A

Figures/Tables

N/A

Action Evaluation: Delta Ecosystem Monitoring and Synthesis

Point of Contact

Rosemary Hartman, DWR

Dates Implemented

February 2021 – ongoing.

Water Year

WY 2022

Timeframe and Milestones

A team of Interagency Ecological Program (IEP) scientists was formed in spring 2021 and developed a workplan for evaluating the 2020–2021 drought, assessing impacts of previous droughts, and assessing management actions. A preliminary study plan was included with the *February Drought Contingency Plan* and refined with updates to the Plan. During the summer and fall 2021, they assembled data set of relevant water quality, phytoplankton, zooplankton, vegetation, and fish data to identify large-scale ecosystem responses to drought and drought actions over the history of previous droughts (Figure 4). During 2021 and 2022, the team analyzed this data set using a variety of analytical and statistical approaches to see how historic droughts compare to historic wet periods, and how the drought of 2020–2022 compares to previous droughts.

A preliminary report on impacts of drought in the Delta was submitted to CDFW and the State Water Board on February 1, 2022, and is available here [online](#).

The long-term analysis of drought impacts is currently being finalized as a series of peer-reviewed journal articles to be submitted to the journal *San Francisco Estuary and Watershed Sciences* in February 2023. Data from 2022 is being combined with information from 2020 –2021 and will be included in a report to be submitted February 1, 2023.

Intended Effect

Improve our understanding of the environmental impacts of drought. Assess the environmental effects of actions included in the *Drought Toolkit* in the Delta and develop recommendations for future drought actions.

Effects/Outcomes

The analysis and report writing are still being finalized. However, some patterns have become clear (Figure 5). Drought responses are driven primarily through decreases in transport of materials via freshwater flow, increases in temperature, or both. Water clarity increases as a result of decreased import of sediment. Nutrients (nitrogen and phosphorus) increase in concentration during droughts because of decreased dilution in most regions of the Delta. Chlorophyll dynamics are more highly localized, with increases during droughts in the South Delta and possibilities of short-term, small-scale blooms, but no Delta-wide trends. Although chlorophyll in general did not show large-scale trends, harmful cyanobacteria, particularly *Microcystis*, increase during droughts. Zooplankton abundance changes by region of the Delta, with increases in the South Delta and decreases in Suisun. Abundance of longfin smelt and striped bass decrease, and most runs of salmon had lower cohort replacement rates when juveniles out-migrate during droughts. The emergency drought barrier may have exacerbated a dense cyanobacterial bloom within Franks Tract in the summer 2021, but no other effects of the barrier or TUCP could be measured above the impact of the drought itself.

Relation to other Drought Actions

The monitoring and synthesis work also can be used in the monitoring plan for various other Drought Toolkit actions, including the emergency drought barrier and TUCP. Work completed by the drought synthesis was used extensively in the report on the impact of the TUCP and emergency drought barrier on harmful algal blooms and weeds in the Delta.

Data Used for Evaluation

The drought synthesis team assembled data from many different IEP datasets, in particular:

- Fish data [from CDFW Fall Midwater Trawl](#) and salmon data from [SacPAS](#).

- [Integrated dataset of discrete water quality.](#)
- [Integrated dataset of zooplankton data.](#)
- Flow data from [CDEC](#), [NWIS](#), and Dayflow.
- Benthic data from the [Environmental Monitoring Program](#).
- Jellyfish catch data from CDFW's Fall Midwater Trawl, [Summer Townet Survey](#), [San Francisco Bay Study](#), and [University of California \(UC\), Davis' Suisun Marsh Survey](#).
- [Vegetation data](#) from State Parks Division of Boating and Waterways and the UC Davis Center for Spatial Technology and Remote Sensing.

Resources Needed/Used

- Amount of Water: 0
- Funding: Approximately \$200,000 in staff time, reallocated from other projects.

Recommendations for Modifications

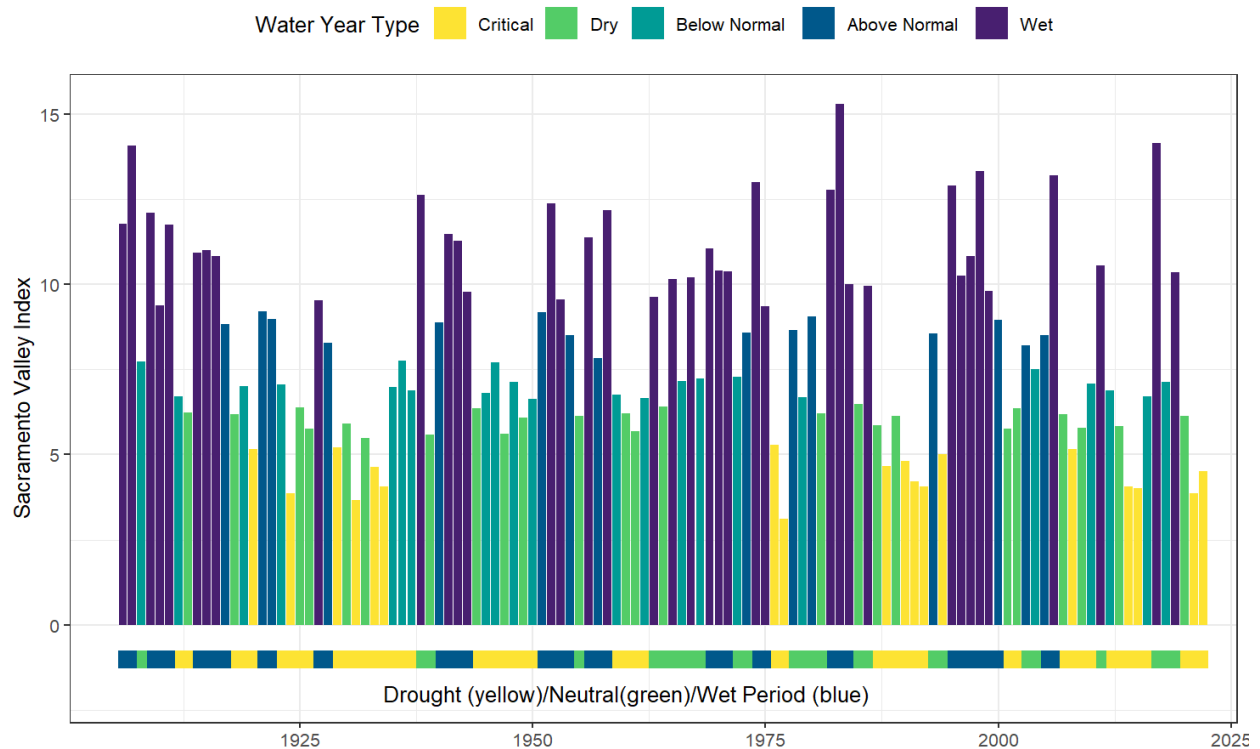
This project is focused on assessing the impacts of drought on the Delta ecosystem. However, many agencies and stakeholders have been interested in upstream impacts of drought on water supply and salmonid population viability. A similar project on drought impacts on salmon across their life history would be a useful addition.

