BUREAU OF RECLAMATION

Delta Smelt Summer-Fall Habitat Seasonal Report for WY 2025

Central Valley Project and State Water Project

California-Great Basin Region 10



U.S. Department of the Interior and State of California

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Delta Smelt Summer-Fall Habitat Seasonal Report for WY 2025

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California-Great Basin Region 10

Prepared by

California Department of Water Resources

United States Bureau of Reclamation

In coordination with the California's Department of Fish and Wildlife, United States Fish and Wildlife Service, National Marine Fisheries Service and Delta Coordination Group

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Contents

Page

Contents **4**
List of Tables 6
List of Figures 6
List of Abbreviations and Acronyms 11

Executive Summary **12**

Purpose **14**
Delta Smelt Summer-Fall Habitat 14
Management Actions 17
Action Plan Revisions 17

Background **18**
Objectives and Hypotheses 18
Delta Coordination Group and Adaptive Management Activities 19

Action Implementation **21**
SMSCG and X2 Implementation 21

Monitoring and Methods **26**
Water Quality 26
Delta Smelt Habitat Hindcast Models 28
Aquatic Vegetation 29
Zooplankton 31
Delta Smelt Abundance and Distribution 33
Experimental Releases 33

Results **34**
Extent of Appropriate Delta Smelt Habitat 34
Observed Water Quality 34
Aquatic Vegetation 39
Hindcast Modeling 43
Zooplankton 50
Delta Smelt Status 56

Flow Action Discussion **58**
Conclusions 60

Additional Food Web Actions **62**
Sacramento Deep Water Ship Channel Food Web study 62
Suisun Marsh Food Subsidy Studies 66

References **83**

Supplemental Tables **92**

Attachments **98**

List of Tables

Table 1. Historical years used for comparison to 2025, with actions taken in each year. 19

Table 2. 2025 Suisun Marsh Salinity Controls Gate Operations. Flashboard Status indicates if they are installed or removed. Boat Lock Status indicates if it is closed or in operation 22

Table 3. Scenario descriptions for SCHISM modeling of proposed operations for Suisun Marsh habitat .28

Table 4. Summary of Delta Smelt hatchery releases into the Delta and marsh and subsequent detections of juveniles during the Summer-Fall Habitat Action period (June-October). 33

Table 5. Number of days with optimal Delta Smelt habitat conditions in each region and year during the summer-fall time period (out of a total possible of 153). No turbidity data was available in Suisun Marsh before 2018 38

Table 6. Results of linear mixed model of *Pseudodiaptomus sp*. biomass versus region, year, and the interaction of region and year. *** = significant at the p<0.001 level. ** = significant at the p < 0.01 level. * = significant at the p < 0.05 level. 54

Table 7. Results of linear model of Limnoithona sp. biomass by region and year, and the interaction between region and year.. *** = significant at the p<0.001 level. ** = significant at the p < 0.01 level. * = significant at the p < 0.05 level 55

Table 8. Delta Smelt catch, from June 1-October 31, 2025. All fish were caught by the USFWS EDSM survey and genetically confirmed as Delta Smelt. 56

List of Figures

Figure 1. Location of X2 for June-October of 2025 (black line), and 2017-2024 (colored lines) as calculated by Dayflow. Dayflow data were only available through September 30, 2025, so October data comes from CDEC station CX2. Real-time calculations for X2 when it is above 81 km from CDEC are not available (green points) 23

Figure 2. Salinity at Belden's landing in 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024) and wet years (2017, 2019, 2023). Green dotted line shows the 6 PSU threshold for good Delta Smelt habitat. 24

Figure 3. Daily Net Delta Outflow Index for the summer-fall period for 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024), and wet years (2017, 2019, 2023). 25

Figure 4. Daily combined exports from the Central Valley Project (CVP) and State Water Project (SWP) for the summer-fall period for 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024), and wet years (2017, 2019, 2023). 26

Figure 5. Map of water quality sonde locations used for analysis of Delta Smelt habitat. 27

Figure 6. Regions used to aggregate low salinity zone and habitat suitability indexes. The category "All" represents the spatial union of areas in the legal Delta, Suisun Marsh and Suisun Bay. 29

Figure 7. Three regions of tidal waterways in and around Suisun Marsh that were used to evaluate the impacts of aquatic vegetation on open water habitat. 31

Figure 8. Map of fixed stations where zooplankton samples are collected 32

Figure 9. Plot of daily average Chlorophyll (µg/L), Salinity (PSU), Temperature (°C) and Turbidity (FNU) at continuous monitoring stations throughout the area (Figure 5). Black dotted lines on salinity, temperature, and turbidity graphs indicate Delta Smelt habitat thresholds, and the gray dotted line on the chlorophyll graph is a commonly used reference point for high plankton growth. Grey shaded areas indicate time periods where the SMSCG were operating 36

Figure 10. Number of days of the summer and fall (out of 153 total) where water quality conditions in the bay, marsh, and river met the suitable smelt habitat criteria (i.e., < 6 PSU salinity, < 22°C temperature, > 12 FNU turbidity) for 2017-2025. Water year type is indicated below the year. 37

Figure 11. Time series of floating aquatic vegetation (FAV) area in and around Suisun Marsh by region.40

Figure 12. Alligatorweed (left) and azolla (right) were the most common FAV species detected by the airborne hyperspectral imagery of Suisun Marsh 41

Figure 13. Submersed aquatic vegetation (SAV) area in and around Suisun Marsh by region 41

Figure 14. Aquatic vegetation map of Suisun Marsh from August 22, 2025 42

Figure 15. Maps of salinity in Suisun Marsh and Suisun Bay for each of the operational scenarios, averaged over the first half of July, August, and September. Blue indicates areas of appropriate smelt habitat, red indicates poor smelt habitat. 44

Figure 16. Time series of LSZ within the Suisun Marsh and Suisun Bay regions shown in Figure 6 45

Figure 17. 14-day average of daily maximum temperature for the historical and alternate scenarios. 46

Figure 18. Map of appropriate Delta Smelt habitat (< 6 PSU and < 22°C) in the historical and alternate scenarios. Colors indicate proportion of the 14-day time period that both parameters were suitable, with 1 being 14 days and 0 being 0 days. 47

Figure 19. Area of appropriate Delta Smelt habitat (both < 6 PSU and < 22°C) in Suisun Marsh for the summer-fall habitat action (July-October). Black line shows historical habitat area, blue shows the alternate scenario 48

Figure 20. Percent of total wetted area less than 6 PSU in Suisun Bay, Grizzly Bay, and Suisun Marsh from 2011-2025. Wet years are shown in shades of blue, above normal years in shades of green, below normal years in shades of yellow, dry years in shades of orange, and critical years in shades of red. 2025 is shown in black. 49

Figure 21. Mean biomass (June-October) of each of the major copepod taxa by region and year from 2010-2025. Number of samples is noted below each bar..... 51

Figure 22. Box plots showing biomass of *Pseudodiaptomus sp*. by region and year..... 52

Figure 23. Box plots showing biomass of *Limnoithona sp*. by region and year. 53

Figure 24. Map of EDSM Delta Smelt catch during the summer-fall action period (June 1 -October 31, 2025). The date of each capture (Month-Day) is indicated next to the point. 57

Figure 25. Average Delta Smelt abundance estimate for July 1 through September 30. Abundance estimates are calculated by EDSM on a weekly basis, then summarized by calculating the average and standard error over the summer-fall habitat season. Plot courtesy of Lara Mitchell, USFWS..... 58

Figure 26. Map of Sacramento Deep Water Ship Channel (SDWSC) water quality and meteorological stations used for analysis. Hydrodynamic exchange ("Exchange") is conceptualized in the inset. Solid horizontal lines indicate the extent of tidal excursion throughout one year, and dashed horizontal lines indicate the 5th and 95th percentiles of conceptual constituent gradients as in Stumpner et al. 2020. Turbidity peaks at CM66, at the upper limit of tidal exchange. 64

Figure 27. Predicted Delta Smelt size (weight in grams) from the DSM bioenergetic model and von Bertalanffy growth equation (black line) based on temperature, turbidity, day length, and zooplankton biomass among DWSC stations (CM51, CM66, CM74, CM84) and depth (Bottom vs Surface). 65

Figure 28. Map of monitoring stations for a plankton productivity study in Suisun Marsh. Stations located within seasonally managed wetlands (orange), a perennially managed wetland (green), tidally restored wetlands (dark blue) and adjacent reference sloughs (light blue) 67

Figure 29. Point and LOESS regression plots of daytime water-temperature trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024.69

Figure 30. Point and LOESS regression plots of salinity trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024. 69

Figure 31. Point and LOESS regression plots of daytime dissolved oxygen trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024.70

Figure 32. Point and LOESS regression plots of sonde chlorophyll-a trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 200 µg/l not shown (n=12 in seasonally managed wetlands) but are factored in LOESS regression trends. Dotted vertical line delineates water years 2023 and 2024..... 70

Figure 33. Box-and-whisker plots comparing distributions of (a) water temperatures, (b) salinities, (c) dissolved oxygen, and (d) chlorophyll concentrations across water years and treatments. Lines

refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR. 71

Figure 34. Point and LOESS regression plots depicting pelagic gross primary production in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh 72

Figure 35. Point and LOESS regression plots depicting pelagic net ecosystem production rates in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh 72

Figure 36. Point and LOESS regression plots depicting pelagic respiration rates in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh 73

Figure 37. Box-and-whisker plots comparing rates of (a) gross primary production, (b) net ecosystem production, and (c) respiration across water years and treatments. Lines refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR. 74

Figure 38. Point and LOESS regression plots of RZA copepod abundance trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 150 counts not shown (n = 1 in perennially managed, n=6 in seasonally managed) but are included in LOESS regression. Dotted vertical line delineates water years 2023 and 2024 75

Figure 39. Point and LOESS regression plots of RZA cladoceran abundance trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 50 counts not shown (n=8 in seasonally managed) but are included in LOESS regression. Dotted vertical line delineates water years 2023 and 2024 76

Figure 40. Box-and-whisker plots comparing (a) daytime dissolved oxygen, (b) chlorophyll-a concentrations, (c) copepod abundance, and (d) and cladoceran abundances across different treatment types and between water years. Plankton abundances are log-transformed. Lines refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR. 77

Figure 41. Stacked bar plots depicting density (size) and composition (color) of monthly zooplankton samples from different wetlands over the two-year study. Y-axis is scaled independently for each wetland (see Figure 8 for fixed-scale comparisons). Dotted vertical lines indicate the start of the water year. Note: data are incomplete as sample processing is still in progress at the time of writing 78

Figure 42. Fixed-scale stacked bar plots depicting density (size) and composition (color) of monthly zooplankton samples from different wetlands over the two-year study. Y-axis is fixed for comparison of total densities between wetlands (see Figure 7 for more detailed within-site trends). Dotted vertical lines indicate the start of the water year. Note: data are incomplete as sample processing is still in progress at the time of writing 79

Figure 43. Box-and-whisker plots comparing zooplankton abundances in different wetlands for each taxon. Abundances are log-transformed with y-axes independently scaled for each taxon. Lines refer to median estimates across the two-year study period. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR. Note: data are incomplete as sample processing is still in progress at the time of writing..... 80

List of Abbreviations and Acronyms

Abbreviation	Definition
BPUE	Biomass per unit effort
CDFW	California Department of Fish and Wildlife
CVP	Central Valley Project
D-1641	Water Rights Decision 1641
DCG	Delta Coordination Group
DOP	Directed Outflow Project
DWR	Department of Water Resources
EDSM	Enhanced Delta Smelt Monitoring Program
EMP	Environmental Monitoring Program
FCCL	Fish Conservation and Culture Laboratory
FMWT	Fall Midwater Trawl Survey
FNU	Formazin nephelometric units
IEP	Interagency Ecological Program
LSZ	Low Salinity Zone (<6 PSU)
LTO	Long-term Operation of the CVP and SWP
NDFS	North Delta Food Subsidies/Colusa Basin Drain Study
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
Reclamation	United States Bureau of Reclamation
ROD	Record of Decision
SCHISM	Semi-Implicit Cross-scale Hydroscience Integrated System Model
SDM	Structured decision making
SDWSC	Sacramento River Deepwater Ship Channel
SFHA	Summer-Fall Habitat Action
SMSCG	Suisun Marsh Salinity Control Gates
State Water Board	State Water Resources Control Board
STN	Summer Townet Survey
SWP	State Water Project
TAF	Thousand Acre-Feet
USFWS	United States Fish and Wildlife Service
WY	Water Year
USGS	United States Geological Survey
X2	Location of the 2 PSU isohaline in kilometers from the Golden Gate

Executive Summary

The Delta Smelt Summer and Fall Habitat Action (SFHA) includes operational actions aimed to improve habitat and food for the species during June-October when the population generally experiences low survival. Water year (WY) 2025 was classified as Above Normal, and a Suisun Marsh Salinity Control Gates (SMSCG) action was implemented. The SMSCG were operated for 70 days from June 23-August 25, and again from September 5-12.

The Bureau of Reclamation (Reclamation) modified the SFHA by no longer maintaining a 30-day average X2 ≤ 80 km from the Golden Gate Bridge for September through October of Wet and Above Normal years. This modification was based upon the U.S Fish and Wildlife's 2024 Biological Opinion (2024 USFWS Biological Opinion) determination that the Modified Fall X2 Component is not anticipated to have observable effects on Delta Smelt survival. An amendment to the State Water Project (SWP) Incidental Take Permit (ITP) issued by the Department of Fish and Wildlife (CDFW) to the Department of Water Resources (DWR) also removed the requirement for a Fall X2 action in 2025 that was replaced with additional SMSCG operations and a new Food and Habitat Enhancement Action to be implemented in 2026-2028.

The primary hypotheses of the SFHA are that Delta Smelt survival will increase through increased habitat quality and increased copepod biomass in Suisun Marsh and Grizzly Bay by SMSCG operations. Habitat quality includes abiotic factors (salinity, turbidity, and temperature) and biotic factors (food availability) and habitat quantity includes the acreage of suitable low salinity habitat. Suitable Delta Smelt thresholds for the abiotic factors are temperature ≤22°C (considered optimal for smelt growth, although smelt can survive at higher temperatures), salinity <6 PSU, and turbidity ≥12 FNU.

After analyzing empirical data on habitat conditions, and Delta Smelt survey detections, our findings inform some of the SFHA hypotheses:

1. **Operating the SMSCG will increase habitat quality and copepod biomass in Suisun Marsh –** *Partially supported*
    a. Area of suitable habitat in Suisun Marsh increased during SMSCG operation, though decreased in late September and October after operations concluded.
    b. *Pseudodiaptomus sp*. biomass in 2025 was high, similar to the years with SMSCG actions (2024 and 2018), and higher than dry years with no actions (2020, 2021, 2022) but lower than wet years with X2 actions (2017, 2019, and 2023).

2. **Operating the SMSCG will increase Delta Smelt habitat in Grizzly Bay –** *Not supported*
    a. Area of Low Salinity Zone (<6 PSU) (LSZ) habitat in Grizzly Bay did not markedly increase during the SMSCG operations.
3. **The increase in habitat and food supply from the SMSCG action will increase Delta Smelt growth and survival** – *Insufficient data to evaluate*
    a. Smelt catch was too low during the action to credibly evaluate the impact of the action on smelt survival.

During June through October, seven juvenile wild-born Delta Smelt (i.e., offspring of hatchery-released fish) were detected by the Enhanced Delta Smelt Monitoring Program (EDSM). Three were detected in Suisun Marsh during summer Gate operations, one in the lower Sacramento River, and three were detected in October (in the Lower Sacramento River and marsh) when no action occurred. Because of low abundance we cannot credibly correlate smelt responses to action or no-action conditions.

Although no food web actions were implemented in 2025, monitoring and ongoing special studies were conducted to help inform their implementation in future years. In the Sacramento Deep Water Ship Channel (SDWSC), Reclamation is working with UC Davis to study ecosystem metabolism, photosynthesis-irradiance dynamics, benthic nutrient pools and fluxes, and zooplankton grazing rates with the ultimate goal of developing flow and nutrient enhancement management actions. In addition, a multi-agency team led by the DWR has recently completed a modeling study identifying the benefits of the SDWSC for smelt habitat, with an emphasis on the high-turbidity area at the midpoint of the channel.

The study of managed wetlands in Suisun Marsh has demonstrated that seasonally managed wetlands have much higher chlorophyll and zooplankton abundance than reference channels outside the site. This could provide an important subsidy of zooplankton during periods when the wetlands are draining, though care needs to be taken to ensure dissolved oxygen is not low during the drain operation. Plans are currently underway to flood several managed wetland parcels in the summer of 2026 to provide additional food resources for Delta Smelt during the summer and fall.

Purpose

The following 2025 Seasonal Report for the Delta Smelt SFHA describes the operations of the CVP and SWP, and Delta Smelt habitat conditions in water year (WY) 2025. This report may support adaptive management adjustments, if necessary, to future operations by documenting the ecological responses that occurred during habitat actions or in some cases the absence of an action (e.g., food actions), and comparisons to previous years where appropriate.

This document informs the Long-Term Operation (LTO) of the CVP and SWP, and acts as the Delta Smelt SFHA report outlined in the 2024 USFWS Biological Opinion and CDFW ITP (Condition of Approval (COA) 9.1.3.1). This document may inform independent reviews and adaptive management of the SFHA and Projects (Proposed Action section 3.7.2.2, ITP Attachment 2). This document serves to provide an integrated view of the factors affecting the low salinity zone and adjacent habitats within the Sacramento-San Joaquin Delta with regard to their suitability to support Delta Smelt growth and survival.

Delta Smelt Summer-Fall Habitat

The Delta Smelt SFHA provides for operational actions that are hypothesized to improve habitat and food availability for Delta Smelt. Operational actions include use of the SMSCG in the summer or fall months, Delta outflow augmentation, and optional food enhancement actions, including food production in managed wetlands in Suisun Marsh and use of nutrient enhancement and flow augmentation in the Sacramento Deepwater Ship Channel to increase food availability for Delta Smelt.

Most Delta Smelt complete their entire life cycle within or immediately upstream of the estuary's low salinity zone (LSZ, Merz et al. 2011). Scientific research has generally shown that lower salinity in Suisun Marsh and Suisun Bay, caused by either increased outflow (Sommer and Meija 2013) or specific management actions (Sommer et al 2020), may be beneficial for the Delta Smelt population due to increased distribution, foraging opportunities, and habitat complexity. The highest quality habitats in this large geographical region include areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands (Bever et al. 2016, Hammock et al. 2019).

Abiotic habitat conditions for Delta Smelt in the San Francisco Bay-Delta are generally better in years when the low salinity zone in the summer and fall (as indexed by X2) is located further downstream (Brown et al. 2014, IEP MAST 2015). Three commonly measured water quality parameters form the underlying basis for this hypothesis:

salinity, water temperature, and turbidity (Nobriga et al. 2008, Mac Nally et al. 2010, Feyrer et al. 2011, Bever et al. 2016). Consequently, abiotic habitat attributes within suitable ranges for Delta Smelt are defined in this report as low salinity conditions of 6 PSU or less, turbidity higher than 12 FNU, and water temperatures below 22°C based on temperatures at which smelt experience positive growth (see DCG Temperature Constructs 2023).

Salinity: Delta Smelt is a semi-anadromous species. The species spawns in freshwater and most juveniles migrate into the low-salinity zone (0.5-6 PSU) where they rear during the summer and fall (Hobbs et al. 2019). Delta Smelt have a physiological stress response to high salinity (18 PSU or higher, Komoroske et al. 2016) and higher occurrence in low salinity habitat (6 PSU or lower, Feyrer et al. 2007, Nobriga et al. 2008), so the size and location of the low salinity zone have been described as indicators of Delta Smelt habitat suitability.

Temperature: Evidence of Delta Smelt sensitivity to warm water temperature has come from both laboratory and field studies. Critical thermal maxima of juvenile Delta Smelt appear to range somewhere between 25 to 29°C in a controlled laboratory setting (Swanson et al. 2000, Komoroske et al. 2014, Davis et al. 2019; Davis et al. 2024), a temperature range that is observed in the field at times; however, recent studies suggest field-derived thermal maxima may be ~2°C lower (Davis et al. 2024). High summer temperature (daily means closer to 23°C than 20°C) was also found to have a negative impact on juvenile Delta Smelt survival from spring to fall based on data analyses and models using field data (e.g., Mac Nally et al. 2010, Polansky et al. 2021). Moreover, occurrence of postlarval and juvenile Delta Smelt peaks near 20°C, indicating that warmer temperatures are increasingly stressful (Nobriga et al. 2008, Sommer and Mejia 2013, Komoroske et al. 2014). This report uses 22°C as a threshold below which Delta Smelt typically experience positive growth. Above 22°C, growth may be limited (Lewis et al. 2021) due to sublethal stress responses (Komoroske et al. 2015, Jeffries et al. 2018), behavioral changes (Davis et al. 2019), and foraging and consumption constraints (Smith and Nobriga, 2023).

Turbidity: Water clarity is also a key determinant in the occurrence and abundance of Delta Smelt in the field (Feyrer et al. 2007, Nobriga et al. 2008, Bever et al 2016), because it improves feeding and reduces predation (Hasenbein et al. 2016, Ferrari et al. 2014). Turbidity >10 FNU has been shown to reduce smelt physiological stress, improve energy availability, and condition, compared to lower turbidity levels in laboratory studies (Pasparakis et al. 2023).

Biotic habitat attributes such as food availability and quality are other essential components of Delta Smelt habitat. The amount of food needed is difficult to evaluate in the field because prey densities necessary to sustain growth vary as a function of physical habitat conditions (Smith and Nobriga 2023). Food may contain toxins due to harmful algal blooms (Lehman et al. 2010; Acuña et al. 2012) or chemical contaminants (Orlando et al. 2024) and access to otherwise available food may be impacted by competition between Delta Smelt and other fishes (IEP MAST 2015). However, it is well established that high densities of calanoid copepods provide the best conditions for Delta Smelt foraging (Hammock et al. 2022; Smith and Nobriga 2023) with the copepod *Pseudodiaptomus forbesi* being particularly important during the summer (Slater and Baxter 2014; Slater et al. 2019), and densities of *P. forbesi* in the low salinity zone increase with increased flow (Kimmerer et al. 2018).