Lessons Learned

The term "drought" is poorly defined, and may be different for water project managers, ecologists, fisheries biologists, and social scientists. An official definition of a "drought" for similar projects would be useful.

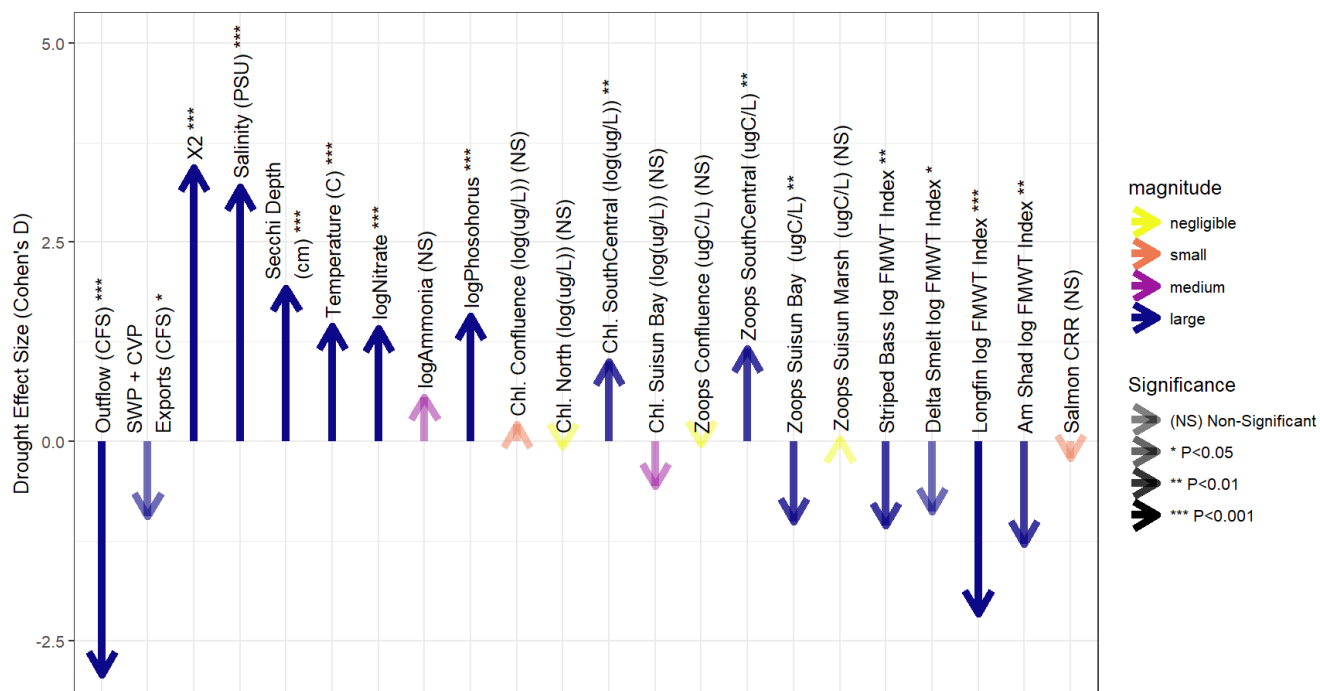
Figures/Tables

Figure 4 Water Year Types and Frequency of Previous Droughts in California over the Past 100 Years



Note: In this project, the researchers have defined a “drought” to be two or more years with a Sacramento Valley water year classification of “Dry,” “Below Normal,” or “Critically Dry.” This is compared to “wet periods,” which have two or more above normal or wet years in a row. “Neutral” periods have alternating wet and dry years.

Figure 5 Ecosystem Changes observed during Droughts



Note: Positive arrows represent increases during droughts and negative arrows represent decreases.

Action Evaluation: Increased Winter Run Chinook Salmon Production at Livingston Stone National Fish Hatchery

Point of Contact

Brett Galyean, USFWS
Kevin Niemela, USFWS
Derek Rupert, Reclamation

Dates Implemented

February 1, 2022, through March 1, 2023 (estimated).

Water Year (description of conditions)

This action was implemented for WY 2022, with some work to be completed in WY 2023.

Timeframe and Milestones

Adult winter-run Chinook salmon collections occurred February through August 2022. Winter-run Chinook salmon spawning occurred from May through August 2022. Egg incubation, hatching, and juvenile production began in May 2022, with the process continuing through to the anticipated release of the fish in early 2023.

Intended Effect

Because of the drought conditions in WY 2022 and the expectation that suitable temperatures likely would not be maintained within natural spawning areas of winter-run Chinook salmon, the USFWS assembled an interagency technical team to consider mitigation measures that could be undertaken at the LSNFH. In February 2022, the technical team recommended to agency managers to increase the number of winter-run brood fish spawned at the hatchery. The additional fish would partially mitigate for lost in-river production. The adult collection and egg take goals were effectively tripled (or more) when compared to normal CVP mitigation goals.

Relation to Other Drought Actions

Because of low storage in Shasta Reservoir and limited cold water pool, the increased production at LSNFH was highly reliant of water chillers to keep water temperatures within acceptable levels. The water chillers and other

infrastructure changes are covered under the *Drought Toolkit* item “Livingston Stone National Fish Hatchery Infrastructure Improvements.”

Data Used for Evaluation

Data used to evaluate this project include adult winter-run Chinook salmon collections utilized for broodstock and the total juvenile production released into the Sacramento River.

In 2022, there were 169 females and 186 males used for broodstock. These adults produced 731,392 juvenile salmon for release.

Other Considerations

Increased production of winter-run Chinook salmon at LSNFH in 2022 maximized the production capacity of pre-smolt juveniles at the facility. Hatchery operations at or near facility capacity, coincident with the emergency rental of chillers to combat critically warm incoming water temperatures, created a high-risk scenario. Future operations will want to avoid high-risk operations through the implementation of infrastructure improvements at LSNFH.

Resources Needed/Used

The increased production at LSNFH was completed by the USFWS and funded by Reclamation. Additional funding is required to procure and apply coded wire tags for the additional production. Large-scale water chillers were rented to maintain adequate water quality for salmon propagation at LSNFH.

Lessons Learned

Aquaculture at LSNFH was again pushed to its limits in 2022. The combination of increased salmon production with the unstable and elevated water temperatures kept stress levels high for the fish and hatchery staff alike. Further preparations and infrastructure improvements are needed to eliminate the weak points in the LSNFH facility and to provide a more stable and resilient aquaculture environment.

Recommendations for Modifications

Infrastructure improvements are needed to eliminate the weak points in the LSNFH facility and to provide a more stable and resilient aquaculture environment. Reclamation is funding a LSNFH infrastructure review and alternatives analysis to plan for future facilities improvements.

Action Evaluation: Drought Feather River Spring Flow Redistribution

Point of Contact

Erica Meyers, CDFW

Crystal Rigby, CDFW

Dates Implemented

This action was implemented from June 9 through June 25, 2022, but redistribution of the flow from the Thermalito Afterbay Outlet (TAO) into the low-flow channel (LFC) was variable during this timeframe.

Water Year (description of conditions)

Action implemented in WY 2022, which was classified as a Critically Dry water year.

Timeframe and Milestones

Beginning in May of WY 2022, the DWR began increasing reservoir releases through the TAO to meet Delta environmental standards. Releases from the TAO increased throughout May from 150 cfs to 2,050 cfs, with the LFC remaining at 650 cfs (Table 1). By the end of May, CDFW and DWR staff had tagged 1,343 adult spring-run Chinook salmon (spring-run) broodstock in the hatchery. On June 22, 2022, CDFW requested an ad-hoc Feather River Operations Group meeting to discuss a potential drought action to redistribute flow from the TAO into the LFC to try to increase the number of adult spring-run Chinook salmon entering the LFC and the Feather River Fish Hatchery (FRFH) for tagging. Meeting hatchery production targets was particularly important in 2022 because of uncertainty in numbers of returning and likely spawning success of naturally spawning adult spring-run related to multi-year drought conditions including warm water temperatures, reduced stream flows, low juvenile survival, increased disease prevalence, and thiamine deficiency. Spring-run salmon that enter the hatchery can be treated for thiamine deficiency and then released to the river to hold and either spawn in-river in the fall or return to the hatchery to be included as adult broodstock in the hatchery program. CDFW and DWR met on June 8, 2022, to discuss the potential fisheries benefits and power generation impacts that could occur if the flow redistribution were implemented. As of June 8, 2022, DWR had

tagged 1,551 spring-run adults. CDFW staff requested a flow redistribution through the end of June to encourage spring-run to migrate into the LFC and conceivably the FRFH. Flow in the LFC was increased from 650 cfs to 1,450 cfs June 9 through June 22 to meet the Robinson Riffle temperature objective (National Marine Fisheries Service 2004), then decreased to 650 cfs on June 13 when air temperatures cooled and increased flows were no longer needed to meet that objective. In an attempt to attract adult spring-run Chinook salmon upstream to the FRFH, DWR increased flow in the LFC to 1,050 cfs on June 17 and 1,450 cfs on June 21. Flow in the LFC was reduced back down to 650 cfs on June 25.

Intended Effect

The action was implemented to achieve the following objectives:

- Attract listed adult spring-run Chinook salmon into the FRFH to facilitate marking broodstock for fall spawning to meet annual spring-run Chinook salmon production goals.
- Provide thiamine hydrochloride injections to as many adult spring-run Chinook salmon as possible to overcome potential thiamine deficiency-related adult mortality and increase survival of natural origin and hatchery juvenile spring-run Chinook salmon.
- Increase adult survival and reduce pre-spawn mortality by increasing the number of adult spring-run Chinook salmon over-summering in the LFC, which offers better over-summer holding temperatures and refuge from recreational angler harvest.

Effects/Outcomes

In total, 2,166 spring-run Chinook salmon were tagged. Of those, 28.4 percent were tagged after flows were redistributed to the LFC beginning on June 9, 2022. Of the tagged salmon, 1,719 returned to FRFH in fall 2022. Spring-run Chinook salmon spawning at FRFH in WY 2022 resulted in more than 3,564,000 million fertilized eggs, which are expected to produce approximately 2.2 million spring-run Chinook salmon to meet hatchery production goals.

Of the total spring-run tagged, 1,966 were thiamine-treated, and 200 control fish were injected with saline. During spawning, UC Davis staff collected egg samples from both thiamine treated adults and controls to

assess actual thiamine levels. Based on the results of those studies, one-third of females in 2022 were found to have “low” or “very low” thiamine levels and likely would benefit from treatment.