Given hypothesized benefits of habitat in Suisun Bay and Suisun Marsh, the consulted upon 2024 LTO Proposed Action and ITP included a Delta Smelt SFHA intended to improve Delta Smelt access to zooplankton and other important physical habitat attributes, which is believed to increase the growth, survival, and recruitment of Delta Smelt (2024 Proposed Action; Pg. 113, 2024 ITP). However, near the completion of the 2024 LTO Record of Decision (ROD) and ITP, new scientific findings of Delta Smelt habitat and freshwater management became available (Polansky et al. 2024) that warranted adaptive changes to the SFHA and ITP. The research indicates that higher outflow in summer has a greater potential to influence smelt population, as compared to no significant population growth from modeled outflow in the fall (Polansky et al. 2024). Coupled with bioenergetics research, an alternative hypothesis has gained support that sustained outflow after June when habitat and food conditions decline, may better support increased Delta Smelt survival through summer (Smith and Nobriga 2023).

Reclamation amended the 2024 Proposed Action in 2025 to reflect the best available science, thereby removing the Fall X2 Component. Subsequently, Reclamation permanently removed the Fall X2 Component in the 2025 LTO ROD adopting the Action 5 Operations Plan. The 2024 ITP was also amended to remove the Fall X2 outflow action in WY2025 that was replaced with additional SMSCG operations to maintain lower salinity in Suisun Marsh region through September, and a new Food and Habitat Enhancement Action to be implemented in 2026-2028 (2025 CDFW).

The SFHA investigates summer-fall habitat to better quantify and integrate information on how food, turbidity, salinity, water velocity, and water temperature interact to contribute to improved overall recruitment in response to one or more actions (2021 Delta Smelt Summer-Fall Habitat Action Guidance Document). Overall, the SFHA is intended to increase the spatial overlap of Delta Smelt habitat attributes with a focus on

Suisun Marsh and to experiment with potential enhancements of prey supply in the Cache Slough Complex.

Management Actions

Actions taken this year:

1. The 60-day SMSCG operation in summer occurred from June 23-Aug 22, with additional operations from Aug 23-25 and Sept 5-12.
2. The block of 100 TAF was not in effect, as water spilled from Oroville following January and February storms. Details can be found in the WY 2025 Action Plan.

Actions that may be taken in future years and studies to explore additional actions included in this report:

1. Sacramento River Deepwater Ship Channel Food Study (SDWSC)
2. Managed Wetland food subsidies in Suisun Marsh

Because WY 2025 was an Above Normal year, Reclamation and DWR developed an SFHA Action Plan for the WY 2025 that included recommendations by the Delta Coordination Group (DCG) and revisions based on real-time modeling. DWR submitted the SFHA Action Plan for final approval by CDFW to satisfy State requirements (Attachment B - 2025 SFHA Action Plan - Final.pdf).

Action Plan Revisions

The 2025 Action Plan underwent a major revision following delivery to CDFW and USFWS in May prior to finalization by the action agencies. This Seasonal Report reflects the final implemented action.

Outcomes from new science and adaptive management activities in April-June resulted in changes to operations and the Action Plan. Based on emergent best available science, Presidential Executive Order (14181) and multicriteria decision analysis outcomes completed in April, Reclamation did not implement the Fall X2 action; however, Fall X2 remained in the May version of the Action plan as an ITP requirement for DWR. Continued modeling efforts evaluating deployment of water equivalent to what SWP would contribute under the Coordinated Operations Agreement to implementation of a joint CVP/SWP Fall X2 action showed the action would be ineffective in increasing smelt survival, and therefore, additional SMSCG operations in exchange for Fall X2 were evaluated and showed to improve freshwater habitat in Suisun Marsh through summer. Proposed changes to the Action Plan were provided to the DCG in June, integrated into

subsequent revision and approved by CDFW on June 23. Following the approval of revised Action Plan, DWR submitted an ITP amendment request to off-ramp Fall X2 on Aug 20, and the ITP was reissued Sept 29.

Background

Objectives and Hypotheses

Hypotheses:

1. X2 above 80 km during summer and fall will decrease the area of low salinity habitat in Suisun Bay with appropriate temperatures and turbidity.
2. X2 above 80 km during summer and fall will decrease biomass of the calanoid copepod *Pseudodiaptomus forbesi* in the low salinity zone.
3. Operating the SMSCG during the summer and fall will increase the duration and area of Delta Smelt habitat in Suisun Marsh with appropriate temperatures, turbidity, and salinity.
4. Operating the SMSCG during the summer and fall will increase biomass of the calanoid copepod *Pseudodiaptomus forbesi* in Suisun Marsh through increased transport from upstream.
5. Operating the SMSCG will increase the area of appropriate Delta Smelt habitat in Grizzly Bay.
6. Delta Smelt survival in 2025 may be lower than years with X2 actions, but higher than drier years without SMSCG actions.

To address each of these hypotheses, Reclamation and DWR rely on two primary comparisons:

1. Inter-annual comparisons –comparing constituents during 2025 to conditions in previous years with X2 actions (2017, 2019, 2023, 2024), previous years with SMSCG actions (2018, 2023, 2024) and dry years with no action (2020-2022). The actions were not implemented in the same way in each year (Table 1), and other differences between water years make these comparisons difficult, but historical years still provide useful context for this year's observations.
2. Regional comparisons – Reclamation and DWR expect X2 actions to improve conditions in Suisun Bay. We expect SMSCG actions to improve conditions in Suisun Marsh and potentially Grizzly Bay. Neither action will change conditions in the river.

Table 1. Historical years used for comparison to 2025, with actions taken in each year.

Year	Water Year Type	X2 Action	SMSCG Action
2017	Wet	X2 at or below 74 km for September and October	None
2018	Below Normal	None	35-day gate operation, Aug. 2 – Sept. 7
2019	Wet	X2 at or below 74 km for September and October	None
2020	Dry	None	SMSCG operation starting Sept. 1*
2021	Critical	None	SMSCG operation starting Sept. 1*
2022	Critical	None	SMSCG operation starting Sept. 1*
2023	Wet	X2 at or below 80 km for September and October	SMSCG operating Aug. 15-Oct. 17
2024	Above Normal	X2 at or below 80 km for September	SMSCG operating July1-Aug. 29 and Sept. 6-Sept. 30
2025	Above Normal	None	SMSCG operation June 23-Aug 25, Sept 5-12

*The Suisun Marsh Preservation Agreement requires SMSCG operation starting in September when the seven-day running average mean daily high tide salinity at any compliance station is 17.0 mS/cm or greater.

Delta Coordination Group and Adaptive Management Activities

The DCG completed several activities in 2025 including updating the Monitoring and Science Plan, reviewing hydrology conditions, smelt status and new effects analyses to provide recommendations for the Action Plan (Attachment B), and discussing outcomes of the National Academies of Sciences Peer review. Reporting for adaptive management activities such as Reclamation's structured decision-making analysis (SDM), independent peer review, and the summer-fall synthesis study occurred just after the WY2025 reporting period; however, these activities are highlighted below when much of the work was implemented.

Between January and March 2025, Reclamation, USGS, and cooperating agencies/entities completed a rapid SDM analysis to evaluate summer-fall habitat actions for 2025. Participants identified eight fundamental values of interest (objectives) and 11 potential management actions (alternatives). Performance and tradeoffs between alternatives and across objectives were analyzed using multicriteria decision analysis. The highest-ranking alternatives, based on weighting, had the poorest performance for

Delta Smelt, despite consistently being a highly ranked objective, and the best performance for CVP and SWP exports and coldwater pool objectives for salmonids. However, results suggested that even in drier years, nonflow actions could benefit the Delta Smelt population, which can be explored further. Additional details about the SDM process and results can be found in the open-file report for this decision analysis (https://doi.org/10.3133/ofr20251055).

During this reporting period, the National Academy of Sciences, Engineering, and Medicine (NAS) completed the first cycle of the biennial review of the Long-Term Operation of the CVP. The first review period was late 2023- November 2025, with the public report (pre-publication copy) released on November 10, 2025 (NAS 2025). Within this cycle, the NAS and a committee of scientists were tasked with an independent review of three main actions within the LTO of the projects, one of which was Summer Fall Delta smelt Habitat (see task details at Review of the Long-Term Operations of the Central Valley Project and the State Water Project). NAS and several committee members gave a presentation to DCG on December 17, 2025. In their report and presentation, the committee commended Reclamation and DWR for taking an ecosystem approach to protecting Delta Smelt through the Summer Fall Habitat action. The committee highlighted the challenges with the action, including the uncertainty of detecting a response to the action due to low Delta smelt abundance. The committee stated the SFHA is unlikely to be sufficient to result in Delta Smelt persistence and recovery, though the SFHA may still provide improvements to habitat. The committee recommended that Reclamation and DWR should continue to improve on components of the SFHA, including food web studies and gate operations. The committee recommended Reclamation and DWR reconsider the concept of 'water year' for triggering summer-fall habitat actions under the climate change era, and consider adjusting the action based on environmental conditions that determine when and how to implement (e.g., wet but warm years). Additional recommendations and conclusions can be found in the report (NAS 2025).

The DCG Science and Monitoring Work Group initiated an effort to synthesize what we have learned from previous SFHA conducted in 2011-2024. This effort analyzed data on water quality, submerged vegetation, food availability, bioenergetic modeling, wild Delta Smelt growth and health, and results from three years of enclosure studies to test the hypotheses behind the SFHA. Overall, their findings reinforce the conclusions of Polansky et al. 2024, showing that higher outflow/low X2 in summer had a greater benefit for Delta Smelt food supply, health, and growth when compared to higher outflow in fall (DCG SMWG, 2026)

Action Implementation

SMSCG and X2 Implementation

The SMSCG were not operated from March 24, 2025, to June 22, 2025; with all of the gates held open, which is typical for spring of an Above Normal water year. The refurbishment project that caused one out of the three gates to be non-operational in 2024 is complete, so all three gates were operational in 2025. SMSCG operations began on June 23, see Table 2 below. The SMSCG were operated from June 23 to August 25, 2025, and again from September 5 through September 12, 2025. Salinity at Belden's Landing in 2025 was similar to 2024 throughout most of June and July, but trended higher in the end of August, September, and October, reflecting the removal of the Fall X2 standard and the shorter SMSCG operations when compared to 2024 (**Figure 2**). Salinity stayed below 3 PSU until September but surpassed 6 PSU at the end of September, reducing the likelihood that Delta Smelt would occupy the western side of the marsh (but see Delta Smelt Status section, below).

To provide a visual comparison of flow conditions in 2025 versus previous years, the daily Delta Outflow and X2 positions from DWR's Dayflow model for 2017- September 30, 2025 are graphed below Dayflow is not available for water year 2026 (including October of 2025), thus, daily estimates of X2 and Delta Outflow from CDEC station DTO are used for the last month of the reporting period. The CDEC estimates of X2 are made by interpolating between the salinity at several discrete monitoring stations in the system, with the furthest upstream station at 81 km. Therefore, this method does not provide estimates of X2 when it is greater than 81 km (Figure 1). The daily estimates from Dayflow are provided as an indicator of habitat conditions but are not used for ensuring compliance with requirements. Calculations for compliance are conducted on a monthly basis.

X2 in 2025 differed from the previous above normal year of 2024 as calculated by the Dayflow model (Figure 1, Figure 3). This difference is consistent with the amendment removing the Fall X2 requirement. Published models of low salinity zone habitat area versus X2 suggest that habitat area is lower with an X2 above 81 km than below 80 (Kimmerer et al. 2013), so Figure 1 indicates lower habitat area in 2025 than 2024 or previous wet years. In 2025, X2 exceeded 81 km by August 16 and continued moving steadily upstream through August and September. By September 18, 2025, X2 exceeded 88 km, comparable to conditions at this time of year in the recent dry and critically dry

years of 2020-2022. More detailed maps of habitat availability are available in the "Results" section below (Figure 15, Figure 16).

Export rates from the SWP and CVP in 2025 were similar to or lower than previous above normal and wet years (Figure 4), but higher than most previous below normal, dry and critical years.

Table 2. 2025 Suisun Marsh Salinity Controls Gate Operations. Flashboard Status indicates if they are installed or removed. Boat Lock Status indicates if it is closed or in operation.

Date	Gate Status	Flashboard Status	Boat Lock Status	Notes
1/1/25 – 3/23/25	3 Operational	Installed	Operational	Gate 2 was reinstalled; all three gates are tidally operating
3/24/25 – 6/22/25	3 Open	Installed	Operational	Operations suspended due to low salinities
6/23/25 – 8/25/25	3 Operational	Installed	Operational	Operations began to comply with SFHA for Delta Smelt
8/25/25 – 9/4/25	3 Open	Installed	Operational	Operations suspended after conclusion of SFHA
9/5/25 – 9/12/25	3 Operational	Installed	Operational	Operations restarted due to 7-day extension of the SFHA.
9/13/25 – 10/31/25	3 Open	Installed	Operational	Operations suspended at the conclusion of non-prescriptive Gate actions.

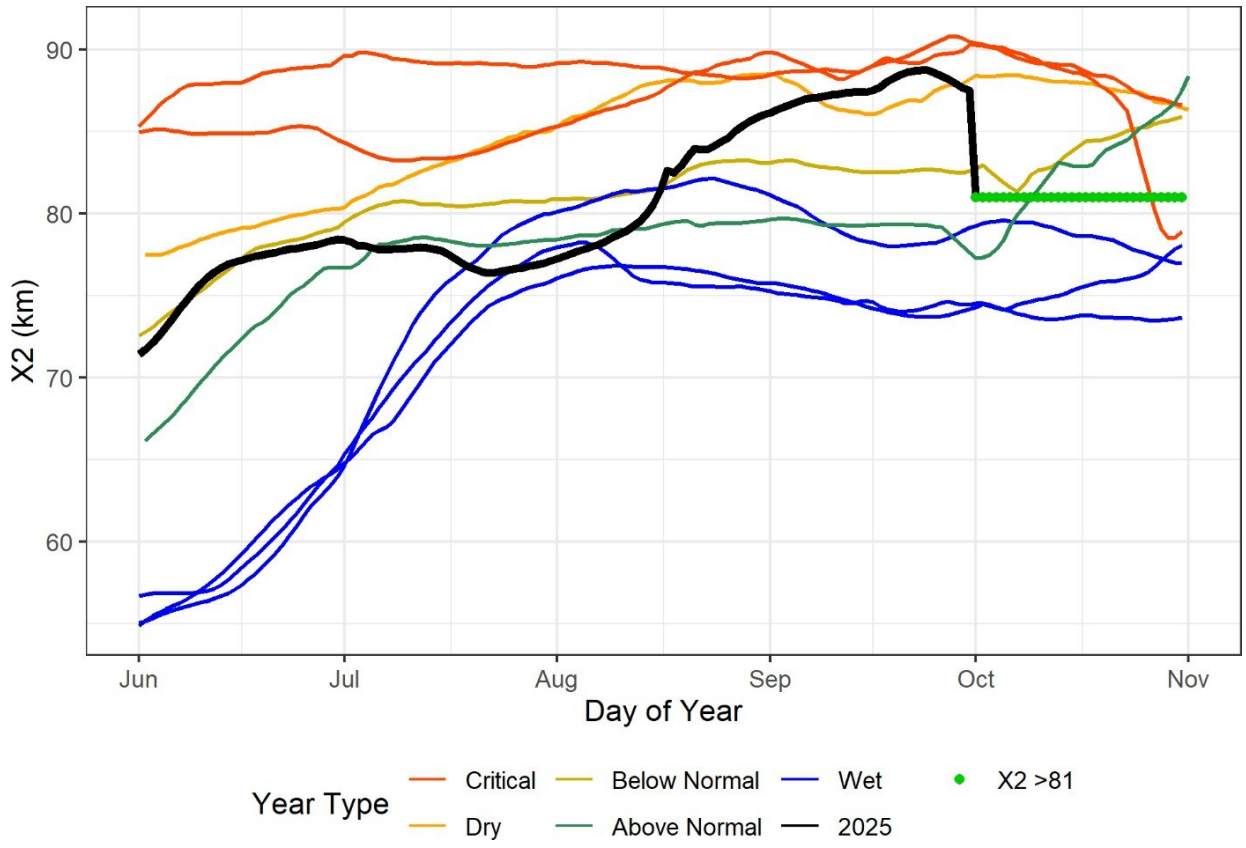


Figure 1. Location of X2 for June-October of 2025 (black line), and 2017-2024 (colored lines) as calculated by Dayflow. Dayflow data were only available through September 30, 2025, so October data comes from CDEC station CX2. Real-time calculations for X2 when it is above 81 km from CDEC are not available (green points).

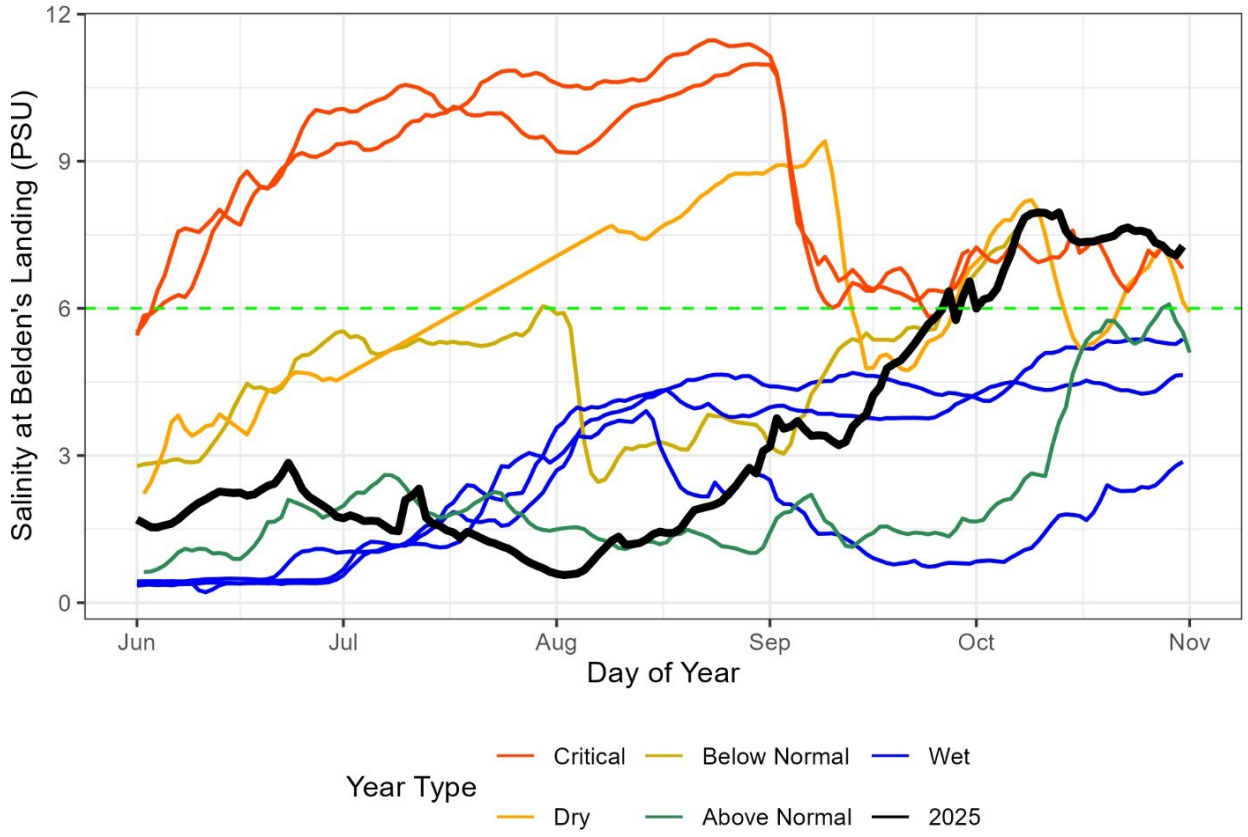


Figure 2. Salinity at Belden's Landing in 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024) and wet years (2017, 2019, 2023). Green dotted line shows the 6 PSU threshold for good Delta Smelt habitat.

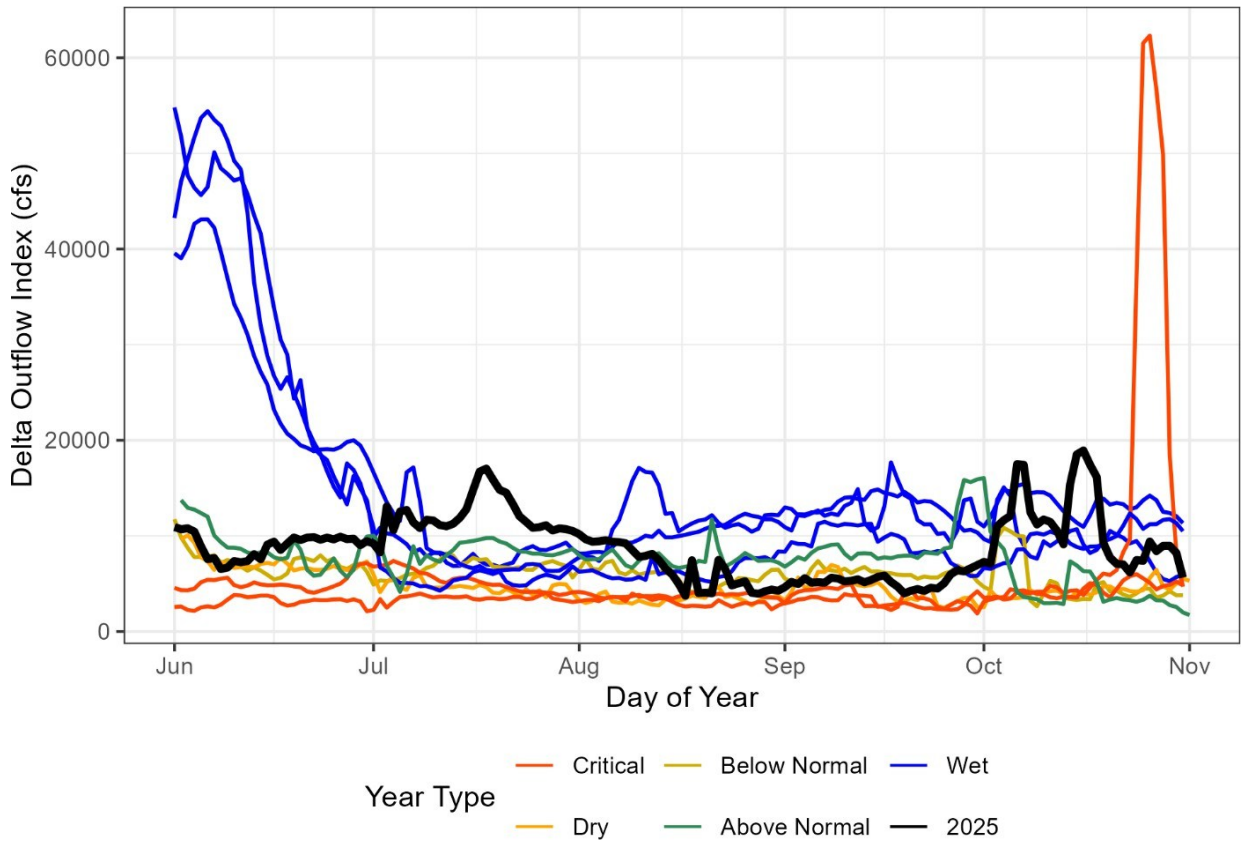


Figure 3. Daily Net Delta Outflow Index for the summer-fall period for 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024), and wet years (2017, 2019, 2023).