Once the spring-run spawning production goals were met, hatchery staff returned 382 healthy adult broodstock that had been treated for thiamine deficiency (134 males and 248 females) back to the river to spawn naturally and promote in-river production. The fish that were returned to the river had their existing tag modified to distinguish them if encountered during in-river carcass surveys.

Relation to Other Drought Actions

N/A

Data Used for Evaluation

- CDFW Hatchery reports
- Thiamine study results

Other Considerations

There was no water cost for this flow redistribution action, but power supply costs should be considered.

Resources Needed/Used

- Amount of Water: This action was water neutral. Flow was redirected from the TAO to the LFC.
- Funding: N/A.
- Impacts to Water/Power Operations: Although this was water neutral, DWR estimated the power cost at \$60,000.

Lessons Learned

This action should be considered annually, when possible, to encourage adult spring-run Chinook salmon to move upstream into the LFC to access more suitable holding and spawning habitat, to provide refuge from angler harvest, and to support the collection and tagging of adult spring-run Chinook salmon in the Feather River. An additional benefit of the action is the ability to prophylactically treat adult salmon with thiamine injections in

years when thiamine deficiency is expected to be prevalent. Implementing this action in drought years helps to increase hatchery production and minimize the impacts of drought on survival of spring-run Chinook salmon.

Redistributing flow between the TAO and LFC should be considered for longer periods, if the FRFH is having difficulty meeting its minimum adult spring-run tagging goal. Additionally, flow redistributions to the LFC earlier in the spring may have benefits to juveniles rearing in the LFC. Discussions on the Feather River flow redistribution should start occurring as early as May during Feather River Operations Group meetings to allow for adequate time for planning and implementation, which includes determining the schedule, length, and feasibility of the action for that water year.

Recommendations for Modifications

Water operations in WY 2022 highlighted that providing additional flow through the LFC may attract adult spring-run Chinook salmon upstream and into the FRFH. Further study is needed to better understand the optimal timing and distribution of flow between the TAO and LFC to attract spring-run Chinook salmon into the LFC and FRFH.

Figures/Tables**Table 3 Approximate Flow Distribution, Flow Changes, and Spring-Run Tagged at FRFH during May and June 2022**

Date	LFC (cfs)	TAO (cfs)	Total Releases (cfs)	Reason for Change	Fish Tagged	Total Fish Tagged
5/4/2022 – 5/05/2022	650	800	1,450		166	166
5/6/2022	650	350	1,000	Delta Needs	-	-
5/7/2022	650	550	1,200	Delta Needs	-	-
5/8/2022	650	1200	1,850	No change	-	-
5/9/2022	650	1,550	2,200	Delta Needs	-	-
5/10/2022 – 5/11/2022	650	1,550	2,200	No change	-	-
5/12/2022 – 5/15/2022	650	1,550	2,200	No change	154	320
5/16/2022 – 5/17/22	650	1,550	2,200	No change	457	777
5/18/2022 – 5/22/2022	650	1,550	2,200	No change	73	850
5/23/2022 – 5/26/2022	650	1,550	2,200	No change	319	1169
5/27/2022	650	2,050	2,700	Delta Needs	174	1343
5/28/2022 – 6/2/2022	650	2,050	2,700	No change	-	-
6/3/2022 – 6/7/2022	650	2,350	3,000	Delta Needs	106	1,449
6/8/2022	650	2,350	3,000	No change	102	1,551
6/9/2022	1,450	2,050	3,500	Delta Needs/ temperature Requirements	-	-
6/10/2022	1,450	2,050	3,500	No change	-	-
6/11/2022	1,150	2,350	3,500	Temperature requirements	-	-
6/12/2022	850	2,650	3,500	Temperature requirements	-	-
6/13/2022	650	2,850	3,500	Temperature requirements	373	1,924
6/14/2022 – 6/16/2022	650	2,850	3,500	No change	-	-
6/17/2022	1,050	2,450	3,500	Fisheries Related	22	1,946
6/18/2022 – 6/20/2022	1,050	2,450	3,500	No change	-	-

Date	LFC (cfs)	TAO (cfs)	Total Releases (cfs)	Reason for Change	Fish Tagged	Total Fish Tagged
6/21/2022	1,450	2,050	3,500	Fisheries Related	-	-
6/22/2022– 6/23/2022	1,450	2,050	3,500	No change	-	-
6/24/2022	1,450	2,050	3,500	No change	88	2,034
6/25/2022	1,150	2,350	3,500	Fisheries Related	-	-
6/26/2022	850	2,650	3,500	Fisheries Related	-	-
6/27/2022	850	2,650	3,500	No change	118	2,152
6/28/2022	650	3,150	4,000	Delta Needs	-	-
6/29/2022	1,050	3,450	4,500	Delta Needs/ temperature Requirements	-	-
6/30/2022	1,050	3,250	4,300	Delta Needs/ temperature Requirements	-	-
7/5/2022*	N/A	N/A	N/A	N/A	14	2,166

Note: *After closing the ladder on June 30, 2022, 14 fish still remaining in the fish ladder were tagged.

Action Evaluation: Harmful Algal Bloom Monitoring

Point of Contact

Rosemary Hartman, DWR

Dates Implemented

Monitoring of drought actions occurred April through November 2022.

The HABs workshop occurred in November 2022.

Water Year

Continued dry conditions in 2022 and the 2022 West False River EDSB and temporary change petition order (TUCO) necessitated extra monitoring of HABs in the Central Delta in the vicinity of the barrier. This monitoring was in addition to routine monitoring of phytoplankton, chlorophyll, and nutrients conducted by existing surveys.

Timeframe and Milestones

Several different components of HAB monitoring were conducted in 2022.

- The State Water Board and Central Valley Regional Water Quality Control Board continued to coordinate data and communicate information regarding blooms through their [HAB portal](#).
- New sampling required to assess the impacts of the EDSB and TUCO – Cyanotoxin monitoring began in April because of predicted onset of HABs in May. Sampling continued every two to four weeks throughout the summer and fall until the Microcystis visual index had declined. After all data were collected, cyanotoxin data from the vicinity of the EDSB was combined with cyanotoxin monitoring by the SWP, other special studies of cyanotoxins, and other environmental data to assess the impacts of the EDSB and TUCO on HABs. A [draft report](#) was submitted to the State Board in December 2022, and a final report submitted in April 2023.
- DWR's North Central Region Office continued sampling to assess the impacts of the temporary agricultural barriers in the South Delta on HABs.
- Several special studies were conducted by researchers from USGS, San Francisco Estuary Institute (SFEI), and Robertson-Bryon to

address questions about bioaccumulation of cyanotoxins, HAB dynamics, and source tracking of Microcystis.

- The Delta Science Program’s HAB workshop (held November 8 and 9, 2022) provided a forum to discuss the future of HAB monitoring and discuss how to develop a plan for a Delta-wide, inter-agency monitoring program. During the workshop, participants identified several priorities for future coordination, including guidance on which methods to use, spatial and temporal frequency of sampling, and a shared data framework.
- The SWP conducts regular cyanotoxin sampling every two weeks during summer at Clifton Court Forebay and the Banks Pumping Plant.

A large cyanobacteria bloom occurred in Franks Tract and Old River in late July and early August 2021, dominated by a non-toxic strain of Dolichospermum (Figure 6; Figure 8). Other than this bloom, visual observations of Microcystis were lower in 2022 than previous years (Figure 7).

Intended Effect

Track development and possible expansion of HABs resulting from decreased flow, increased water temperatures, increased nutrients and other possible water quality changes and assess impacts of other drought actions (e.g., temporary barriers).

Outcomes

Monitoring of HABs in the Delta has resulted in several reports and manuscripts for publication. These reports describe major in HAB abundance and drivers.

- Reclamation. 2022. [*Impact of Temporary Urgency Change Petition of 2022 and Emergency Drought Salinity Barrier on Harmful Algal Blooms and Aquatic Vegetation in the Delta: Interim Draft Report to the State Water Resources Control Board.*](#)
- Hartman R, Bosworth D, Rasmussen N, Flynn T, Bouma-Gregson K, Khanna S, Frantzich J. 2023. [*Harmful algal bloom and aquatic weeds data from the Sacramento-San Joaquin Delta, collected to evaluate the impact of the 2021 Temporary Urgency Change Order and Emergency Drought Barrier. ver 1.*](#) Environmental Data Initiative.

- Bouma-Gregson K, Bosworth D, Flynn TM, Maguire A, Rinde J, Hartman R. In prep. Delta Blue(green)s: *The Impact of Drought and Drought Management Actions on Microcystis in the Sacramento-San Joaquin Delta*. Draft manuscript.
- IEP Drought Synthesis Team. 2023. *Ecological Impacts of Drought on Suisun Bay and the Sacramento-San Joaquin Delta with special attention to the extreme drought of 2020–2022*. IEP Technical Report #100. Sacramento, CA: Interagency Ecological Program for the San Francisco Estuary.

Major conclusions from these reports:

- HABs are more frequent and more severe in dry years.
- HABs are more frequent when water temperature is higher.
- TUCPs did not impact HAB frequency.
- The EDB may have contributed to HABs in Franks Tract.

Relation to Other Drought Actions

This action will help assess the impact of other Drought Toolkit actions, including Delta outflow and temporary barriers, as well as plan mitigation strategies, if the drought continues.

Data Used for Evaluation

Water quality and phytoplankton from existing IEP monitoring programs (see details as described in the Delta Science Program [HABs draft monitoring strategy](#)). Existing satellite imagery from the SFEI and Freshwater and Estuarine Harmful Algal Bloom (FHAB) [Satellite Analysis Tool](#) (see Figure 8 on the Satellite Analysis Tool website). Field work, analysis and data processing will be completed by monitoring personnel from the IEP, including participants in the IEP Water Quality and Phytoplankton Project Work Team and the California CyanoHAB Network.

Other Considerations

N/A

Resources Needed/Used

Total funding spent on HABs in the Delta across programs in 2022 has not been tabulated, but most likely exceeded \$1 million in staff time, laboratory analyses, vehicle operation, and equipment.