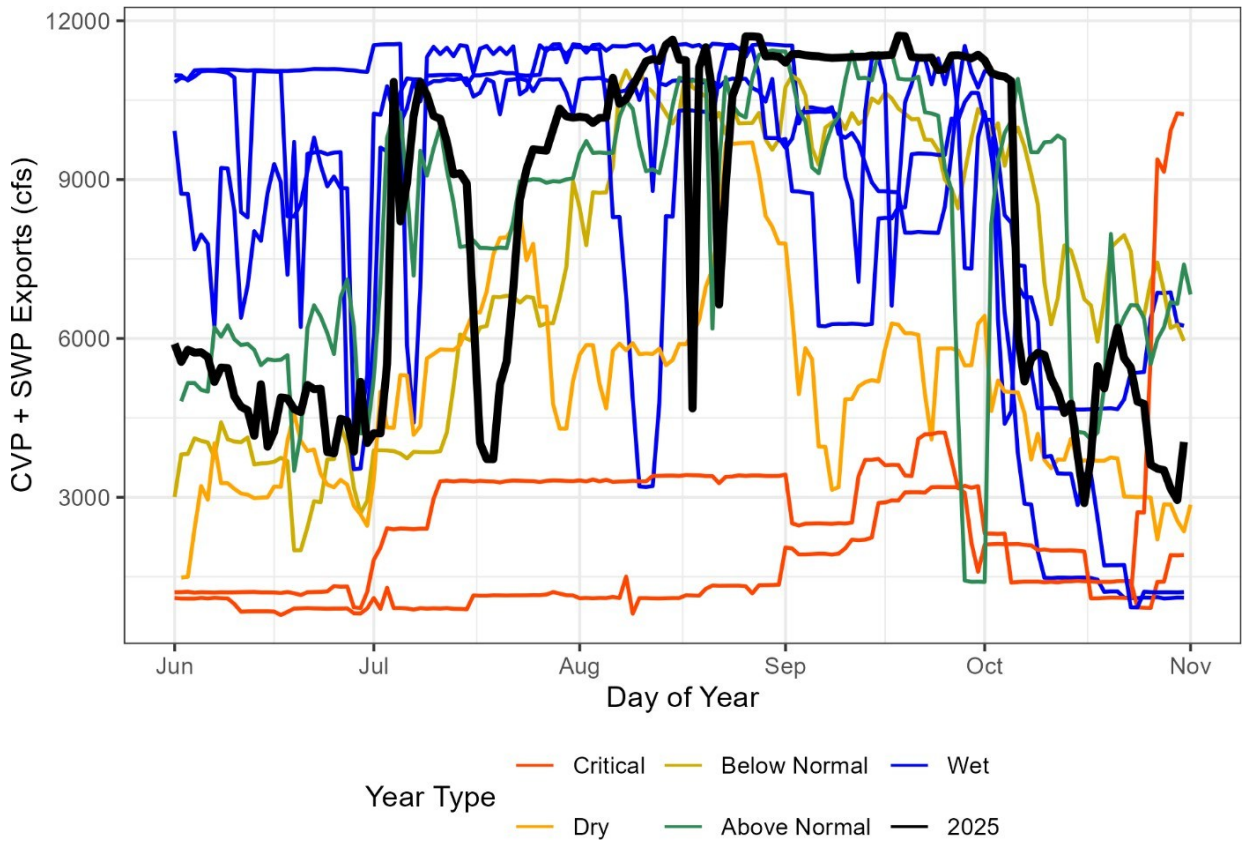


Figure 4. Daily combined exports from the Central Valley Project (CVP) and State Water Project (SWP) for the summer-fall period for 2025 (black line) in comparison to previous critical years (2021, 2022), dry years (2020), below normal years (2018), above normal years (2024), and wet years (2017, 2019, 2023).

Monitoring and Methods

Water Quality

Water quality monitoring relies on the network of continuous sondes distributed throughout the region (Figure 5). In 2021, three new sondes were placed in Grizzly Bay, as per the requirements in the 2020 ITP, one at the mouth of Montezuma Slough (GZM), one in the eastern region of Grizzly Bay (GZB), and one at the Tule Red restoration site (TRB) (Figure 5). After evaluation of four years of data collection, analyses demonstrated that data collected from these sondes were not significantly different from data collected at existing sonde locations (GZL and HUN), so the GZM and GZB sondes were

removed in early winter of 2025 (Attachment C: Memo on decommissioning of real-time water quality stations GZM and GZB). This analysis also provides validation of the 3D hydrodynamic modeling used in development of the 2024 ITP, which showed anticipated benefits of the SMSCG extending into the upper portion of Grizzly Bay. TRB remains in place for monitoring conditions at the wetland restoration site, but the data are no longer included in analyses for this report. Sondes are calibrated and exchanged per their organization's Quality Assurance Project Plans.

Water temperature, specific conductance, and turbidity data were compiled from the continuous stations showed in Figure 5. Specific conductance values were converted to salinity using the wql R package (Jassby et al. 2017) and daily averages were calculated for water temperature, turbidity, and salinity. We then compared the number of days each region had salinities below 6 PSU, turbidities above 12 FNU, and temperatures below 22 °C from June-October of each year. Increased duration of suitable temperature, turbidity, and salinity in Suisun Marsh would support the hypothesis that the SMSCG action increased Delta Smelt habitat.

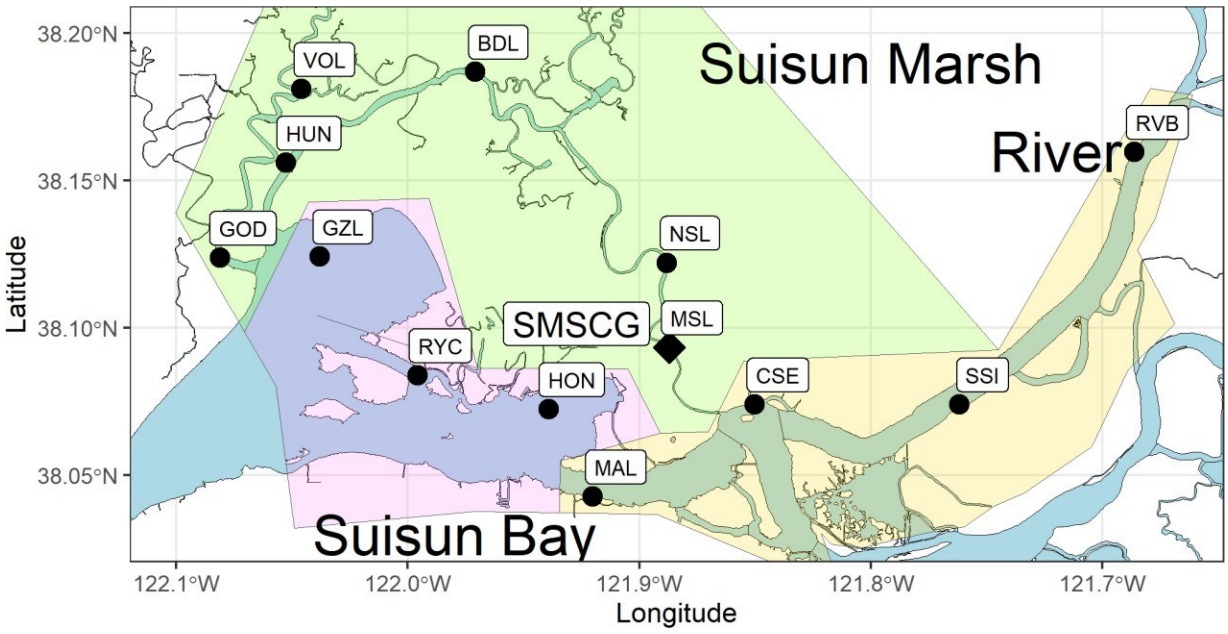


Figure 5. Map of water quality sonde locations used for analysis of Delta Smelt habitat.

Delta Smelt Habitat Hindcast Models

Reclamation and DWR modeled the area of habitat with appropriate salinity, temperature, and turbidity for Delta Smelt using the Bay-Delta SCHISM model, which is based on the Semi-Implicit Cross-scale Hydroscience Integrated System Model (SCHISM) (Zhang et al. 2016). The SCHISM hydrodynamic algorithm is based on mixed triangular-quadrangular unstructured grids in the horizontal plane and a flexible coordinate system in the vertical plane (Zhang et al. 2015). The DWR application of SCHISM to the Bay-Delta as well as a regional description of performance is described in Ateljevich et al. (2014). We used the SCHISM model to produce the area below 6 PSU that also has a turbidity of 12 FNU or higher, and water temperature of 22°C or lower, similar to the metric used in the DCG decision-making process. Temperature and turbidity may be interpolated from discrete water quality monitoring stations and/or data collected from continuous sondes.

DWR studied the impact of the 2025 SMSCG operations on habitat in Suisun Marsh and Suisun Bay. The scenarios are composed of 1) 2025 historical run which included SMSCG operations 2) no SMSCG operation.

Table 3. Scenario descriptions for SCHISM modeling of proposed operations for Suisun Marsh habitat

Label	SMSCG Gate operation	Start	Days	Compensating flow (cfs)
Historical (with SMSCG)	Tidal	23 Jun	63	525/700**
No SMSCG	None	NA	0	0

Notes: ** 525cfs used for 63 days starting June 23, 700cfs starting September 5.

The main metric produced by the SCHISM model is the acreage of habitat that met a LSZ threshold of 6 PSU as a time series over the summer-fall season. SCHISM model elements were queried based on their daily and depth averaged salinity, and the spatial area of each element included if the area met the 6 PSU criterion. LSZ acreage was summarized by aggregating within the zones shown in Figure 6. The different zones overlap, and though the acres of benefit are redundant, they are presented because they give a perspective on scale, not because they represent independent habitat. Two other metrics are computed: a 14-day average of daily maximum temperatures and a combined habitat that includes both LSZ and the maximum temperatures to provide more context.

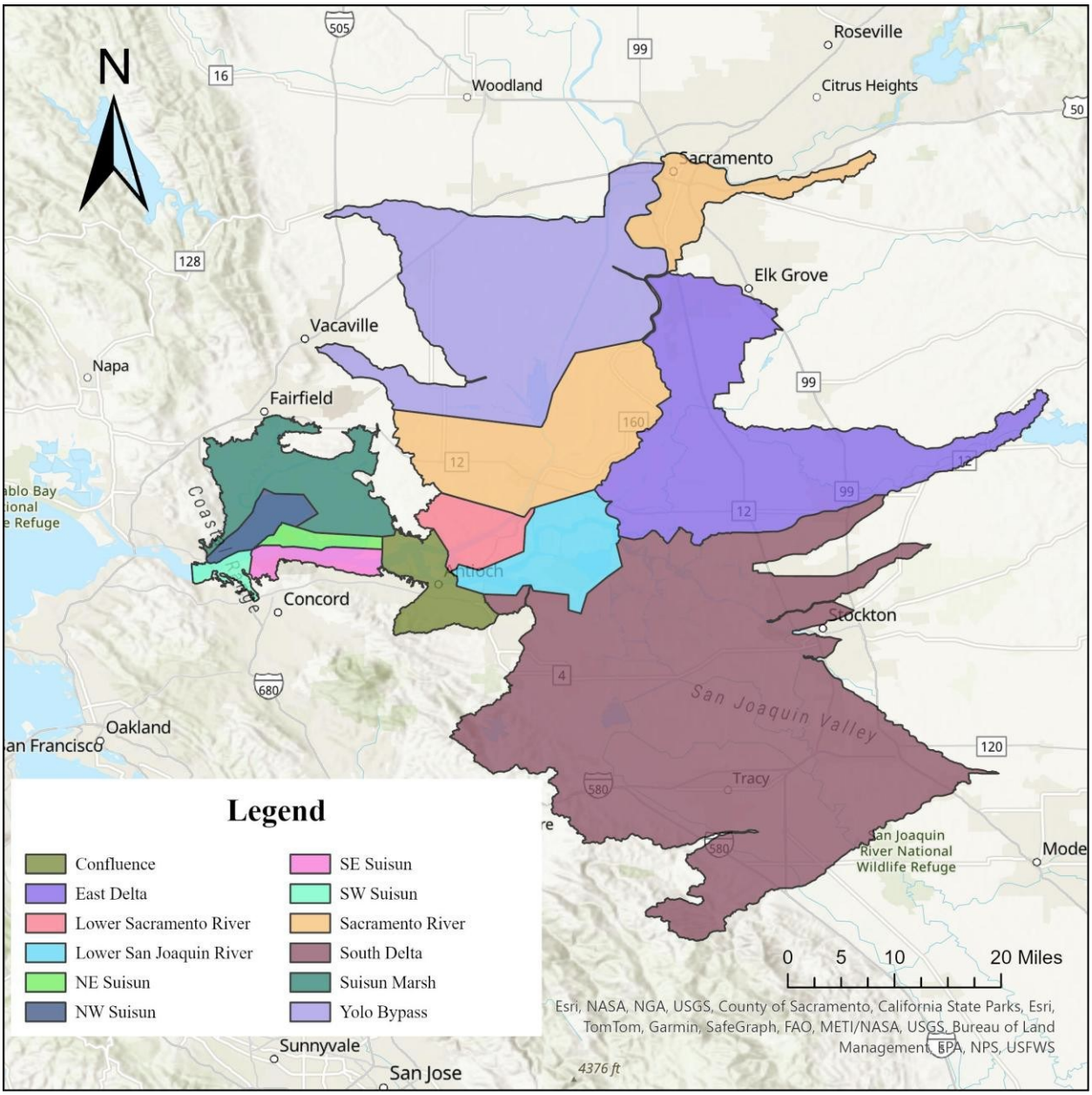


Figure 6. Regions used to aggregate low salinity zone and habitat suitability indexes. The category "All" represents the spatial union of areas in the legal Delta, Suisun Marsh and Suisun Bay.

Aquatic Vegetation

Floating aquatic vegetation (FAV) and submersed aquatic vegetation (SAV) degrade the open water habitat preferred by Delta Smelt, so determining the extent of aquatic

vegetation in Suisun Marsh is an important part of the integrated approach for evaluating the availability of suitable Delta Smelt habitat. Suisun Marsh has exhibited less cover of invasive FAV and SAV compared to the Delta, likely because most of these plant species cannot tolerate the brackish conditions that are typical of the marsh. The SMSCGs are operated to move more freshwater from the Delta into Suisun Marsh during the summer and fall months, which could increase the cover of FAV and SAV in the marsh by two mechanisms: (1) increasing the transport of FAV and SAV propagules from the highly infested Delta; and (2) reducing the salinity of the marsh to levels amenable to these plants during their peak months for growth and reproduction.

To better understand the distribution of FAV and SAV in Suisun Marsh and how it is changing through time, vegetation maps based on airborne hyperspectral imagery collected annually during summer or fall during several recent years (2018, 2022 – 2025) were created. Ground truthing field surveys were conducted around the time of imagery collection to ensure accurate vegetation classification. While FAV is straightforward to monitor with these remote sensing tools, SAV is more challenging because turbidity reduces visibility, and therefore detection, of this type of vegetation (i.e., SAV cover is underestimated. For all years, imagery collection with low tide has been timed to minimize underestimation of SAV cover. The entirety of Suisun Marsh is included in all vegetation maps, but not all of this area is suitable fish habitat. Therefore, the focus of this report is on the areas in and around the marsh that consist of permanently inundated, tidally influenced sloughs and channels that could provide open water fish habitat. Suisun March is divided into three regions: East Marsh, West Marsh, and Bay (Figure 7).

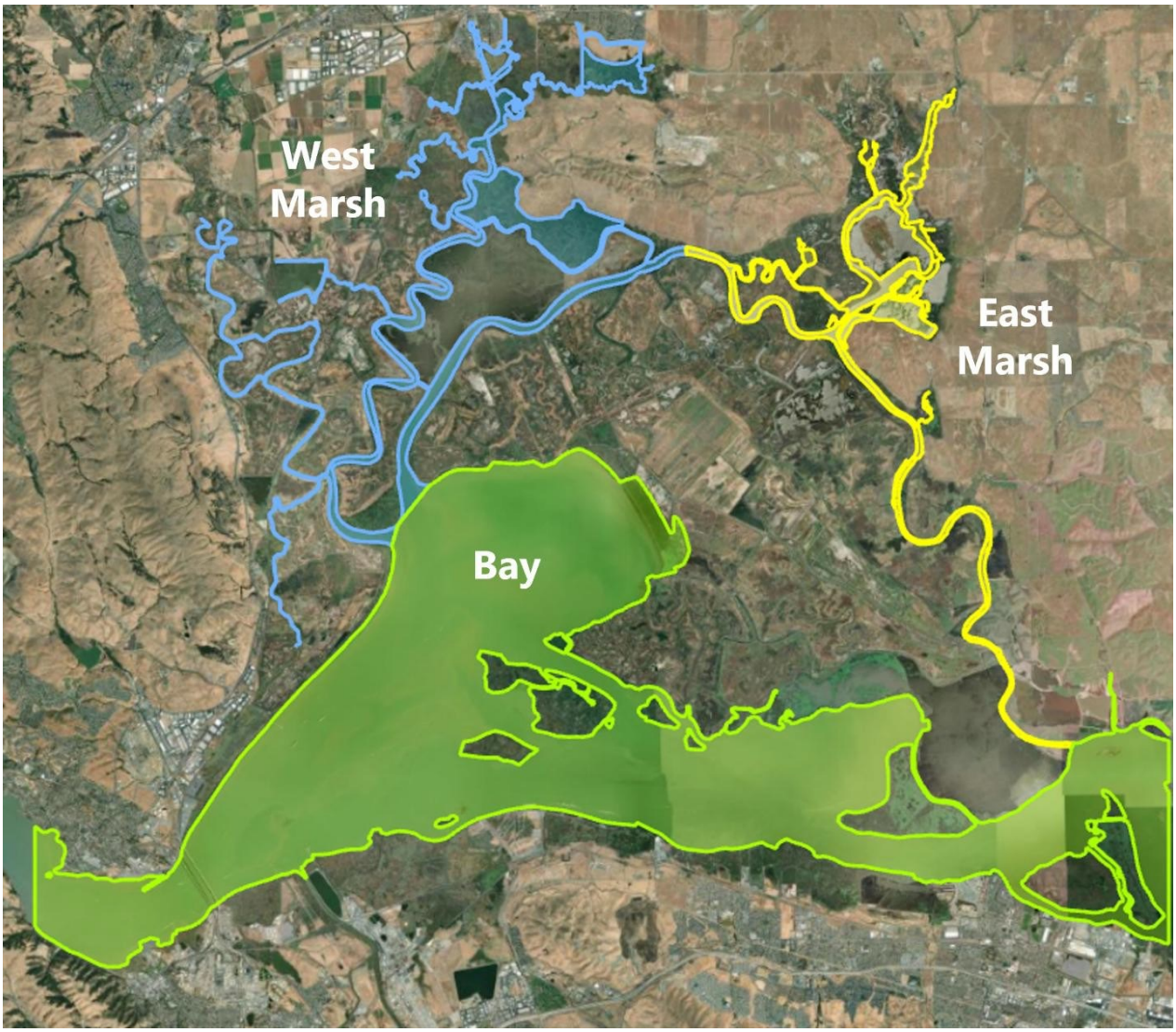


Figure 7. Three regions of tidal waterways in and around Suisun Marsh that were used to evaluate the impacts of aquatic vegetation on open water habitat.

Zooplankton

Zooplankton were monitored primarily using three existing surveys, the CDFW Summer Townet (STN), CDFW Fall Midwater Trawl (FMWT), and the DWR/CDFW/Reclamation Environmental Monitoring Program (EMP) (Kayfetz et al. 2020) (Figure 9). Additional sampling is conducted specifically for this management action to increase the spatial and temporal resolution of data in the area of interest (see SMSCG monitoring plan for details). EMP data for 2025 was not available in time for this report.

Abundance trends were analyzed in two of the most important zooplankton taxa for Delta Smelt: *Pseudodiaptomus forbesi* (a calanoid copepod and the most important source of smelt food in the summer) and *Limnoithona tetraspina* (a smaller cyclopoid copepod that dominates the LSZ). Biomass of each taxon in the LSZ in 2025 was compared to previous years with different salinity conditions in Suisun Marsh and Suisun Bay using linear mixed effect models with a random effect of month (logBPUE~ Region*Year + (1|Month)). Biomass of each taxon was also compared in upstream areas to the LSZ. Increased zooplankton biomass in Suisun Marsh during 2025 and other years with low salinity supported the hypothesis that operating the SMSCGs increases food availability for Delta Smelt. Lower *P. forbesi* biomass in Suisun Bay and Grizzly Bay during 2025 when compared to years with X2 actions supported the hypothesis that lower X2 increases food availability for Delta Smelt in Suisun Bay.

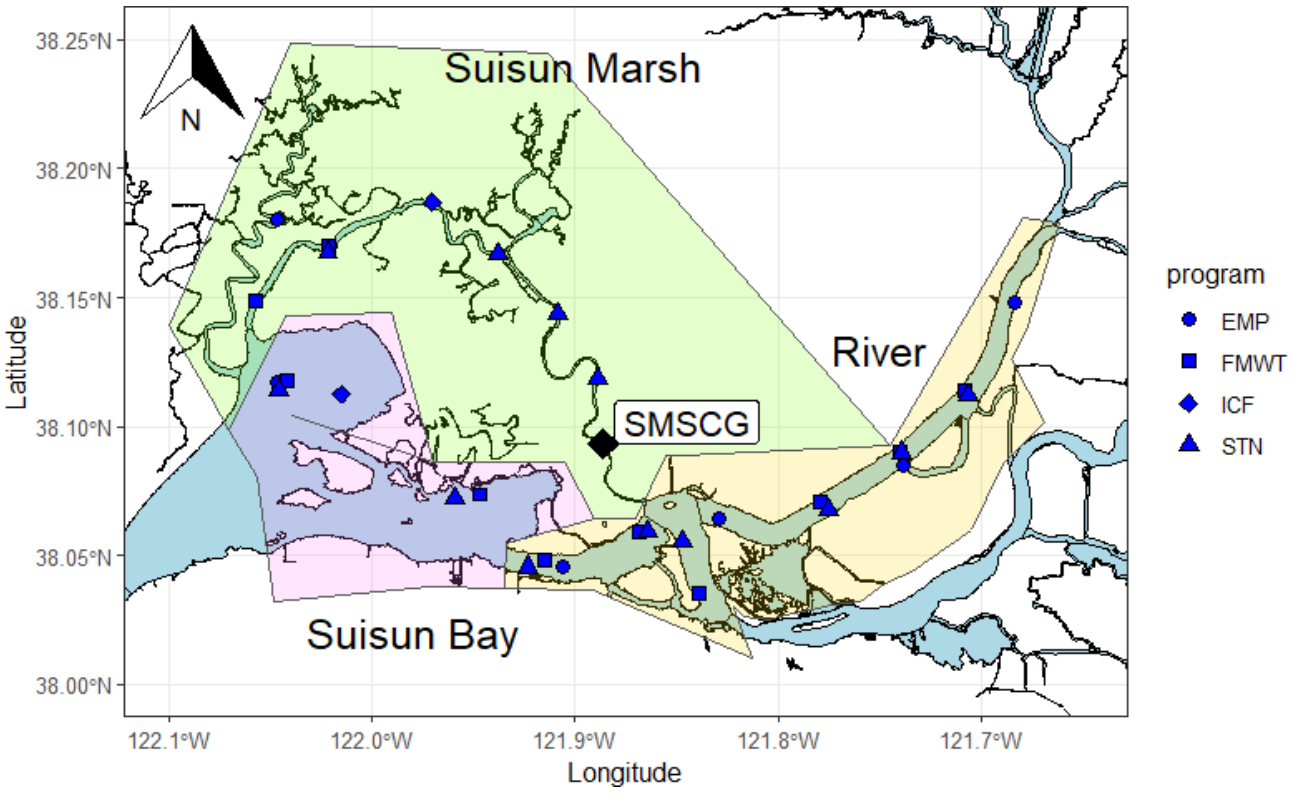


Figure 8. Map of fixed stations where zooplankton samples are collected.

Delta Smelt Abundance and Distribution

Fish monitoring relied entirely on existing surveys such as the USFWS Enhanced Delta Smelt Monitoring Program (EDSM) and Delta Juvenile Fish Monitoring Program (DJFMP), the UC Davis Suisun Marsh Survey, and CDFW's STN, San Francisco Bay Study, and FMWT under agreements with Reclamation and DWR. We did not have high enough Delta Smelt catch to statistically analyze any changes in Delta Smelt abundance or distribution as a result of the actions in 2025. However, we graphically present data on Delta Smelt catch to see whether they are using habitat in Grizzly Bay, Suisun Bay, and Suisun Marsh made available by the SMSCG action. We also present average summer-fall abundance indices of Delta Smelt as calculated by EDSM by year to track the population trends over time.

Experimental Releases

WY 2025 was the last year of experimental releases of Delta Smelt prior to implementation of releases under the new supplementation program in WY 2026. Cultured Delta Smelt have been regularly released from November through February of each year at varied locations, with varied methodologies, and releases have increased over time (**Table 4**). In WY 2025, 124,946 Delta Smelt were either released at Rio Vista on the Sacramento River or Lookout Slough in the upper Cache Slough complex. As of October 2025, there was a total of 86 Delta Smelt detections. EDSM did not sample for larvae March-June 2025 due to unreliable identification methods; however, CDFW SLS and 20 mm did sample for larvae but no larvae were detected. Regardless, 7 un-marked juveniles and/or subadults were detected in summer and fall. Shortly following the 2025 summer-fall period, 163,349 Delta Smelt were supplemented in November. Experimental release reports are available from the USFWS upon request.

Table 4. Summary of Delta Smelt hatchery releases into the Delta and marsh and subsequent detections during the Summer-Fall Habitat Action period (June-October)

Water Year	Number Released	Release Period	Release Regions	Summer-Fall detections (Jun-Oct)
2021	Pre-release	N/A	N/A	1
2022	55,733	Dec-Feb	Lowr Sac River, Sac Ship Channel, Suisun Marsh	8
2023	43,705	Nov-Jan	Lower Sac River, Sac Ship Channel	10
2024	91,468	Nov-Jan	Lower Sac River	2
2025	124,946	Nov-Feb	Cache Slough, Lower Sac River	7

Results

Extent of Appropriate Delta Smelt Habitat

Observed Water Quality

In years of high summer Delta outflow (averaging over 10,000 cfs from June-August), habitat with suitable salinity for Delta Smelt (<6 PSU) may extend contiguously from the freshwater Delta to Suisun Bay and Suisun Marsh. All of Suisun Marsh and Suisun Bay are less than 6 PSU when X2 is less than 75 km (FLOAT-MAST 2021), with a large portion of Grizzly Bay and Honker Bay as suitable habitat when X2 is less than 80 km (ITP effects analysis 2024).

During 2025, two of the three Suisun Bay stations (GZL, RYC) exceeded 6 PSU during most of the gate action periods, but the station in Honker Bay (HON), the furthest east station, remained below 6 PSU through nearly the entirety of these periods (**Figure 9**). All three stations were below 6 PSU in late July. Suisun Bay was the coolest of the three regions, with temperatures nearly always below 22°C. Turbidity was the highest of all three regions with stations at or above 12 FNU throughout June to November. Chlorophyll concentration, estimated from fluorescence, was low throughout the period, never exceeding the 10 µg/L used to define a bloom.

Most stations in Suisun Marsh remained below 6 PSU during the main period of gate operations (June 23 – August 26) (**Figure 9**). The exception was Goodyear Slough (GOD) on the far western edge of the marsh, which was between 6 and 8 PSU during this period. During the ten days between the two periods of gate operations, salinity at all marsh stations increased, with the three stations in western Suisun Marsh (GOD, HUN, VOL) reaching or exceeding 6 PSU. During the week of gate operations in September, salinity at all marsh stations decreased. GOD and HUN remained above 6 PSU during this period, but all other marsh stations stayed below this threshold until after the gate operations ended. Temperatures in the marsh were similar to those in the Delta and higher than those in the bay. There were multiple periods over 22°C, particularly in August. Turbidity was at or above 12 FNU at all stations throughout the gate action periods with the exception NSL and MSL, which were slightly lower but only after the main gate action ended in late August. Chlorophyll was low at all stations, particularly during the gate action periods.

In the Sacramento River, all stations exhibited salinities below 6 PSU during the periods of gate operations, though Mallard Island (MAL) exceeded this threshold on a single day between the two periods of operations (**Figure 9**). Water temperatures were similar to

those in the Marsh. The stations near Rio Vista (RVB) and Sherman Island (SSI), the two furthest upstream stations, exhibited the highest water temperatures and most frequently exceeded 22°C. Turbidity in the river was lower than that in the other two regions, with only the two downstream stations (CSE, MAL) frequently exhibiting levels greater than 12 FNU. Chlorophyll was generally low at the river stations. However, MAL showed spikes in chlorophyll in September that were high enough to be considered a bloom (>10 µg/L) and was the only station in any region to exceed this threshold at any time.

When comparing conditions in 2025 to previous years (**Figure 10**, **Table 5**), it can be discerned how many days each water quality factor was limiting the extent of Delta Smelt habitat in each area. On any given day, either salinity, water temperature, or turbidity may be out of the range of optimal Delta Smelt habitat, and which factor(s) is limiting may change from day to day or region to region. In 2025, salinity limited the number of days of suitable habitat in Suisun Bay more than in years with both X2 and SMSCG actions (2023, 2024) and more than in wet years with X2 actions (2017, 2019) but less than in years with either no actions (2020-2022) or with a short SMSCG action and no X2 action (2018). Salinity conditions in Suisun Marsh and the River were similar to other years with SMSCG or X2 actions (2017-2019, 2023, 2024). Turbidity in Suisun Bay and Suisun Marsh was almost never limiting, while conditions in the River were more limiting than in some recent years (2022, 2024) but comparable to those in others (2021, 2023). Across regions, temperature was not as limiting as in the past few years (2022-2024). Total days of suitable water temperatures were as numerous or nearly as numerous as those of the previous most favorable years (e.g., 2018, 2021).

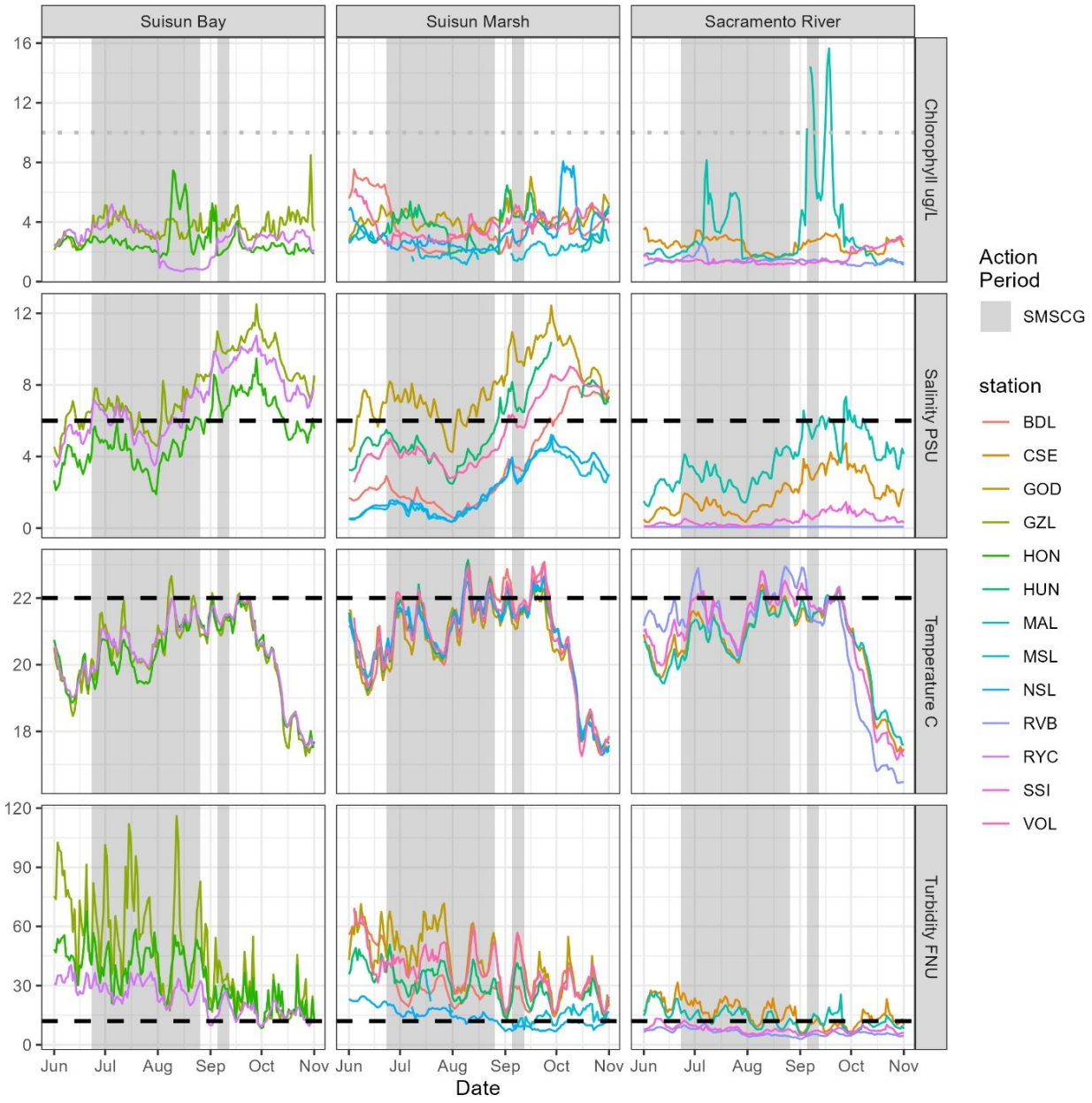


Figure 9. Plot of daily average Chlorophyll (µg/L), Salinity (PSU), Temperature (°C) and Turbidity (FNU) at continuous monitoring stations throughout the area (Figure 5). Black dotted lines on salinity, temperature, and turbidity graphs indicate Delta Smelt habitat thresholds, and the gray dotted line on the chlorophyll graph is a commonly used reference point for high plankton growth. Grey shaded areas indicate time periods where the SMSCG were operating.

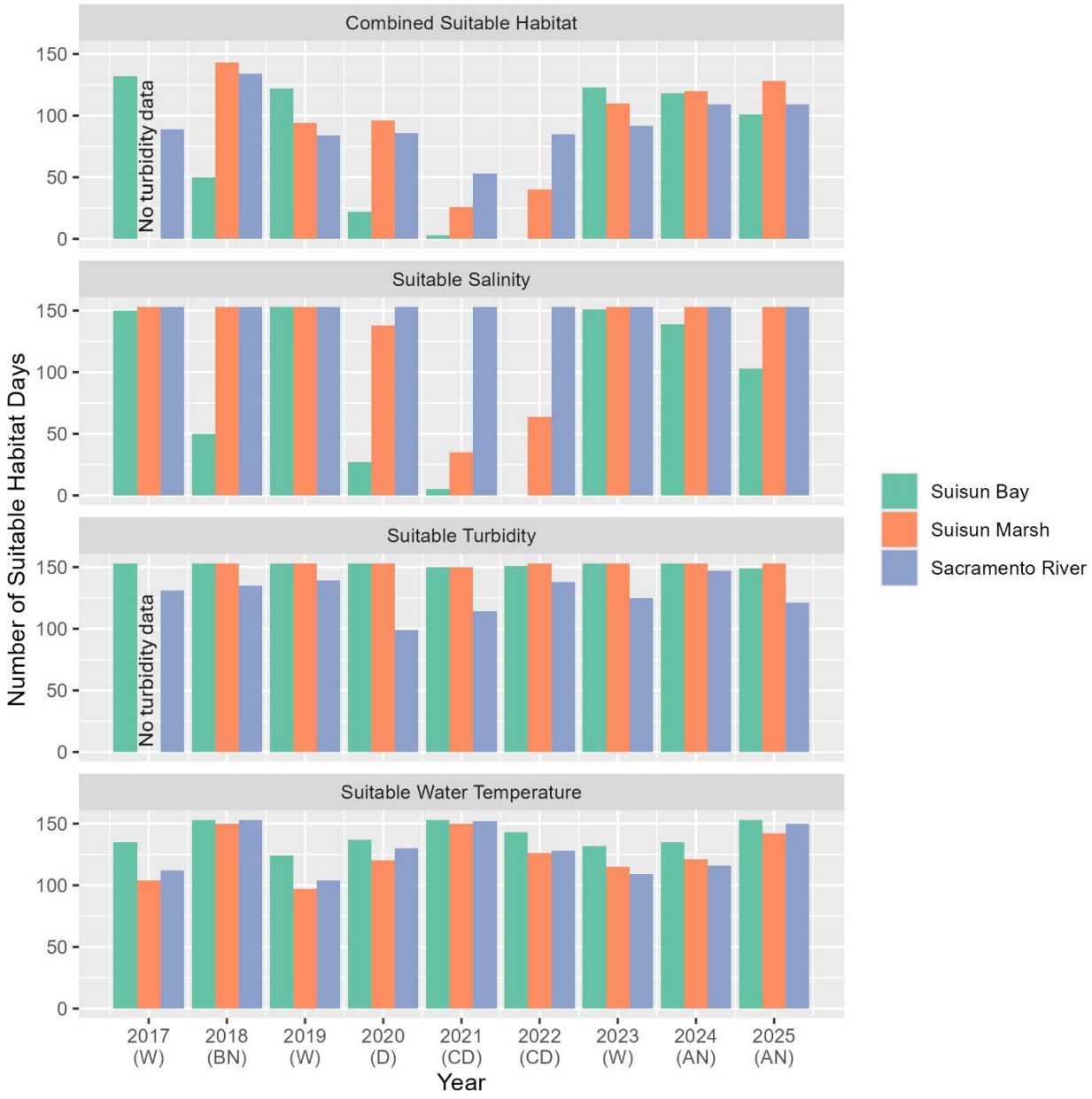


Figure 10. Number of days of the summer and fall (out of 153 total) where water quality conditions in the bay, marsh, and river met the suitable smelt habitat criteria (i.e., < 6 PSU salinity, < 22°C temperature, > 12 FNU turbidity) for 2017-2025. Water year type is indicated below the year.

Table 5. Number of days with optimal Delta Smelt habitat conditions in each region and year during the summer-fall time period (out of a total possible of 153). No turbidity data was available in Suisun Marsh before 2018.

Year	Region	Combined good smelt habitat days	Days >12 FNU	Days < 22 °C	Days < 6 PSU
2017	Bay	132	153	135	150
2017	Marsh	NA	NA	104	153
2017	River	89	131	112	153
2018	Bay	50	153	153	50
2018	Marsh	143	153	150	153
2018	River	134	135	153	153
2019	Bay	122	153	124	153
2019	Marsh	94	153	97	153
2019	River	84	139	104	153
2020	Bay	22	153	137	27
2020	Marsh	96	153	120	138
2020	River	86	99	130	153
2021	Bay	3	150	153	5
2021	Marsh	26	150	150	35
2021	River	53	114	152	153
2022	Bay	0	151	143	0
2022	Marsh	40	153	126	64
2022	River	85	138	128	153
2023	Bay	123	153	132	151

Year	Region	Combined good smelt habitat days	Days >12 FNU	Days < 22 °C	Days < 6 PSU
2023	Marsh	110	153	115	153
2023	River	92	125	109	153
2024	Bay	118	153	135	139
2024	Marsh	120	153	121	153
2024	River	109	147	116	153
2025	Bay	101	149	153	103
2025	Marsh	128	153	142	153
2025	River	109	121	150	153

Aquatic Vegetation

To determine the potential impacts of aquatic vegetation on Delta Smelt habitat in and around Suisun Marsh, the waterway area occupied by FAV and SAV based on our hyperspectral maps was quantified. In 2018 and 2021, no FAV was detected (Figure 11). In 2022, FAV area became detectable in the imagery (1.5 ha across all regions) and increased to 6.5× and 11.4× of the 2022 levels by 2023 and 2024, respectively. FAV area in 2025 was 7.1 ha across all regions, which was 54.6% lower than that of 2024. FAV area was lower in all three regions (East Marsh: -9.3%, West Marsh: -70.1%, Bay: -72.2%) compared to 2024 (Figure 11). In previous years, the West Marsh exhibited the highest proportion of FAV cover, but in 2025, FAV area in this region was so much lower than usual that the East Marsh became the region with the highest proportion of cover. As in other years, the Bay region showed the lowest proportion of FAV coverage. The decline in FAV was primarily driven by a decrease in the aquatic fern, azolla (*Azolla spp.*) (Figure 12). From 2024 to 2025, the total area of azolla across all regions dropped from 8.8 ha to 2.6 ha. The remaining FAV area in 2025 was alligatorweed (*Alternanthera philoxeroides*) (4.5 ha) (Figure 12). The patches of FAV found within the tidal channels included in this analysis were small and scattered, so they are difficult to locate visually in the map (Figure 14).

In 2025, SAV occupied 96.2 ha, which was 1.6% of the total waterway area, and for just the two marsh regions, it occupied 73.1 ha, which was 3.5% of the waterways. The East Marsh region exhibited the highest proportion of waterway area occupied by SAV, while the Bay region exhibited the lowest (Figure 13). In the East Marsh, there were patches of SAV along the margins of many sections of eastern Montezuma Slough, but the greatest concentration of SAV was in the Nurse Slough complex, especially Little Honker Bay, adjacent to several tidal wetland sites (Bradmoor Island, Blacklock, and Arnold Slough) (Figure 14). In the West Marsh, SAV was most abundant in Suisun Slough, particularly along the margins where the slough curves, and in the Bay region, it was most abundant around the mouth of Suisun Slough and along the margins of the tidal wetland site Tule Red. Across the three regions, the 2025 total area of SAV was 25.7% lower compared to that of 2024. It is unclear why FAV and SAV cover was lower in 2025 than in 2024, given that both years were above normal water years and that in 2025 salinity in the marsh remained low through mid-August when the imagery for vegetation mapping was collected (Figure 2).

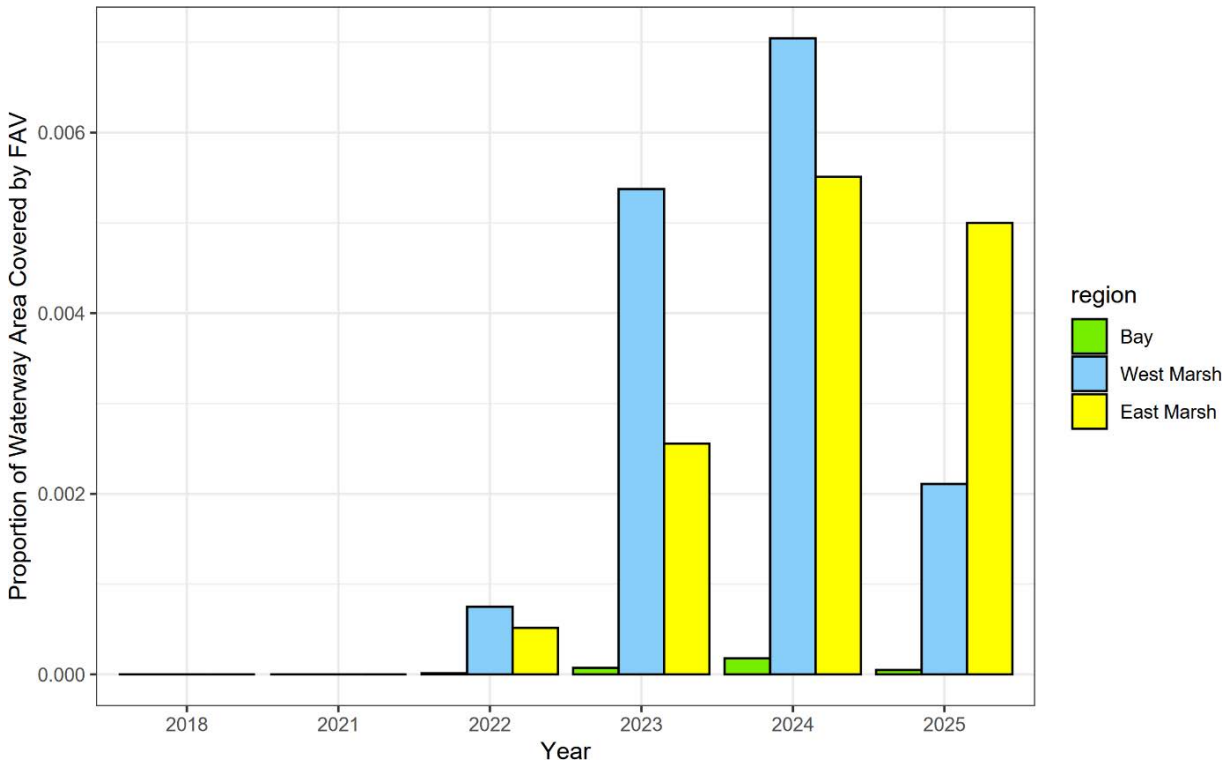


Figure 11. Time series of floating aquatic vegetation (FAV) area in and around Suisun Marsh by region.