Lessons Learned

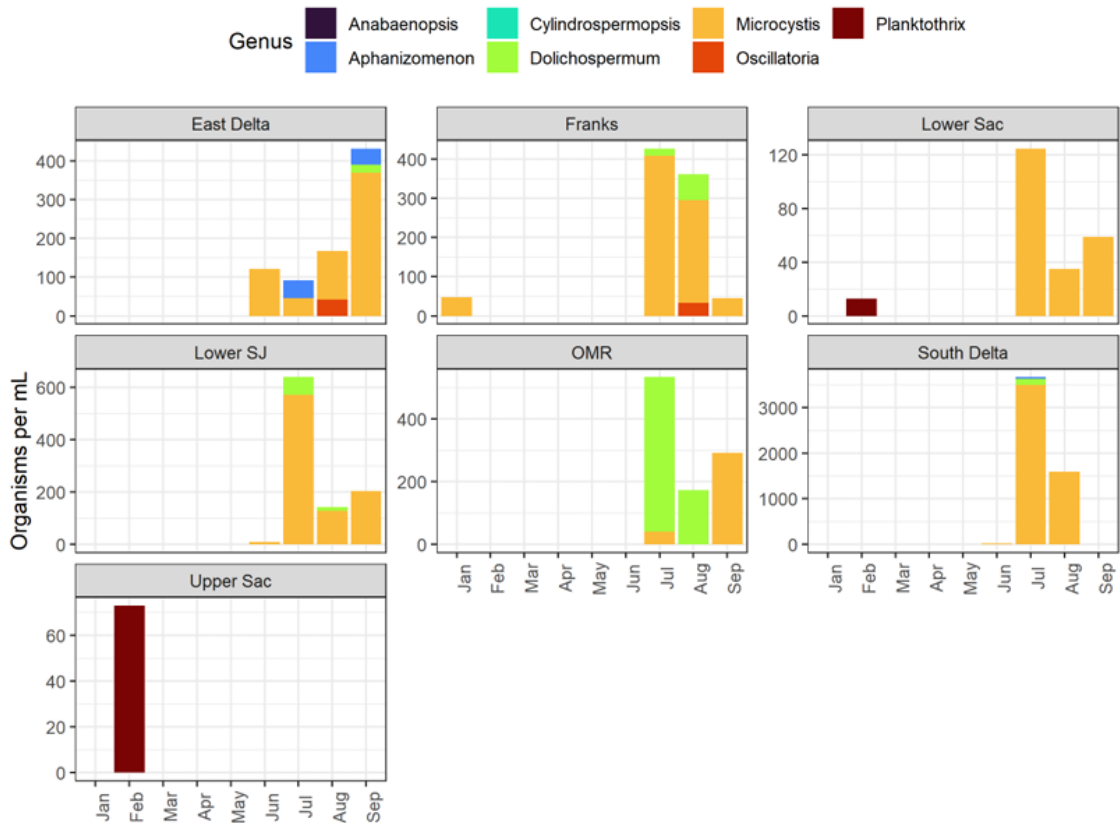
N/A

Recommendations for Modifications

Current monitoring is still conducted in a somewhat piecemeal manner, including many small-scale projects, special studies, and short-term sampling. Regular, standardized monitoring that is conducted on a regular basis and a consistent manner would be needed to adequately assess the impact of drought actions on HABs and the impact of HABs on people and the ecosystem.

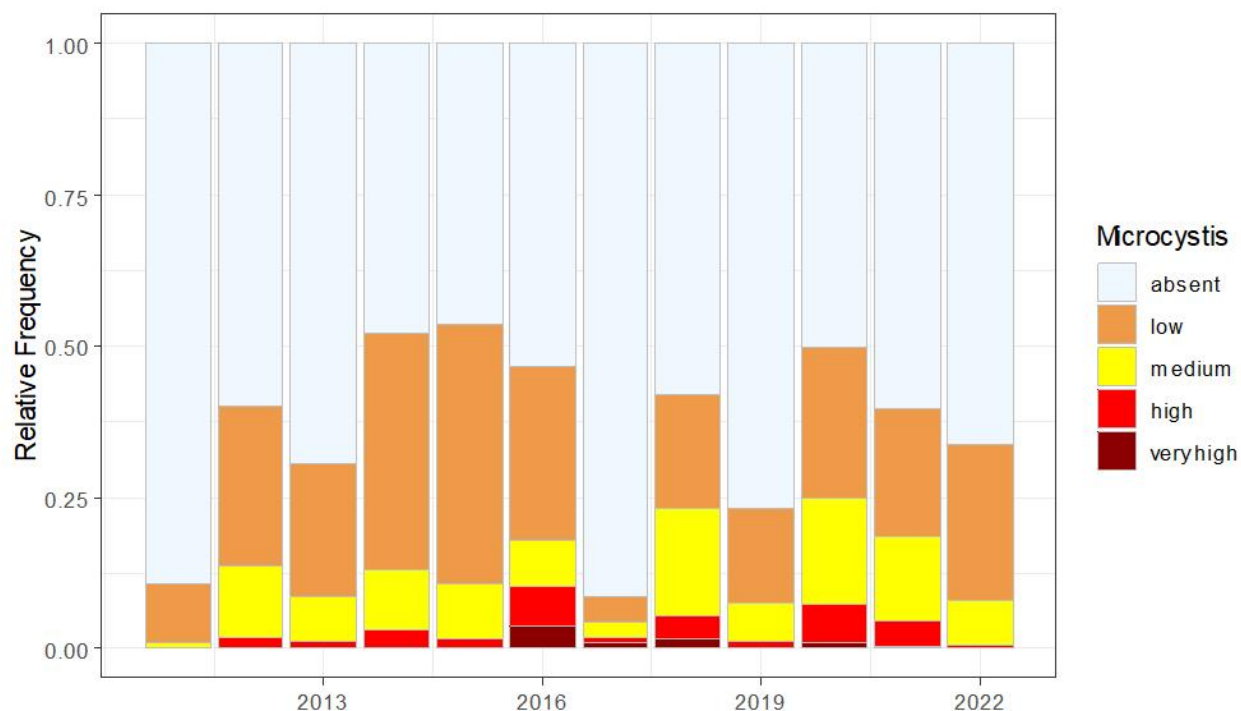
Figures/Tables

Figure 6 Concentration of Potentially Toxic Cyanobacteria collected in Different Regions of the Delta by the Environmental Monitoring Program