Figure 12. Alligatorweed (left) and azolla (right) were the most common FAV species detected by the airborne hyperspectral imagery of Suisun Marsh.

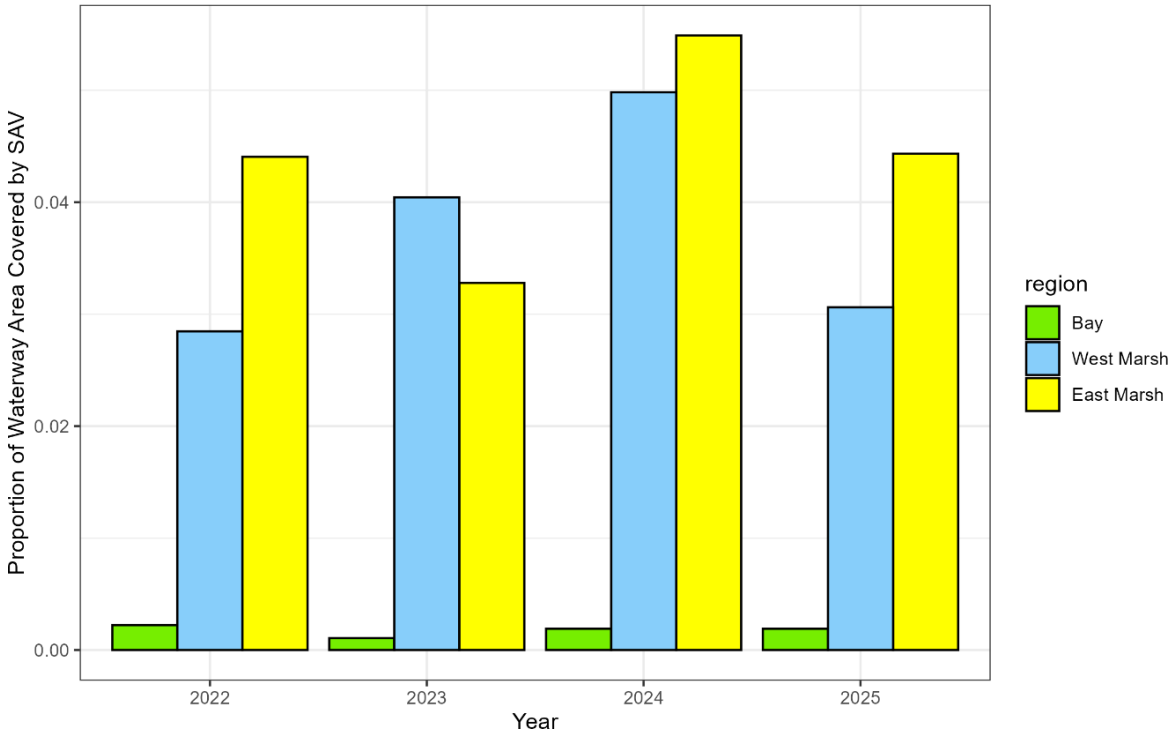


Figure 13. Submersed aquatic vegetation (SAV) area in and around Suisun Marsh by region.

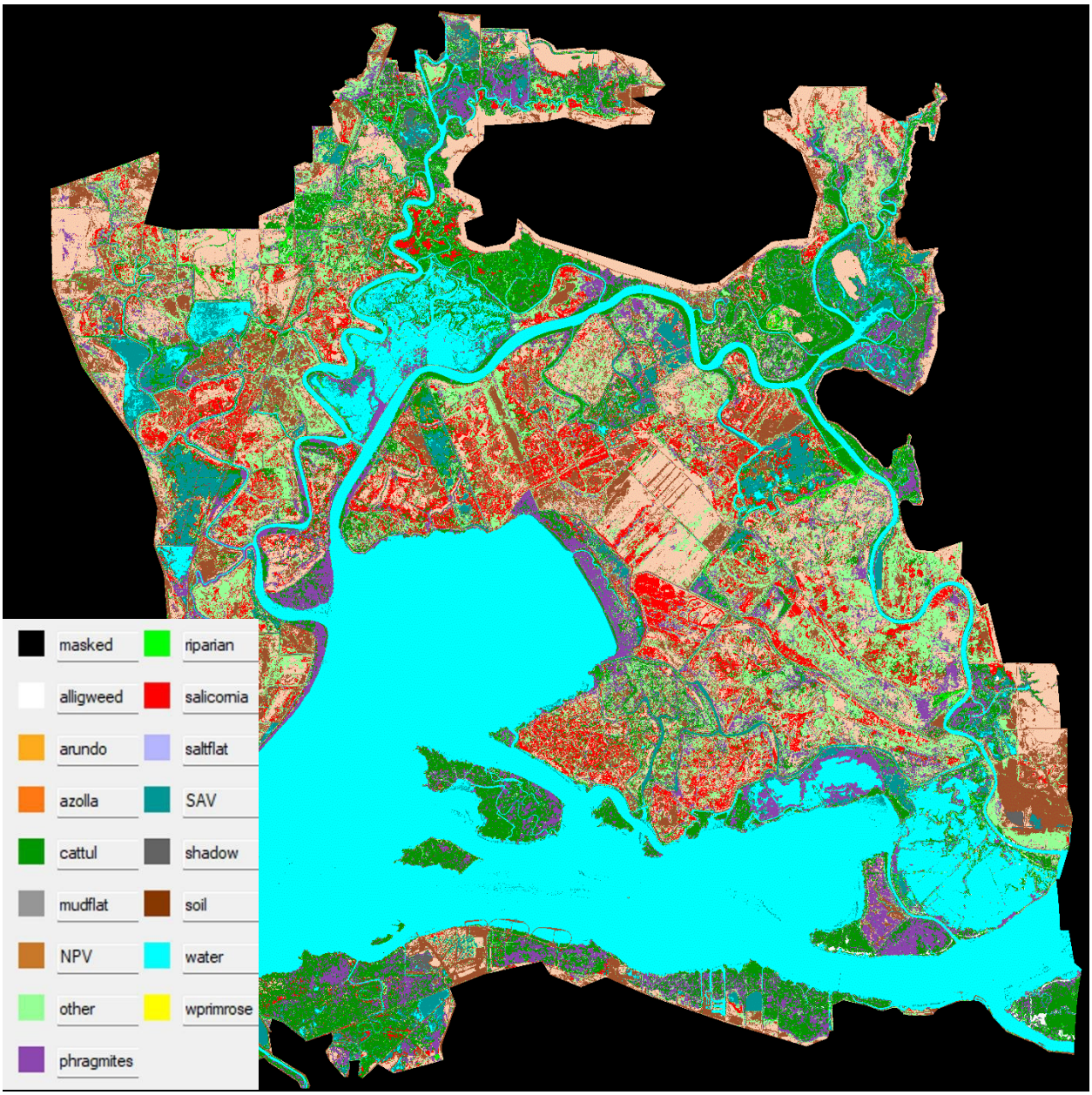


Figure 14. Aquatic vegetation map of Suisun Marsh from August 22, 2025.

Hindcast Modeling

The hydrodynamic modeling results of salinity in Suisun Bay and Suisun Marsh for the historical (with SMSCG) and no SMSCG operation shows that salinity begins to intrude into Suisun Marsh earlier without the operation (Figure 15). The greatest increase in the Low Salinity Zone (LSZ) occurred in the western side of Suisun Marsh and the northwest side of Grizzly Bay in the Suisun Bay region.

The chart below shows the modeled quantity of LSZ acreage in the Suisun Marsh over time (Figure 16), with and without the SMSCG operation. The SMSCG operations freshens Suisun Marsh compared to the without SMSCG operations. However, the SMSCG operations do not impact the water temperatures in Suisun Marsh, Suisun Bay, and Grizzly Bay which are similar for both with and without operations (Figure 17).

While the area of the LSZ was over 3,500 acres in Suisun Marsh during most of the summer, when looking at the area of the LSZ that also had water temperatures below 22 °C, much of the Marsh and Bay was not considered suitable habitat for Delta Smelt during much of the summer, including the later period of the gate operation (Figure 19). The difference in habitat for both temperature and salinity combined was chiefly in the western end of Montezuma Slough and Suisun Slough (Figure 18).

When comparing conditions in 2025 to previous years, conditions in June were very similar to the Above Normal year in 2024, with some habitat available in Grizzly Bay and Suisun Bay, but not as much as the wet years of 2017, 2019, or 2023 (**Figure 20**). As the summer progressed, LSZ area fell in Suisun Bay when compared to 2024, but remained high in Suisun Marsh. In August, September, and October, LSZ area was similar to the below normal years of 2016 and 2018, with no habitat available in Grizzly Bay (**Figure 20**).

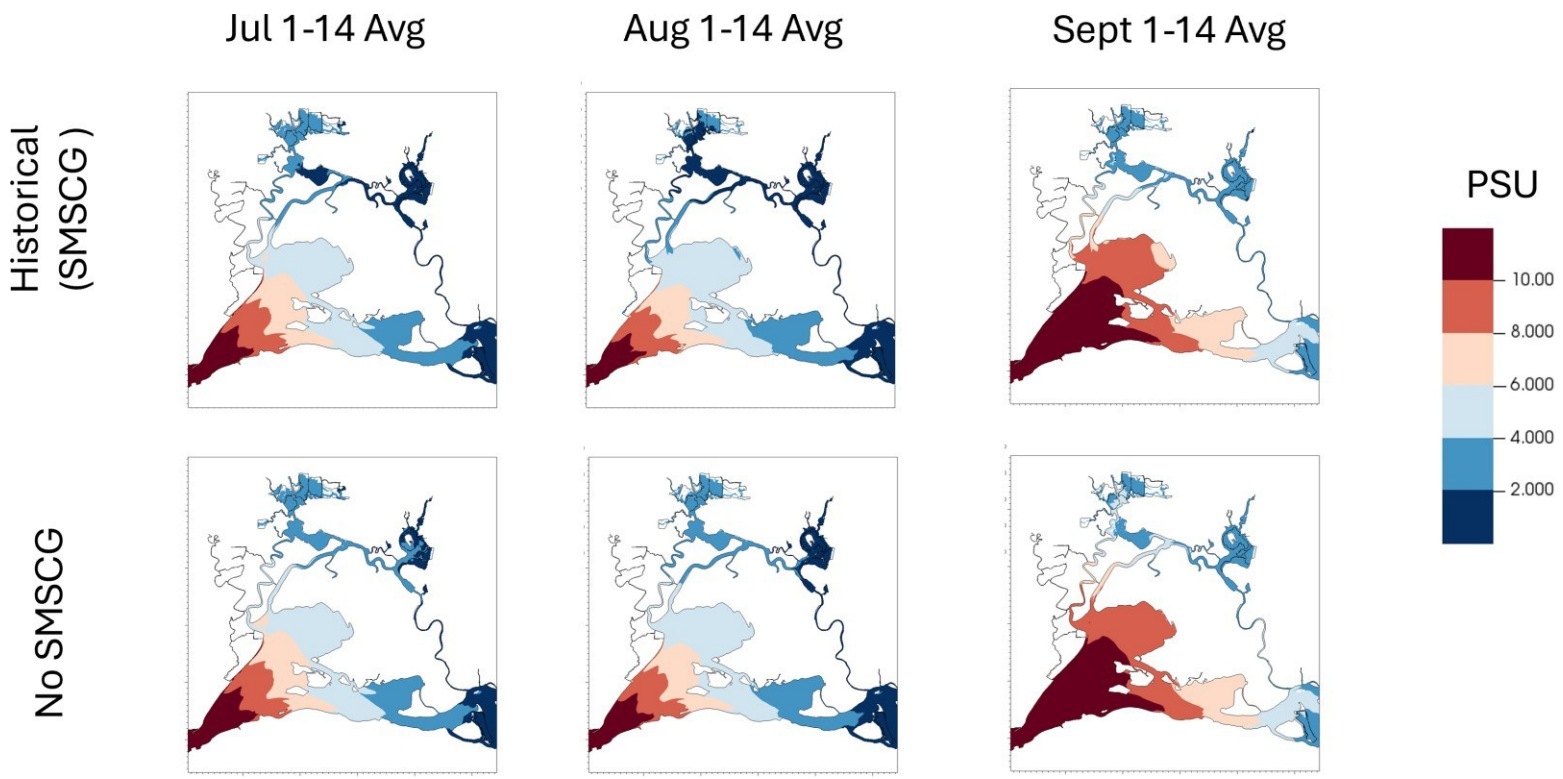


Figure 15. Maps of salinity in Suisun Marsh and Suisun Bay for each of the operational scenarios, averaged over the first half of July, August, and September. Blue indicates areas of appropriate smelt habitat, red indicates poor smelt habitat.

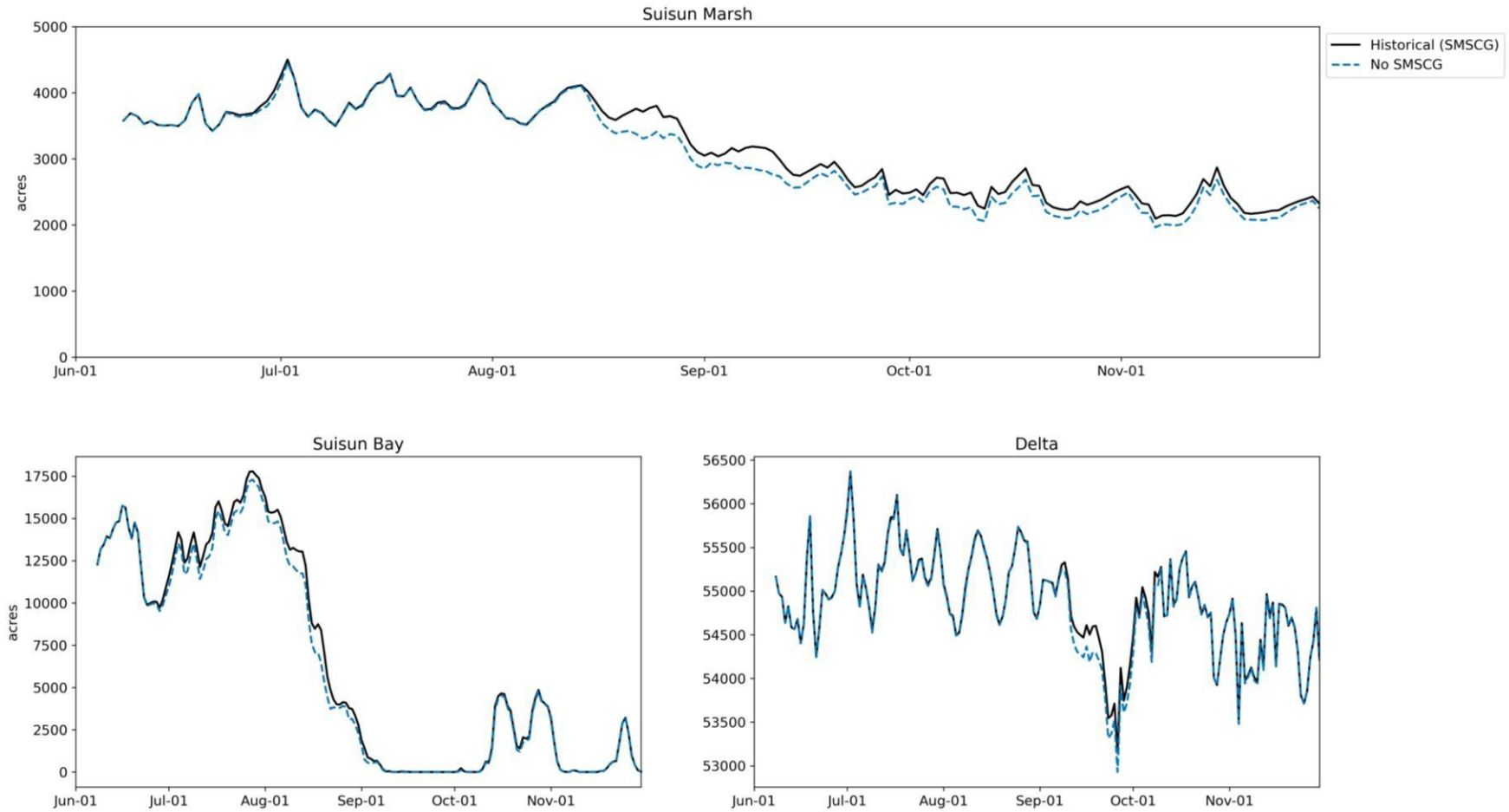


Figure 16. Time series of LSZ within the Suisun Marsh and Suisun Bay regions shown in Figure 6.

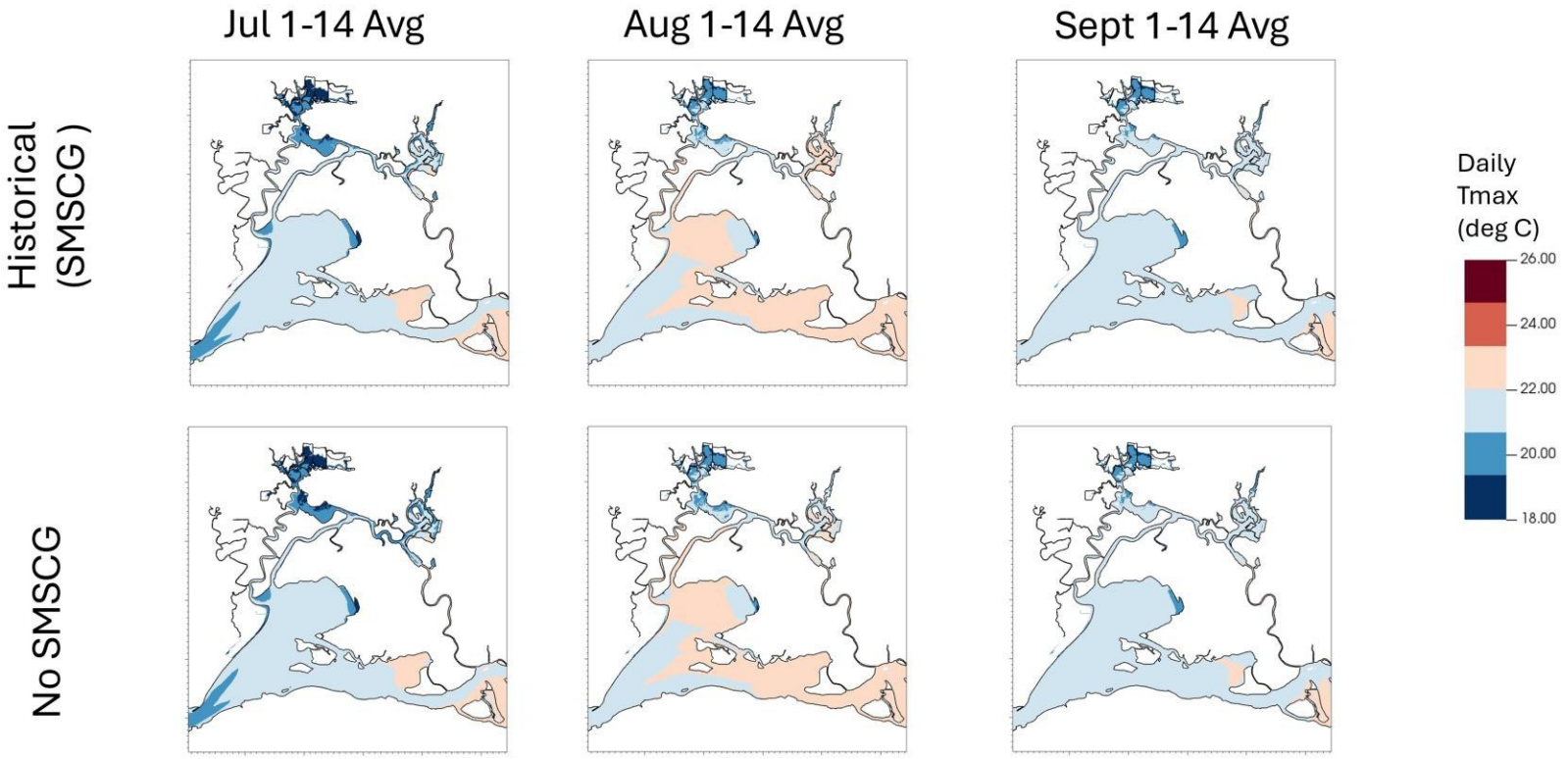


Figure 17. 14-Day average of daily maximum water temperature for the historical and alternate scenarios.

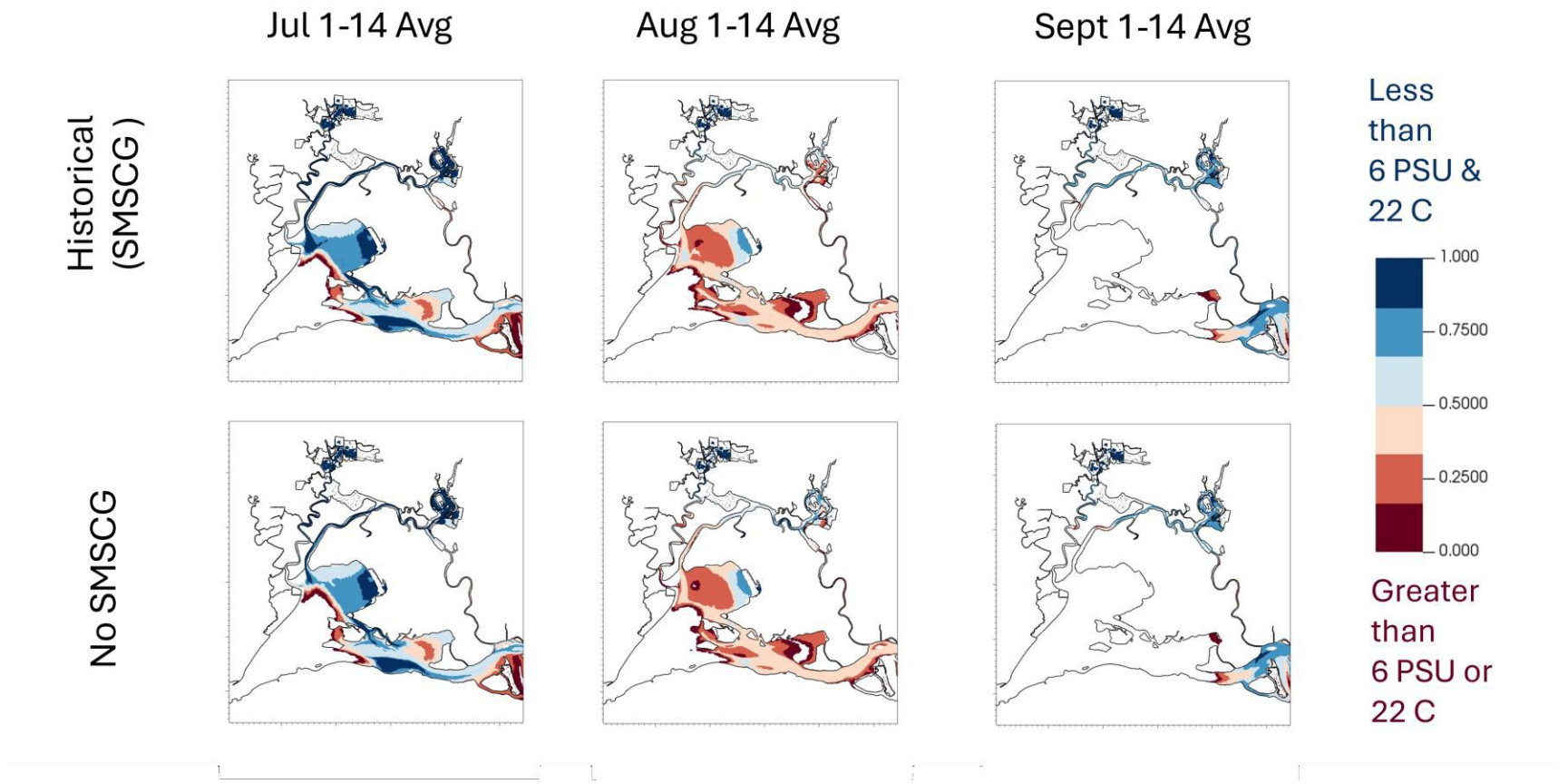


Figure 18. Map of Appropriate Delta Smelt Habitat (< 6 PSU and < 22°C) in the Historical and Alternate Scenarios. Colors indicate proportion of the 14-day time period that both parameters were suitable, with 1 being 14 days and 0 being 0 days.

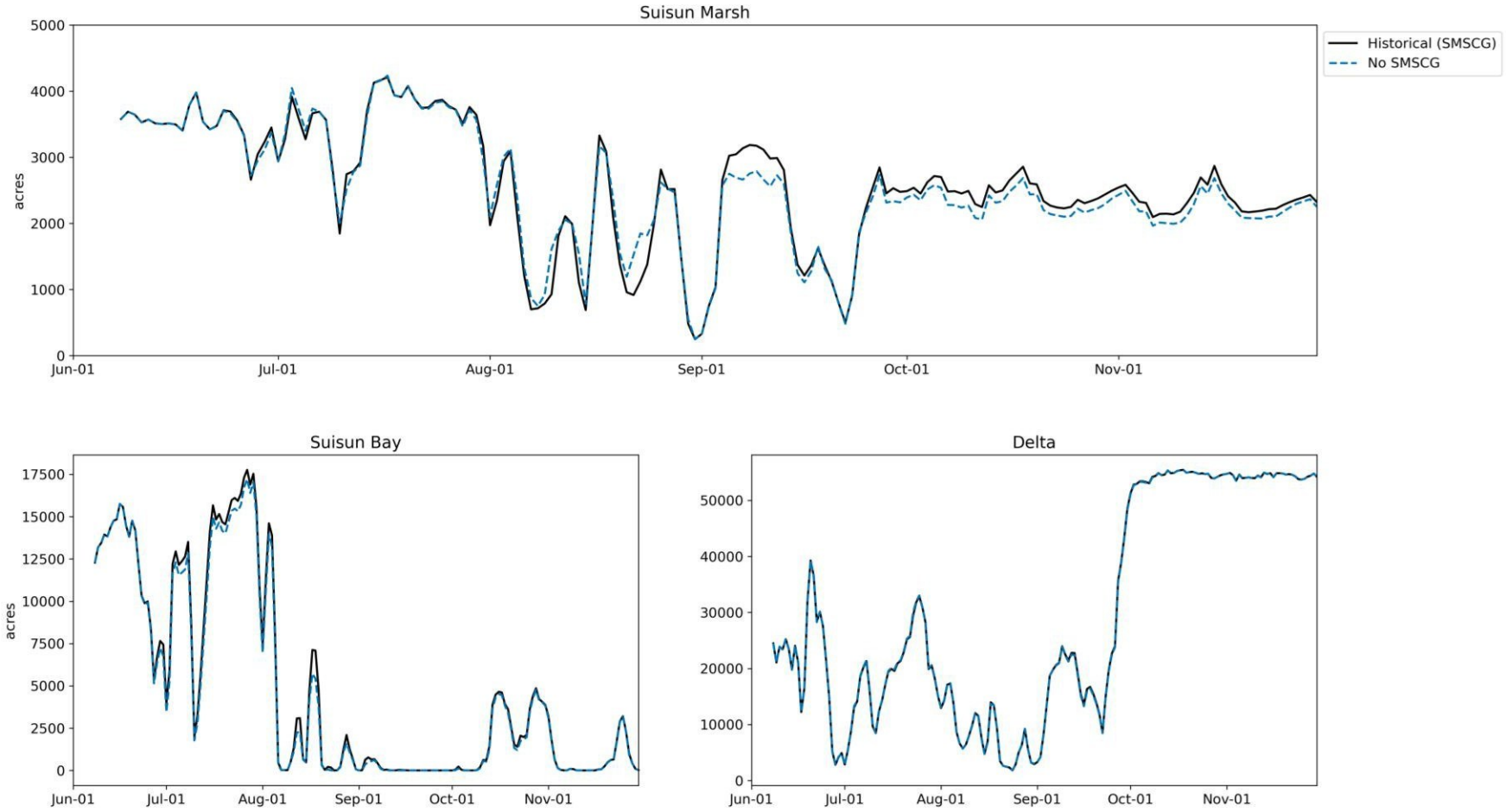


Figure 19. Area of appropriate Delta Smelt habitat (both < 6 PSU and < 22°C) in Suisun Marsh for the Summer-Fall Habitat Action (July-October). Black line shows historical habitat area, blue shows the alternate scenario.

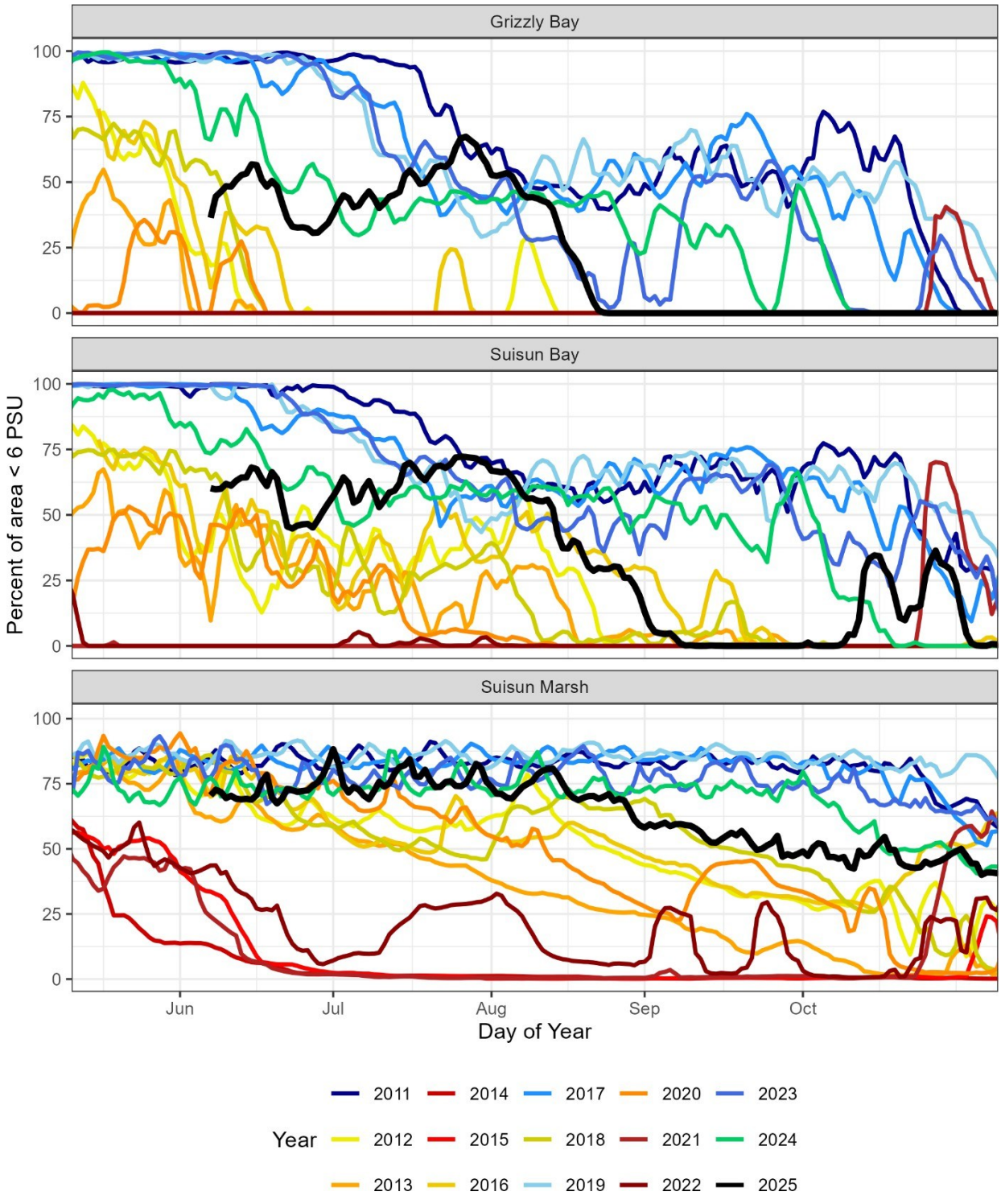


Figure 20. Percent of total wetted area less than 6 PSU in Suisun Bay, Grizzly Bay, and Suisun Marsh from 2011-2025. Wet years are shown in shades of blue, above

normal years in shades of green, below normal years in shades of yellow, dry years in shades of orange, and critical years in shades of red. 2025 is shown in black.

Zooplankton

STN and FMWT collected 108 mesozooplankton samples in the regions of interest in 2025. In 2025, *Pseudodiaptomus forbesi* was highest in the River region, which is consistent with most years (**Figure 21**, **Figure 22**). When comparing between years within each region (see post-hoc results, Table S1), abundance in Suisun Bay in 2025 was similar to 2024, 2023, 2021, and 2018, higher than 2020 and 2022, and lower than 2017 and 2019. Abundance in Suisun Marsh was similar to 2024 and 2018, lower than 2023, 2019, and 2017, and higher than 2020, 2021, and 2022 (Table S1).

Acartiella sinensis biomass in 2025 was the highest recorded within our study period and greatest in the Suisun Bay and Sacramento River regions (**Figure 21**). Although *L. tetraspina* continued to show low abundance in 2025, detections were more frequent at upstream stations than in Suisun Bay (**Figure 23**). Because *L. tetraspina* is not quantitatively sampled by the 150 um mesh zooplankton net, these results should be interpreted qualitatively, not quantitatively.

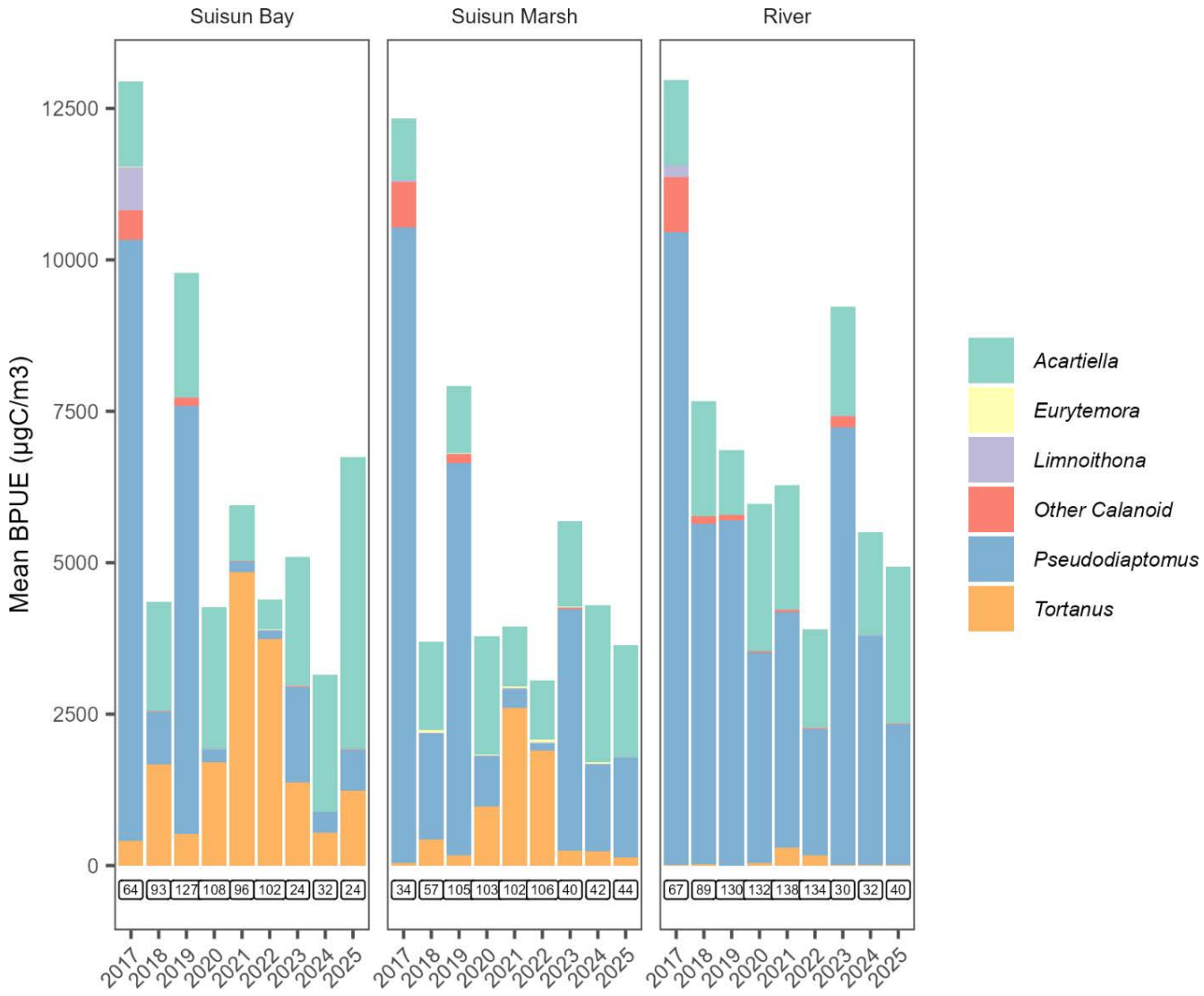


Figure 21. Mean biomass (June-October) of each of the major copepod taxa by region and year from 2010-2025. Number of samples is noted below each bar.

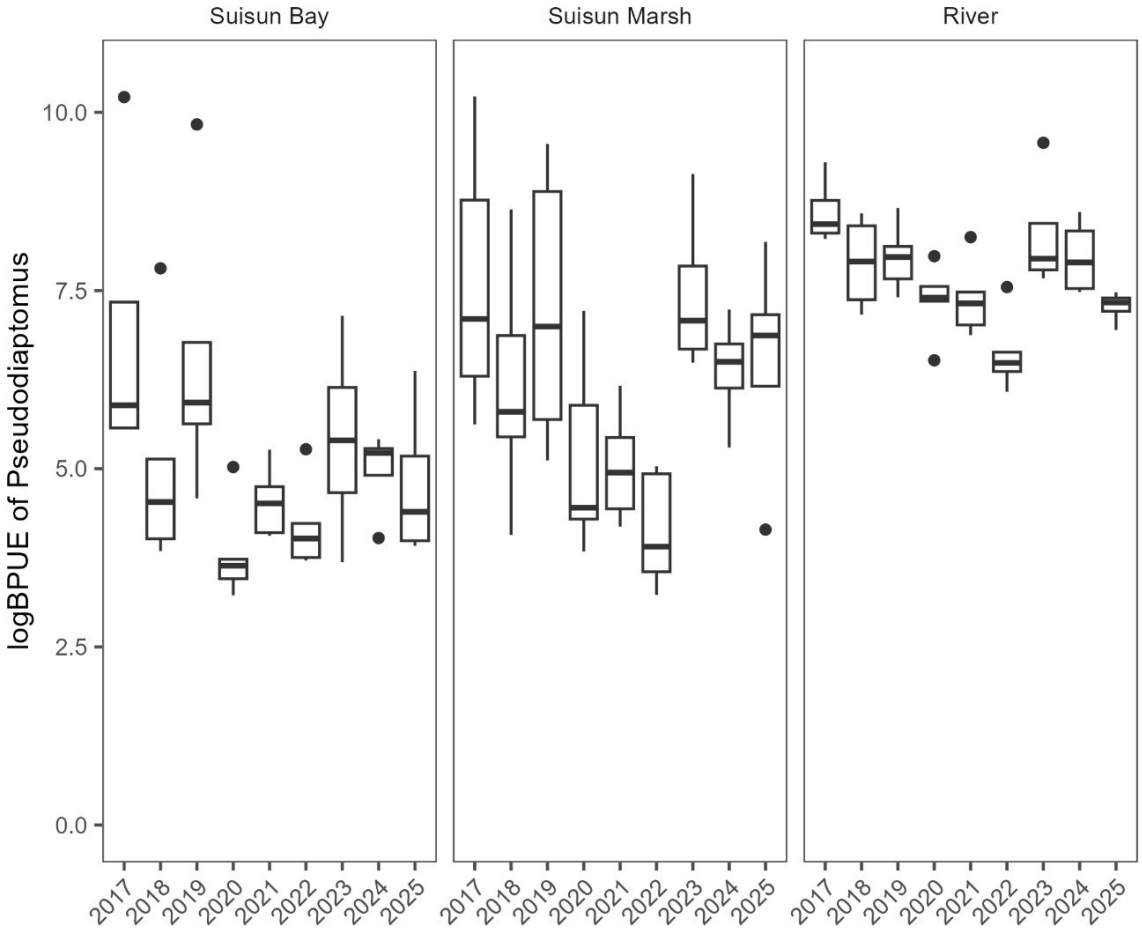


Figure 22. Box plots showing biomass of *Pseudodiaptomus sp*. by region and year.

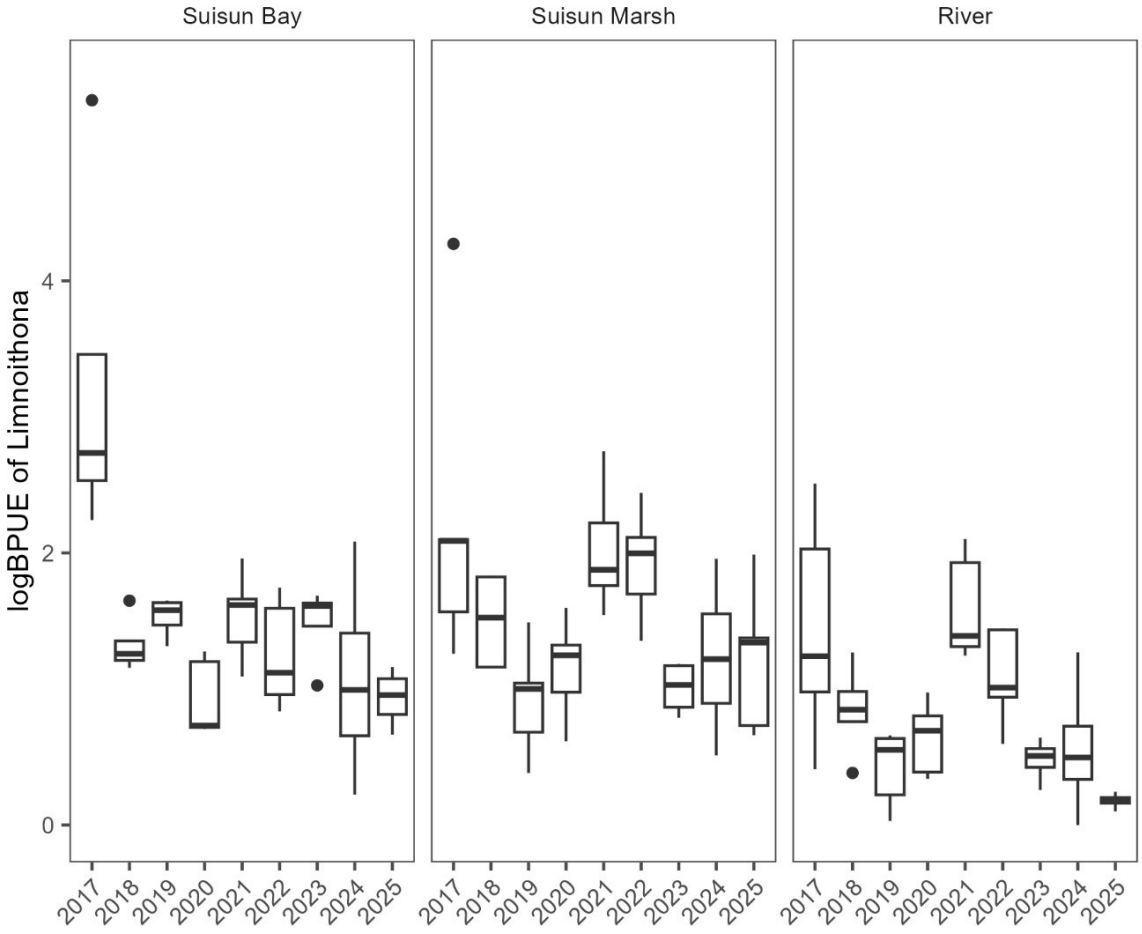


Figure 23. Box plots showing biomass of *Limnoithona sp*. by region and year.