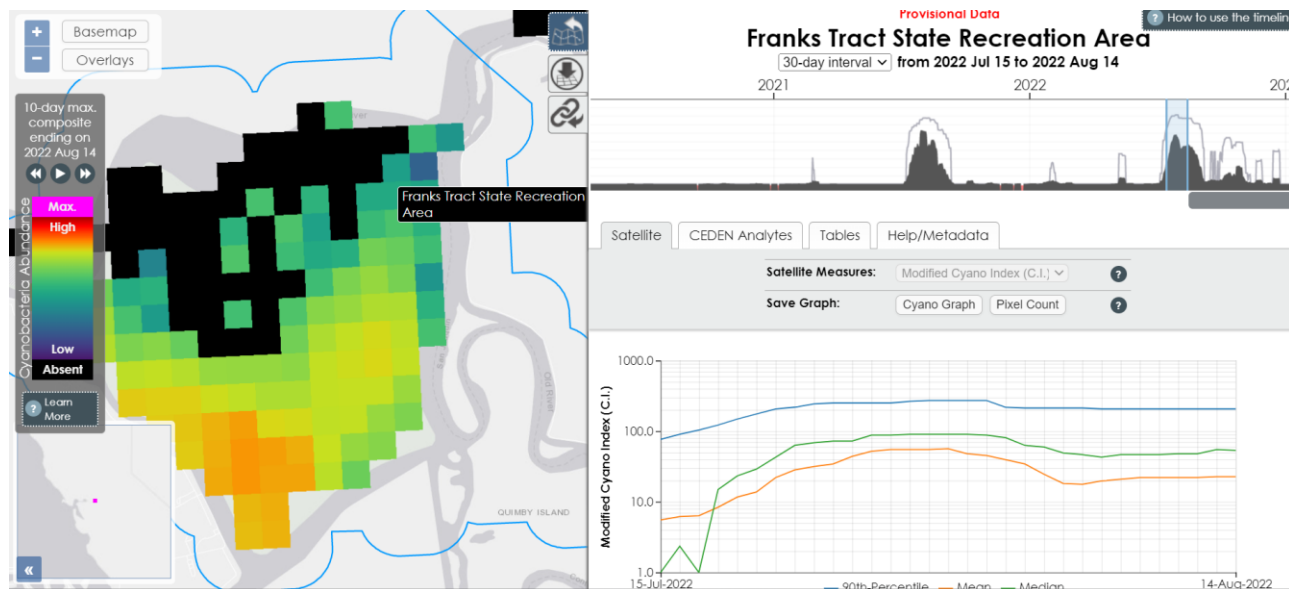
Note: Figure from draft temporary change petition order/barrier report.
U.S. Bureau of Reclamation, courtesy of Kristin Arend.

Figure 7 Frequency of Occurrence of Microcystis Visual Observations recorded by Long-Term Monitoring Programs across the Delta from 2014 through 2022



Note: Figure from draft temporary change petition order/barrier report.
U.S. Bureau of Reclamation, courtesy of Kristin Arend. Additional information on sampling distribution and frequency is included in the report.

Figure 8 Screenshot of the SFEI HAB Satellite Analysis Tool showing Large Dolichospermum Bloom in Franks Tract during Summer 2022



Action Evaluation: Exchanges through the Consolidated Place of Use

Point of Contact

Janice Wu, DWR

Dates Implemented

July 22, 2022, through July 21, 2023.

Water Year (description of conditions)

Critically dry WY 2022

Timeframe and Milestones

On May 11, 2022, Reclamation and DWR jointly submitted the water right change petition to the State Water Board to temporarily consolidate the SWP and CVP places of use.

Intended Effect

The requested changes were made to allow DWR and Reclamation to more effectively and efficiently utilize the potential operational flexibility of the combined SWP and CVP facilities and water supply south of the Banks Pumping Plant and Jones Pumping Plant. The requested changes will facilitate the delivery of available Project supplies south of the Delta and maximize the beneficial use of available Project supplies. Approval of this Petition will not result in diversion of additional water from the Delta, a change in the timing of SWP or CVP diversions, or the delivery of more water from the Projects than has been delivered historically.

Relation to Other Drought Actions

Independent action.

Data Used for Evaluation

Accounting of exchanges.

Other Considerations

N/A

Resources Needed/Used

The total amount of water to be exchanged is up to 393,385 acre-feet.

Lessons Learned

N/A

Recommendations for Modifications

N/A

Figures/Tables

N/A

Action Evaluation: Release of Water from Friant Dam for Contractual Demands in Mendota Pool

Point of Contact

Liz Kiteck, Reclamation

Dates Implemented

April 1, 2022, through July 10, 2022.

Water Year

Critically Dry water year for San Joaquin Basin.

Timeframe and Milestones

Because of the inability of Reclamation to provide enough water from the Delta in 2022 for the contractual demands of senior water rights contractors in Mendota Pool, Reclamation began making releases from Friant Dam on April 1, 2022, to meet these demands. As a result, the San Joaquin River Restoration Program had to cease San Joaquin River releases on April 11, 2022, because of the unavailability of river capacity for the Restoration Program flows. The Friant Dam releases began decreasing in late June and releases for the exchange contractors ended by July 10 because of an increase in water available in the Delta.

Intended Effect

N/A

Relation to Other Drought Actions

N/A

Data Used for Evaluation

N/A

Other Considerations

N/A

Resources Needed/Used

N/A

Lessons Learned

N/A

Recommendations for Modifications

N/A

Figures/Tables

N/A

Action Evaluation: Sacramento River Settlement Contractors Delivery Reduction

Point of Contact

Liz Kiteck, Reclamation

Dates Implemented

WY 2022

Water Year

Critically Dry water year.

Timeframe and Milestones

Because of the very low storage at Shasta Reservoir and the two back-to-back years of low egg-to-fry survival for the endangered winter-run Chinook salmon, Reclamation, DWR, NMFS, FWS, CDFW and the State Water Board worked with the SRSC to develop a Keswick Reservoir release plan that conserved Shasta Reservoir storage and prioritized temperature management in the Sacramento River. This release plan was used to determine the available water for diversion by the SRSC and the wildlife refuges north of the Delta. During WY 2022, the SRSC were entitled to 75 percent of the water provided under the SRSC contracts. The operations plan adopted, however, furnished only 18 percent of the water under the SRSC contracts.

The very low deliveries to the SRSC resulted in large amounts of fallowed Sacramento Valley farmland and serious economic impacts to the contractors and the surrounding communities. The action also resulted in a large decrease in Sacramento Valley in-basin use, which helped to support the rest of the CVP-SWP system.

Intended Effect

To increase Shasta Reservoir storage and prioritize Sacramento River temperature management.