Table 6. Results of linear mixed model of *Pseudodiaptomus sp*. biomass versus region, year, and the interaction of region and year. * = significant at the p<0.001 level. ** = significant at the p < 0.01 level. * = significant at the p < 0.05 level.**

Description	Estimate	Std. Error	df	t value	Pr(>|t|)	Sig.
(Intercept: 2025, Suisun Marsh)	6.29	0.41	8.03	15.38	<0.0001	***
Region-River	1.15	0.33	2064.07	3.54	0.0004	***
Region-Suisun Bay	-1.11	0.38	2064.05	-2.93	0.0035	**
Year-2024	0.58	0.32	2064.06	1.81	0.0709	N/A
Year-2023	1.44	0.33	2064.07	4.43	<0.0001	***
Year-2022	-2.11	0.27	2064.03	-7.89	<0.0001	***
Year-2021	-1.27	0.27	2064.03	-4.74	<0.0001	***
Year-2020	-1.14	0.27	2064.03	-4.24	<0.0001	***
Year-2019	1.01	0.27	2064.05	3.79	0.0002	***
Year-2018	-0.42	0.30	2064.03	-1.40	0.1612	N/A
Year-2017	1.37	0.34	2064.08	4.04	<0.0001	***
River:2024	0.15	0.48	2064.02	0.32	0.7503	N/A
Suisun Bay:2024	-0.49	0.51	2064.03	-0.94	0.3456	N/A
River:2023	-0.27	0.48	2064.02	-0.55	0.5840	N/A
Suisun Bay:2023	-0.91	0.54	2064.02	-1.69	0.0915	N/A
River:2022	1.28	0.38	2064.07	3.38	0.0007	***
Suisun Bay:2022	0.99	0.43	2064.07	2.30	0.0217	N/A
River:2021	1.21	0.38	2064.08	3.18	0.0015	**
Suisun Bay:2021	0.63	0.43	2064.06	1.46	0.1437	N/A
River:2020	1.05	0.38	2064.06	2.77	0.0056	**
Suisun Bay:2020	-0.23	0.43	2064.05	-0.55	0.5851	N/A
River:2019	-0.46	0.38	2064.04	-1.21	0.2248	N/A
Suisun Bay:2019	0.31	0.43	2064.04	0.72	0.4733	N/A
River:2018	0.84	0.41	2064.05	2.04	0.0417	*
Suisun Bay:2018	0.10	0.45	2064.02	0.22	0.8263	N/A
River:2017	-0.20	0.45	2064.01	-0.45	0.6547	N/A
Suisun Bay:2017	0.27	0.49	2064.02	0.55	0.5844	N/A

Table 7. Results of linear model of *Limnoithona sp*. biomass by region and year, and the interaction between region and year. * = significant at the p<0.001 level. ** = significant at the p < 0.01 level. * = significant at the p < 0.05 level.**

Description	Estimate	Std. Error	df	t value	Pr(>|t|)	Sig.
(Intercept: 2025, Suisun Marsh)	1.19	0.19	468.25	6.44	<0.0001	***
Region-River	-1.04	0.26	2065.81	-3.99	<0.0001	***
Region-Suisun Bay	-0.27	0.30	2065.41	-0.89	0.3755	N/A
Year-2024	0.18	0.26	2065.68	0.72	0.4745	N/A
Year-2023	-0.16	0.26	2065.82	-0.62	0.5370	N/A
Year-2022	0.72	0.21	2065.14	3.37	0.0008	***
Year-2021	0.81	0.21	2065.11	3.78	0.0002	***
Year-2020	-0.05	0.21	2065.10	-0.22	0.8237	N/A
Year-2019	-0.25	0.21	2065.55	-1.19	0.2357	N/A
Year-2018	0.30	0.24	2065.18	1.24	0.2159	N/A
Year-2017	1.16	0.27	2066.08	4.28	<0.0001	***
River:2024	0.27	0.38	2064.86	0.71	0.4769	N/A
Suisun Bay:2024	0.24	0.41	2064.97	0.59	0.5521	N/A
River:2023	0.49	0.39	2064.87	1.27	0.2035	N/A
Suisun Bay:2023	0.73	0.43	2064.72	1.69	0.0919	N/A
River:2022	0.22	0.30	2065.70	0.73	0.4639	N/A
Suisun Bay:2022	-0.35	0.34	2065.76	-1.01	0.3123	N/A
River:2021	0.61	0.30	2065.90	2.02	0.0432	*
Suisun Bay:2021	-0.20	0.35	2065.61	-0.58	0.5631	N/A
River:2020	0.51	0.30	2065.55	1.67	0.0960	N/A
Suisun Bay:2020	0.03	0.34	2065.44	0.10	0.9224	N/A
River:2019	0.54	0.30	2065.33	1.79	0.0739	N/A
Suisun Bay:2019	0.85	0.34	2065.27	2.50	0.0125	*
River:2018	0.42	0.33	2065.39	1.29	0.1988	N/A
Suisun Bay:2018	0.11	0.36	2064.80	0.30	0.7619	N/A
River:2017	0.15	0.36	2064.67	0.41	0.6809	N/A
Suisun Bay:2017	1.20	0.39	2064.74	3.05	0.0023	**

Delta Smelt Status

The STN and FMWT have historically provided abundance indices for Delta Smelt in the summer and fall periods, respectively. However, Delta Smelt numbers have declined below the detection limits of both surveys. Neither the STN nor the FMWT surveys captured Delta Smelt at their fixed index stations in 2025, making a 0 index for both surveys.

EDSM Delta Smelt catch and abundance estimates in summer-fall period 2025 were higher than the summer-fall period of 2024, but lower than 2023 (Table 8, Figure 25)

Table 8. Delta Smelt catch, from June 1-October 31, 2025. All fish were caught by the USFWS EDSM survey and genetically confirmed as Delta Smelt.

Date	Location	Fork Length (mm)	Temp. (C)	Turbidity (FNU)	Salinity (PSU)
2025-06-20	Suisun Marsh	44	20.3	40	3.7
2025-07-14	Lower Sacramento River	58	21.3	11.4	0.3
2025-07-15	Suisun Marsh	36	20.9	27.5	1.7
2025-08-25	Suisun Marsh	46	22.1	24.9	2.1
2025-10-06	Lower Sacramento River	54	19.2	10.2	0.4
2025-10-09	Suisun Marsh	54	19.8	50.4	9.3
2025-10-17	Suisun Marsh	59	17.7	33.3	7.3

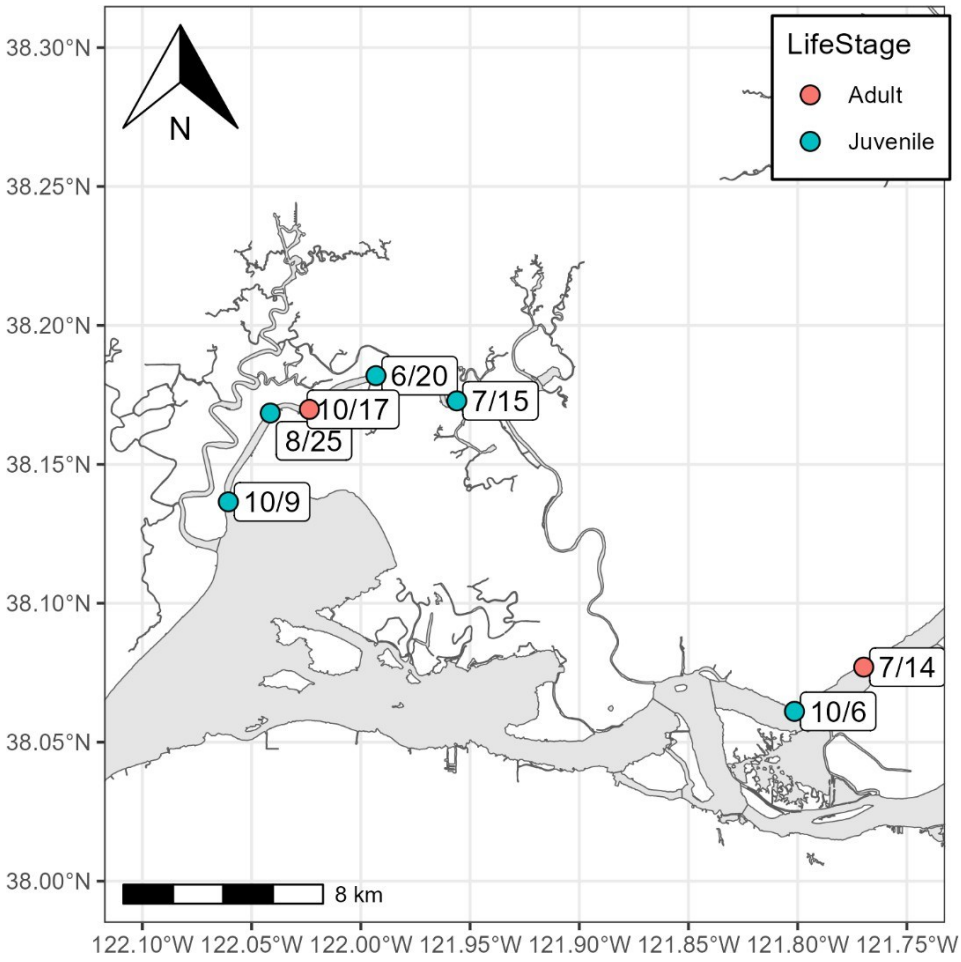


Figure 24. Map of EDSM Delta Smelt catch during the summer-fall action period (June 1 -October 31, 2025). The date of each capture (Month-Day) is indicated next to the point.

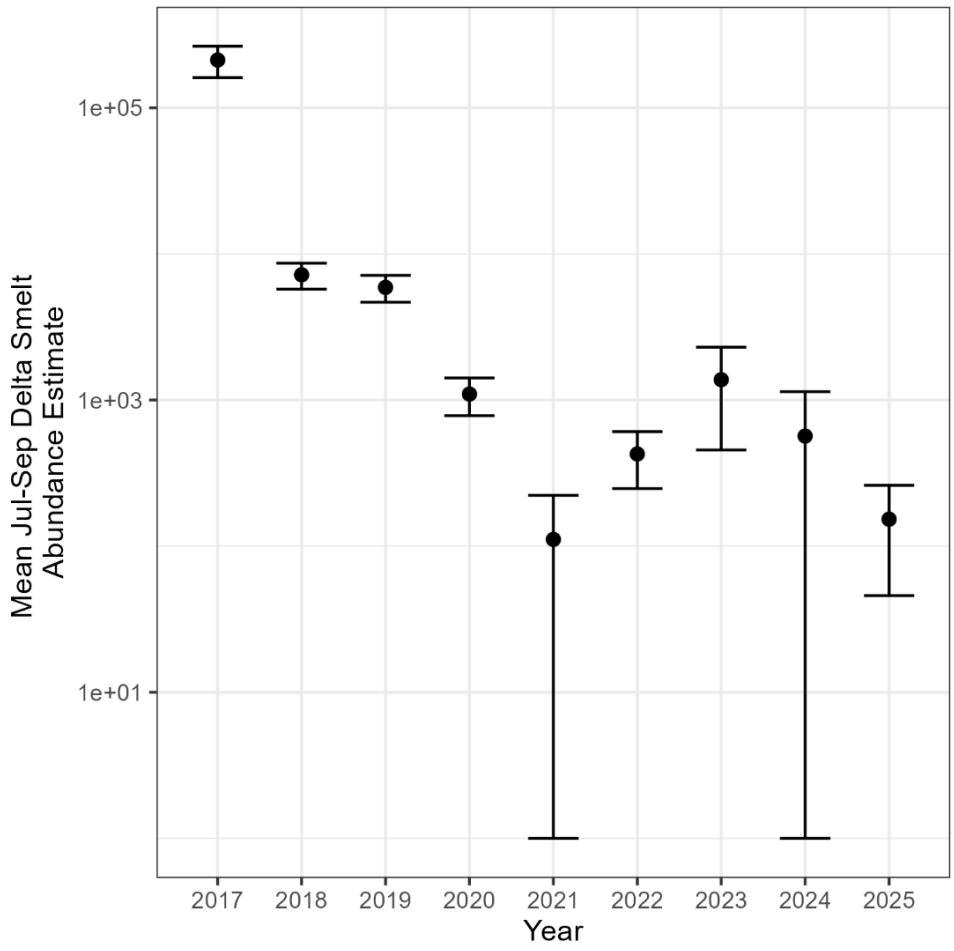


Figure 25. Average Delta Smelt abundance estimate for July 1 through September 30. Abundance estimates are calculated by EDSM on a weekly basis, then summarized by calculating the average and standard error over the summer-fall habitat season. Plot courtesy of Lara Mitchell, USFWS.

Flow Action Discussion

The 2025 Sacramento Valley Water Year designation was Above Normal, and the SMSCG were operated for most of the summer. In wetter years, Delta Smelt habitat is expected to have higher quality and quantity than in drier years due to the increased Delta outflow. Most of this increase in outflow is from increased snowmelt, increased reservoir releases for flood control, and an increase in runoff from below the major reservoirs rather than from higher outflow requirements listed in regulatory permits (Gartrell et al. 2022). Flow actions taken during these wetter year types add to the already high benefits caused by the increased precipitation. In 2025, flow during the

beginning of the summer was similar to 2024, another Above Normal Year, and higher than below normal, dry, or critically dry years, indicating that some amount of increased outflow may have been due to higher precipitation (Figure 3). During the fall, outflow in 2025 was lower than 2024 due to the removal of the fall X2 requirement.

Suitable Delta Smelt habitat measured at continuous stations across the monitoring region demonstrated that the number of days with suitable salinity in Suisun Marsh in 2025 was similar to other years with an X2 action (2017 and 2019, 2023, 2024) or a SMSCG action (2018, 2023, 2024) (Figure 10). Hindcast modeling showed that the area of LSZ habitat in Suisun Marsh increased during the SMSCG action, with the largest increase in late August and September, and relatively small differences between the action and no-actions scenarios in June or July (Figure 16). Water temperatures in 2025 were cooler than 2024, so temperature was less limiting on the overall extent and duration of suitable habitat.

Number of days of suitable habitat and area of the LSZ in Suisun Bay were lower than previous action years by 20 to 30 days because the X2 standard was removed (Table 5), and overall conditions were not as wet as 2017, 2019, or 2023. Area of habitat in 2025 was similar to the Above Normal year of 2024 in June and July, but resembled the Below Normal years of 2016 and 2018 in September and October (Figure 20). Area of the LSZ in Grizzly Bay was generally high in July and August with and without the SMSCG action, but none of Grizzly Bay was in the LSZ in September or October (Figure 15), and there was no increase in area of the LSZ in Grizzly Bay with SMSCG operations, unlike some previous years.

The relatively low temperatures in 2025 when compared to 2024 meant that the additional LSZ area may have provided significant benefits to Delta Smelt in June and July. Higher temperatures in August may have limited the benefits of habitat in Suisun Bay and Grizzly Bay later in the summer, but cool temperatures returned in early September. Higher salinities in in September limited habitat in Suisun Bay, though habitat in Suisun Marsh remained suitable for the first half of the month (**Figure 18**, Figure **19**).

Area of submerged and floating vegetation in Suisun Marsh was lower in 2025 than 2024, particularly in the West Marsh where area of FAV coverage dropped by 200% (Figure 11), and SAV dropped by 40% (Figure 13). This drop in SAV coverage could have

provided an increase in habitat availability, though further research is required to figure out why the drop in coverage occurred.

The high abundance of *Pseudodiaptomus* spp. in Suisun Marsh during the action period is similar to previous years with SMSCG actions along (2018 and 2024 – though 2024 also had a one-month X2 action) (Figure 22, Table S1), indicating that the SMSCG action may have helped to support increased food supply to the Marsh.

The abundance of *Pseudodiaptomus* spp. in Suisun Bay in 2025 was lower than years with X2 actions (2017, 2019, and 2023, though higher than the dry years of 2020 and 2022), highlighting the benefit of the X2 action in increasing *Pseudodiaptomus* spp. in Suisun Bay (**Figure 22** Table S1). The high abundance of *A. sinensis* in 2025, mostly due to two particularly high samples in late September in Suisun Bay, is unusual, and *A. sinensis* controls the downstream distribution of *P. forbesi* by predating on young life stages (Kayfetz and Kimmerer 2017) and could have contributed to lower *P. forbesi* biomass in 2025.The reason behind the increase in *A. sinensis* increased in 2025 is unknown but it is unlikely to have been caused by the removal of the Fall X2 component because high abundance of *A. sinensis* was not seen in drier years with higher salinity, such as 2020 and 2021.

Given the extremely low catch of Delta Smelt in 2025, changes in the distribution and abundance of Delta Smelt to the SFHA operations cannot be attributed to a specific factor. While catch in 2025 (5 smelt in Suisun marsh) was higher than 2024 (one smelt), it does not provide strong evidence regarding effectiveness of the action in either direction. Overall, Delta Smelt population during the summer and fall of 2025 was slightly higher than 2024, but the very low catch rates make it difficult to credibly assess population trends.

Conclusions

The described findings only partially inform summer-fall hypotheses, with potential benefits to Delta Smelt habitat and food availability observed, but limited Delta Smelt catch data prevented the evaluation of fundamental hypothesis about the impact of these habitat actions on Delta Smelt survival.

1. **Hypothesis:** X2 above 80 km during summer and fall will decrease the area of low salinity habitat in Suisun Bay with appropriate temperatures and turbidity
   Supportive findings:

a. 2025 had fewer days with salinity < 6 PSU than 2024, another above-normal year that had a partial X2 action, and much fewer days than the wet years of 2017, 2019, and 2023.
b. The area of the LSZ in Suisun Bay in June and July of 2025 was similar to June and July of 2024, but much lower than 2024 in September and October.
c. Lower temperatures in 2025 meant that more of the LSZ was suitable for Delta Smelt growth than in 2024.

2. **Hypothesis:** X2 above 80 km during summer and fall will decrease biomass of the calanoid copepod *Pseudodiaptomus forbesi* in the low salinity zone.
   Supportive findings:
   a. Biomass of the calanoid copepod *Pseudodiaptomus spp.* in Suisun Bay was lower in 2025 than 2024.
   b. High abundance of the predatory copepod *Acartiella sinenesis* may have influenced the observed *Pseudodiaptomus* spp. biomass trends.

3. **Hypothesis:** Operating the SMSCG during the summer and fall will increase the duration and area of Delta Smelt habitat in Suisun Marsh with appropriate temperatures, turbidity, and salinity.
   Supportive findings:
   a. The number of days with salinities below 6 PSU in Suisun Marsh was similar to other years with SMSCG actions, and suitable habitat remained in Suisun Marsh even when Suisun Bay had become too salty.
   b. Area of LSZ modeled with and without the action found that gate operation did increase area of the LSZ in Suisun Marsh by several hundred acres, though this increase was larger later in the summer when salinity in Suisun Bay had begun to increase.
   c. High temperatures in August limited habitat in Suisun Marsh, but the return of cooler temperatures in September meant that habitat in the marsh lasted longer than in the bay.

4. **Hypothesis:** Operating the SMSCG during the summer and fall will increase biomass of the calanoid copepod *Pseudodiaptomus forbesi* in Suisun Marsh through increased transport from upstream.
   Supportive findings:
   a. Biomass of the calanoid copepod *Pseudodiaptomus sp.* in 2025 was similar to 2018 and 2024, other years with SMSCG actions, and higher than dry years with no action (2020, 2021, 2022). However, this increase cannot be

conclusively attributed to the SMSCG operations because the transport mechanism was not explicitly modeled.

5. **Hypothesis:** Operating the SMSCG will increase the area of appropriate Delta Smelt habitat in Grizzly Bay.
   Non-supportive findings:
   a. Hindcast modeling of LSZ area showed no increase in area in Grizzly Bay with the action versus without the action.
   b. Continuous sondes in Grizzly Bay did not show a direct response to SMSCG operations.

6. **Hypothesis:** Delta Smelt survival in 2025 may be lower than years with X2 actions, but higher than drier years without SMSCG actions.
   Inconclusive findings since Delta Smelt catch is too low to credibly evaluate this hypothesis.

Additional Food Web Actions

No food web actions were implemented in 2025, but monitoring and special studies were conducted to help inform their implementation in future years.

Sacramento Deep Water Ship Channel Food Web study

The Sacramento Deepwater Ship Channel (SDWSC) is one of the few areas in the Delta in which Delta Smelt are detected fairly consistently. Understanding why and how this region can support Delta Smelt throughout the year is important for identifying the potential for management actions to further enhance Delta Smelt support. Ongoing research in the Sacramento Deepwater Ship Channel continues to focus on understanding how water exchange and residence time mediate abiotic and biotic drivers of phytoplankton and zooplankton dynamics.

In 2023, DWR and USGS initiated a bioenergetics modeling study to better understand the relatively consistent occurrence of Delta Smelt in the SDWSC. USFWS, Reclamation, and UC Davis are collaborators in this study. The following is a summary of their findings, which have been submitted for publication to the journal Endangered Species Research.

The participants in the study used the Delta Smelt Bioenergetic Model developed by Smith and Nobriga (2023) to look at spatial and temporal differences in potential juvenile growth rate in the SDWSC. The study integrated water quality data and zooplankton samples from different depths and different locations within the channel to see whether vertical stratification or longitudinal variation provided localized areas of increased habitat suitability (Figure 26). The study also looked at how habitat suitability may have changed with changes to water temperatures across time and examined how an increase in zooplankton abundance may benefit Delta Smelt in the channel.