Relation to Other Drought Actions

N/A

Data Used for Evaluation

N/A

Other Considerations

N/A

Resources Needed/Used

N/A

Lessons Learned

N/A

Recommendations for Modifications

N/A

Figures/Tables

N/A

References

- Bouma-Gregson K, Bosworth D, Flynn TM, Maguire A, Rinde J, Hartman R. In prep. Delta Blue(green)s: The Impact of Drought and Drought Management Actions on Microcystis in the Sacramento-San Joaquin Delta. Draft manuscript.
- California Department of Water Resources and U.S. Bureau of Reclamation. 2022. *State Water Project and Central Valley Project Drought Contingency Plan*. 30 pp. [Government Report.]
- Hartman R, Bosworth D, Rasmussen N, Flynn T, Bouma-Gregson K, Khanna S, Frantzich J. 2023. *Harmful algal bloom and aquatic weeds data from the Sacramento-San Joaquin Delta, collected to evaluate the impact of the 2021 Temporary Urgency Change Order and Emergency Drought Barrier. ver 1*. Environmental Data Initiative. Viewed online at: <https://doi.org/10.6073/pasta/9e53e6f97568cacabf5f307a5645efc3>. Accessed: Apr 13, 2023.
- IEP Drought Synthesis Team. 2023. *Ecological Impacts of Drought on Suisun Bay and the Sacramento-San Joaquin Delta with special attention to the extreme drought of 2020–2022*. IEP Technical Report #100. Sacramento, CA. Interagency Ecological Program for the San Francisco Estuary.
- National Marine Fisheries Service. 2004. *Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan*. [Government Report.]
- U.S. Bureau of Reclamation. 2022. *Drought Toolkit*. 61 pp.
- U.S. Bureau of Reclamation. 2022. *Impact of Temporary Urgency Change Petition of 2022 and Emergency Drought Salinity Barrier on Harmful Algal Blooms and Aquatic Vegetation in the Delta: Interim Draft Report*. Report Prepared for: California State Water Resources Control Board. Viewed online at: https://www.waterboards.ca.gov/drought/tucp/docs/2022/20221215_condition8_usbr.pdf. Accessed: Dec 7, 2023.

Useful Web Links

California Data Exchange Center

<https://cdec.water.ca.gov/>

California Department of Fish and Wildlife, Jellyfish Catch Data from Fall Midwater Trawl, San Francisco Bay Study

<https://filelib.wildlife.ca.gov/Public/BayStudy/>

California Department of Fish and Wildlife, Jellyfish Catch Data from Fall Midwater Trawl, Summer Townt Survey

<https://filelib.wildlife.ca.gov/Public/TowntFallMidwaterTrawl/TNS%20MS%20Access%20Data/TNS%20data/>

California Department of Fish and Wildlife, Fall Midwater Trawl

<https://filelib.wildlife.ca.gov/Public/TowntFallMidwaterTrawl/FMWT%20Data/>

California Harmful Algal Blooms (HABs) Portal

<https://mywaterquality.ca.gov/habs/>

Delta Harmful Algal Bloom Monitoring Strategy. A Working Document to Develop a Community Monitoring Strategy. Draft report.

<https://deltacouncil.ca.gov/pdf/science-program/information-sheets/2022-10-21-draft-delta-harmful-algal-bloom-monitoring-strategy.pdf>

Ecological Impacts of Drought on the Sacramento-San Joaquin Delta, with Special Attention to the Extreme Drought of 2020–2021.

https://www.waterboards.ca.gov/drought/tucp/docs/2021/20220201_report_cond7.pdf

Emergency Drought Barrier Effectiveness Report

<https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Endangered-Species-Protection/Emergency-Drought-Barrier-Effectiveness-Report.pdf>

Environmental Monitoring Program

<https://portal.edirepository.org/nis/mapbrowse?packageid=edi.1036.1>

Harmful algal bloom and aquatic weeds data from the Sacramento-San Joaquin Delta, collected to evaluate the impact of the 2021 Temporary Urgency Change Order and Emergency Drought Barrier. Ver 1.

<https://portal.edirepository.org/nis/mapbrowse?packageid=edi.1337.1>

Impact of Temporary Urgency Change Petition of 2022 and Emergency Drought Salinity Barrier on Harmful Algal Blooms and Aquatic Vegetation in the Delta: Interim Draft Report

https://www.waterboards.ca.gov/drought/tucp/docs/2022/20221215_conditi on8_usbr.pdf

Interagency Ecological Program, Integrated Dataset of Discrete Water Quality

<https://github.com/InteragencyEcologicalProgram/discretewq>

Interagency Ecological Program, Suisun Marsh Survey

<https://iep.ca.gov/Science-Synthesis-Service/Monitoring-Programs/Suisun-Marsh>

SacPAS

<https://www.cbr.washington.edu/sacramento/>

Sacramento-San Joaquin Delta Genus and Community-Level Classification Maps derived from Airborne Spectroscopy Data

<https://knb.ecoinformatics.org/view/doi%3A10.5063%2FF1N014ZX>

SFEI and Freshwater and Estuarine Harmful Algal Bloom Satellite Analysis Tool

<https://fhab.sfei.org/>

SpecTIR

<https://www.spectir.com/>

State Water Project and Central Valley Project Temporary Urgency Change Petition

https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/

Temporary Urgency Change Petition of 2021 and Emergency Drought Salinity Barrier. Impacts on Harmful Algal Blooms and Aquatic Weeds in the Delta

<https://www.waterboards.ca.gov/drought/tucp/docs/2022/2022-10-14-habs-weeds-report.pdf>

University of California, Davis, Center for Remote Sensing and Spatial Technologies

<https://cstars.ucdavis.edu/>

U.S. Geological Society National Water Information System: Web Interface

<https://waterdata.usgs.gov/nwis>

Zooplankton Data Synthesizer: Version 2.4.1.9000. Integrated Dataset of Zooplankton Data

<https://deltascience.shinyapps.io/ZoopSynth/>



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RECLAMATION