The study identified elevated potential growth rate in the middle region of the channel where tidal hydrodynamics creates a peak in turbidity and supports preferred prey items (Figure 26). This is also the region where Delta Smelt have been historically captured in greatest abundance. Potential growth rates to the north (characterized by high summer temperatures and minimal tidal exchange with downstream regions) and the south (characterized by lower prey densities), were lower than in the middle. Potential growth rates at the bottom of the water column were higher than the top of the water column due to increased zooplankton abundance, however the vertical differences in potential growth were lower than the longitudinal differences.

This spatial pattern persisted across both hot and cool summers, providing a buffer against inter-annual variation in temperature. Simulated increases in zooplankton concentration had only a small benefit to Delta Smelt growth rates, highlighting the greater importance of turbidity and water temperature in driving the patterns in potential growth rates. Together, these findings highlight why the SDWSC is such an important “hot spot” for Delta Smelt, and it may help to identify other habitat hot spots throughout the estuary.

Reclamation also continued to work with UC Davis to study ecosystem metabolism, photosynthesis-irradiance dynamics, benthic nutrient pools and fluxes, and zooplankton grazing rates in the SDWSC with the ultimate goal of developing flow and nutrient enhancement management actions. This project was initiated in 2021 and published studies associated with the project were highlighted in previous seasonal reports. UC Davis continued to sample water chemistry and zooplankton, and maintained field instruments to measure ecosystem metabolic rates in 2025. UC Davis also continued to carry out laboratory incubation and sediment nutrient flux experiments to model the SDWSC ecosystem metabolism and dynamics.

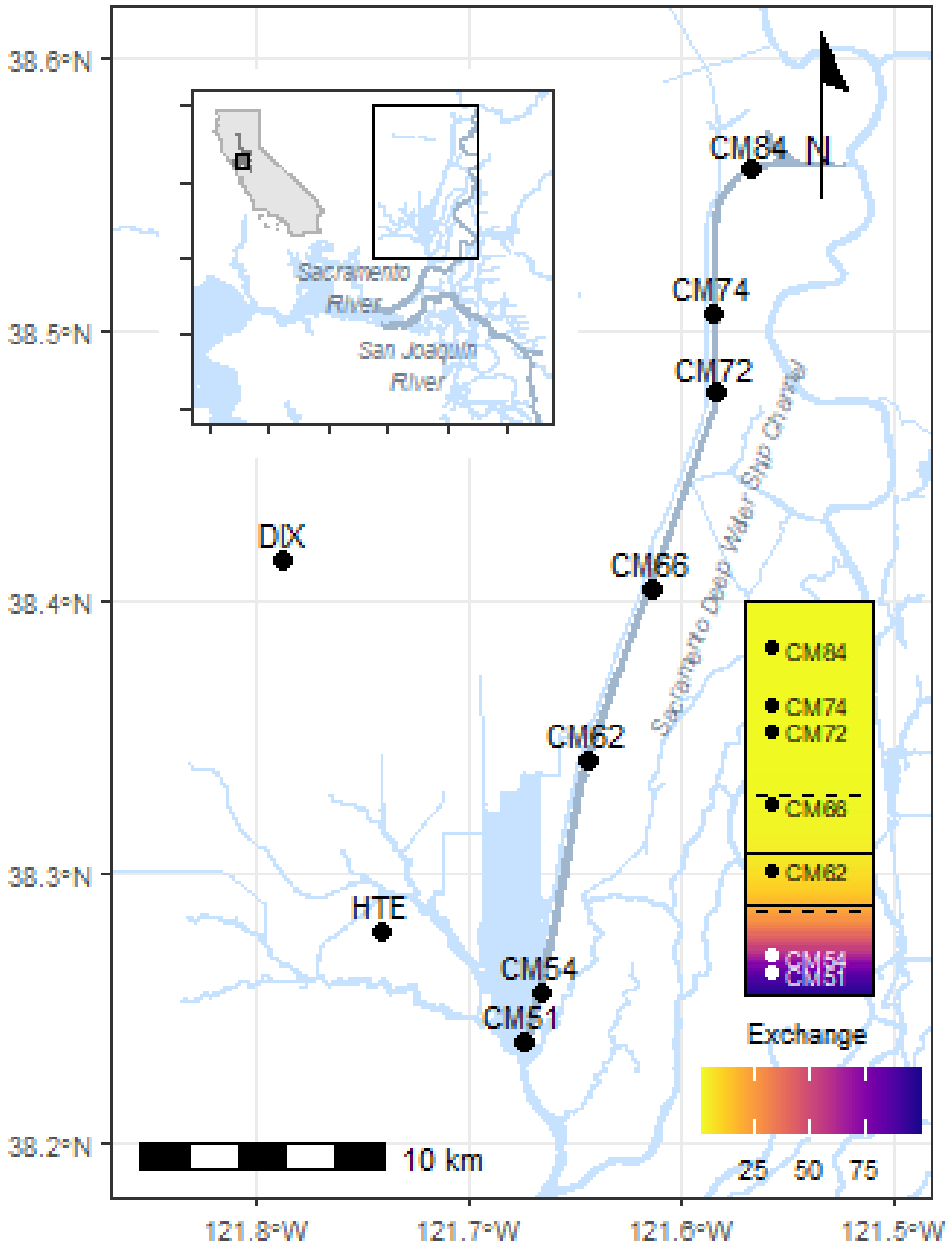


Figure 26. Map of Sacramento Deep Water Ship Channel (SDWSC) water quality and meteorological stations used for analysis. Hydrodynamic exchange ("Exchange") is conceptualized in the inset. Solid horizontal lines indicate the extent of tidal excursion throughout one year, and dashed horizontal lines indicate the 5th and 95th percentiles of conceptual constituent gradients as in Stumpner et al. 2020. Turbidity peaks at CM66, at the upper limit of tidal exchange.

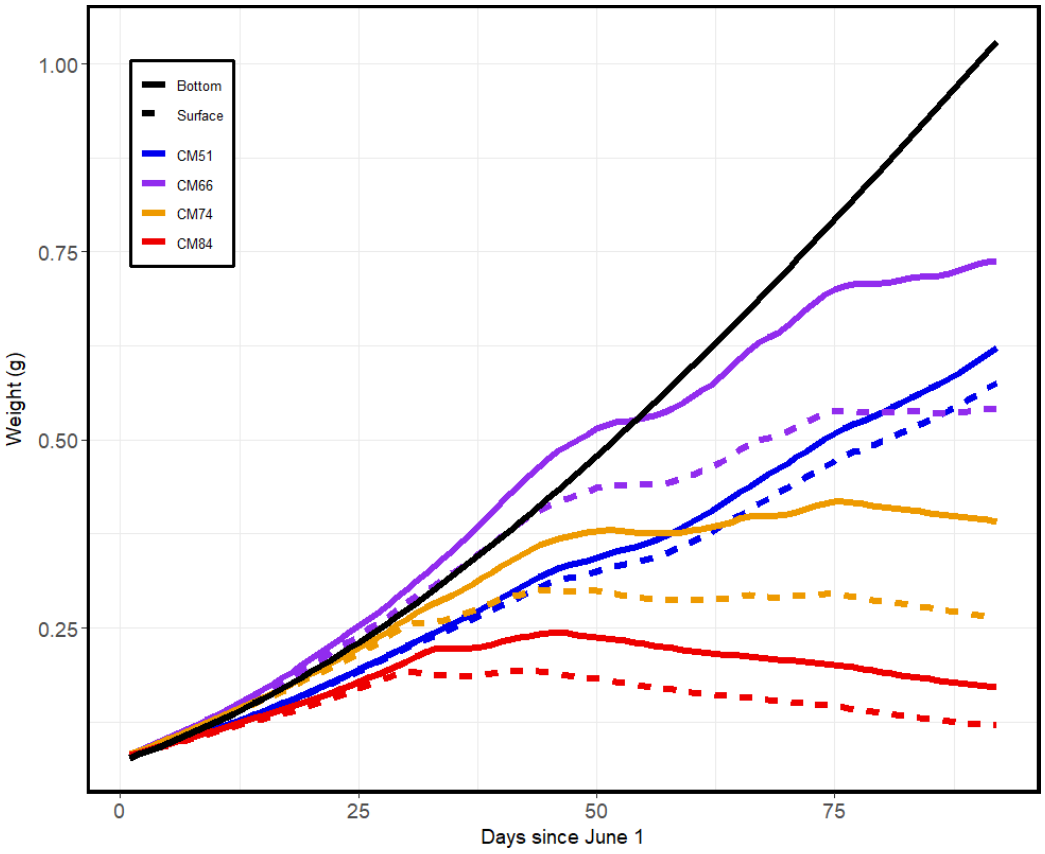


Figure 27. Predicted Delta Smelt size (weight in grams) from the DSM bioenergetic model and von Bertalanffy growth equation (black line) based on temperature, turbidity, day length, and zooplankton biomass among DWSC stations (CM51, CM66, CM74, CM84) and depth (Bottom vs Surface).

Suisun Marsh Food Subsidy Studies

Prepared in coordination with Durand Laboratory, University of California Davis

Introduction

Studies suggest that managed wetlands–principally operated by duck hunting clubs–enhance plankton productivity in Suisun Marsh within the San Francisco Estuary (SFE) (Aha et al., 2021; Williamshen et al., 2021; Tung et al., 2021; Phillips et al., 2024; Phillips et al., 2026). Plankton have declined throughout much of the SFE, largely because of channel modifications and introduced clams that disrupt the food web, limiting food for native planktivorous fish, including Delta smelt (Cloern & Jassby, 2012). Managed-wetland operations may pose a useful tool in subsidizing plankton abundance in adjacent tidal habitats because they are free of clams and allow for exponential growth and concentration of plankton. However, mechanistic understanding of how managed wetlands influence food webs remains limited, and optimal management regimes for promoting plankton abundances at critical times for pelagic fish are unknown.

An ecosystem-scale Before-After Control-Impact (BACI) study was conducted to understand how managed wetland practices affect phytoplankton and zooplankton production. The two-year study encompassed two complete flood hydroperiods in managed wetlands (Fall 2022 through Spring 2024). It was hypothesized that seasonally flooded wetlands promoted high plankton production, that perennially flooded wetlands promoted intermediate plankton production, and that unrestricted tidal habitats (tidally restored wetlands and reference tidal sloughs) produced comparably low plankton production likely due to differences in water residence times and the presence/absence of flood-pulse effects.

Methods

From October 2022 to June 2024, we collected monthly data on chlorophyll-a concentrations, zooplankton densities, and water quality at five managed wetlands, three tidally restored wetlands, and reference sloughs associated with each wetland distributed throughout Suisun Marsh (Figure 28). Of the managed wetlands, Denverton Duck Club (DDC) stayed perennially flooded for the duration of the study, while the rest flooded seasonally in keeping with typical duck club operations. Whole water grabs were collected for measurements of chlorophyll a, nitrate, ammonium, phosphate, dissolved organic carbon, total suspended solids, and volatile suspended solids. Additional water quality data included Secchi depth and YSI EXO2 sonde measurements: chlorophyll fluorescence, dissolved oxygen, temperature, conductivity, turbidity, pH, and fluorescent dissolved organic matter. Monthly rapid zooplankton assessments (RZA;

described in Phillips et al. 2026) were collected, alongside tow-net samples evaluated for species ID, life stage, and egg counts (partially completed). Quarterly, we conducted *in vitro* incubation trials to estimate phytoplankton and zooplankton growth rates in water collected from different wetlands in controlled temperature and light environments. Field sampling and incubation trials concluded in early summer 2024 after all managed wetlands were drained, followed by sample post-processing and analysis (partially completed). During data analysis pre- and post-restoration plankton monitoring data from Wings Landing (restored in 2020) were compared to consider before-after effects of tidal restoration on plankton abundances.

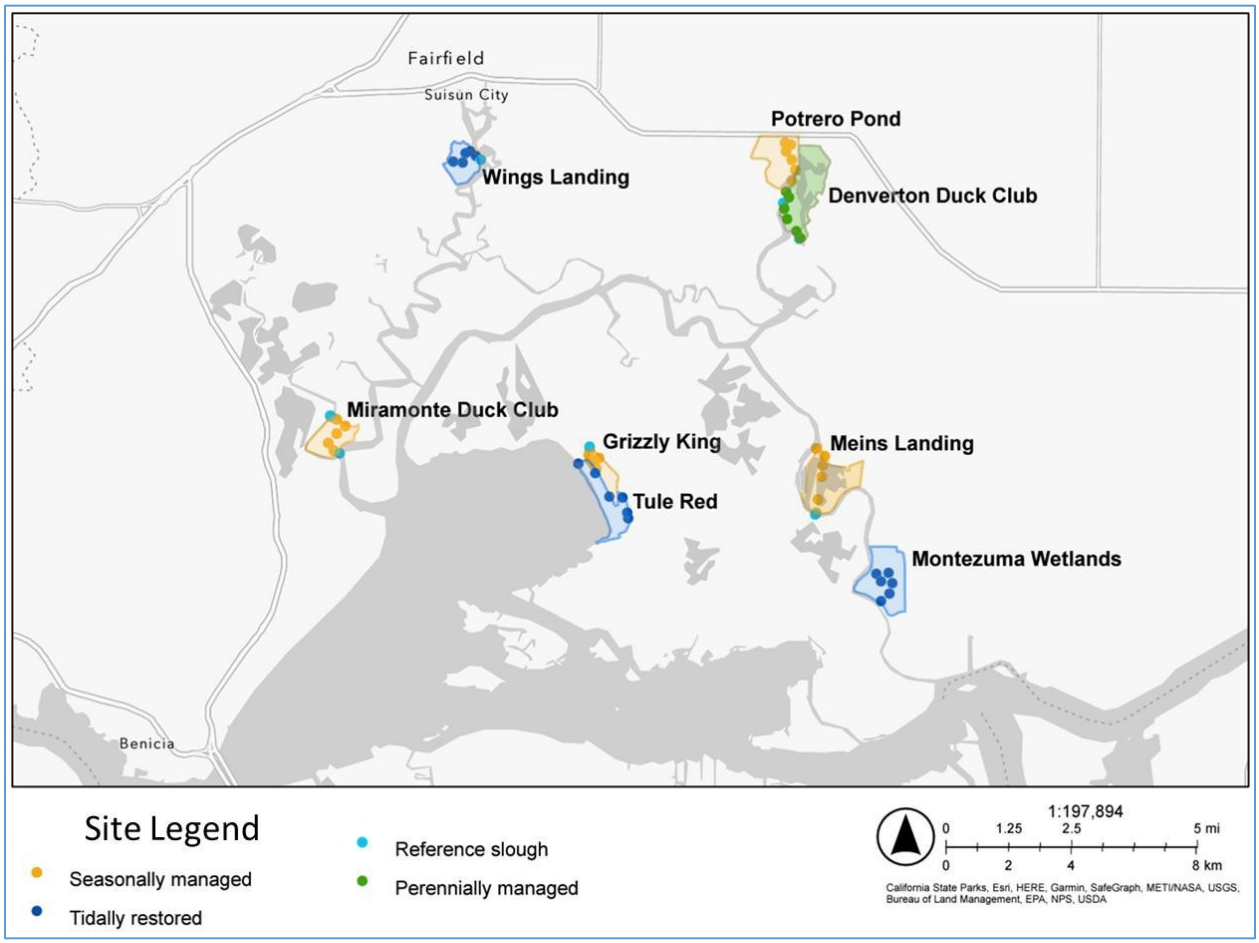


Figure 28. Map of monitoring stations for a plankton productivity study in Suisun Marsh. Stations located within seasonally managed wetlands (orange), a perennially managed wetland (green), tidally restored wetlands (dark blue) and adjacent reference sloughs (light blue).

Preliminary Results

Below is a preliminary summary of sonde readings, primary production rates, rapid zooplankton assessments, and zooplankton sample data from Water Years 2023 and 2024, with water years defined as the period between October 1st and September 30th and which also align with typical flood cycles in managed wetlands. 129 of 167 zooplankton net samples have been quantified and are presented here. Processing and QA/QC of remaining zooplankton samples is still in progress. Other results, like water-quality grab samples and zooplankton incubations are still pending. Of the available results, we report trends of each treatment group (seasonally managed, perennially managed, tidally restored, and reference tidal sloughs), although future analyses will consider site-level comparisons.

Water Quality

Across seasons, water-temperature trends were similar between all habitat treatments (Figure 29and Figure 33A). On average, salinities were higher in managed wetlands compared to tidal sloughs and restorations, with highest salinities observed in fall of 2022 (Figure 30and Figure 33B). Average daytime dissolved oxygen (DO) trends were similar between all treatment types (Figure 31 and Figure 33C). However, DO varied more widely in seasonally managed wetlands, particularly in the fall flood-up months where DO levels reached hypoxic levels at some stations and supersaturated levels elsewhere. Meanwhile, the range of DO levels in the perennially managed wetland were comparable to tidal habitats. DO levels were relatively stable in all wetland treatment groups during winter, spring, and summer, and rarely decreased to levels <5 mg/L in the tidal environments. Phytoplankton biomass—as measured by chlorophyll-a concentration—was highest in seasonally managed wetlands throughout the study period during flooded periods, with peak concentrations occurring in the months following fall flood-up (Figure 31and Figure 33D). The perennially managed wetland promoted intermediate chlorophyll-a concentrations between seasonally managed and tidal habitats.

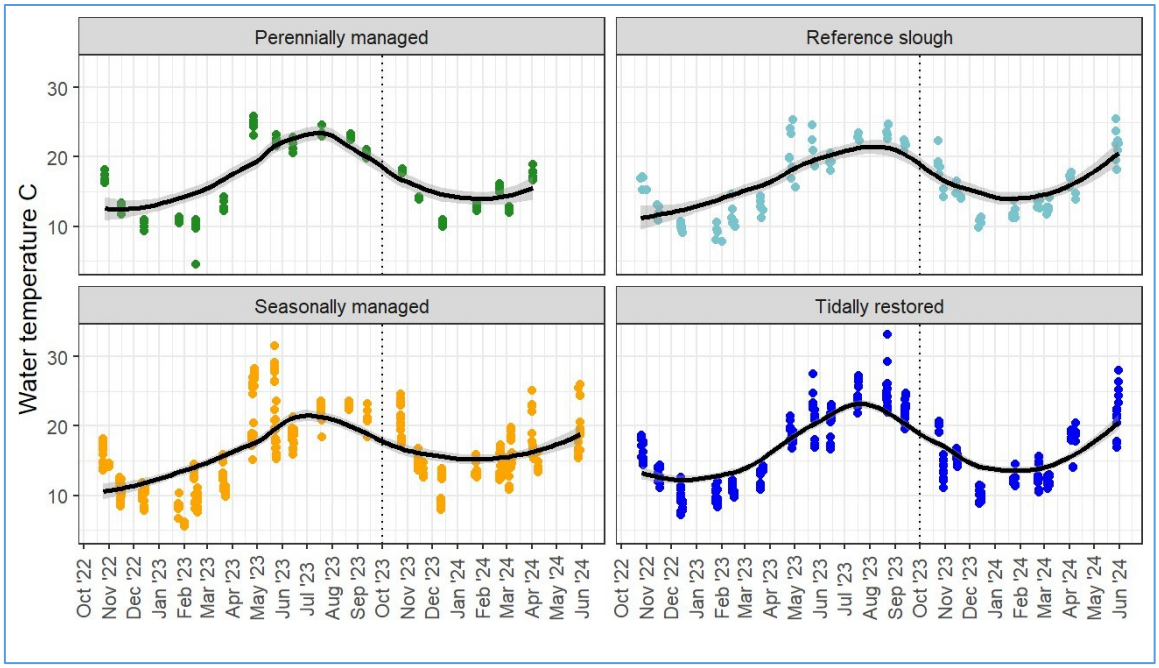


Figure 29. Point and LOESS regression plots of daytime water-temperature trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024.

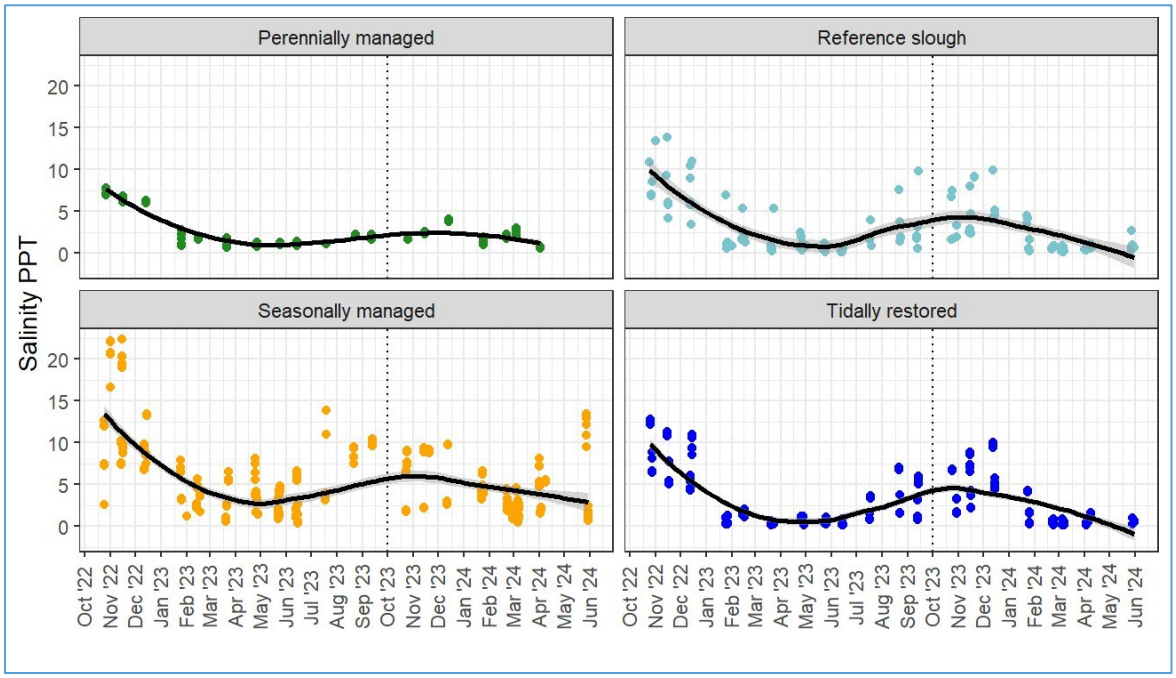


Figure 30. Point and LOESS regression plots of salinity trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024.

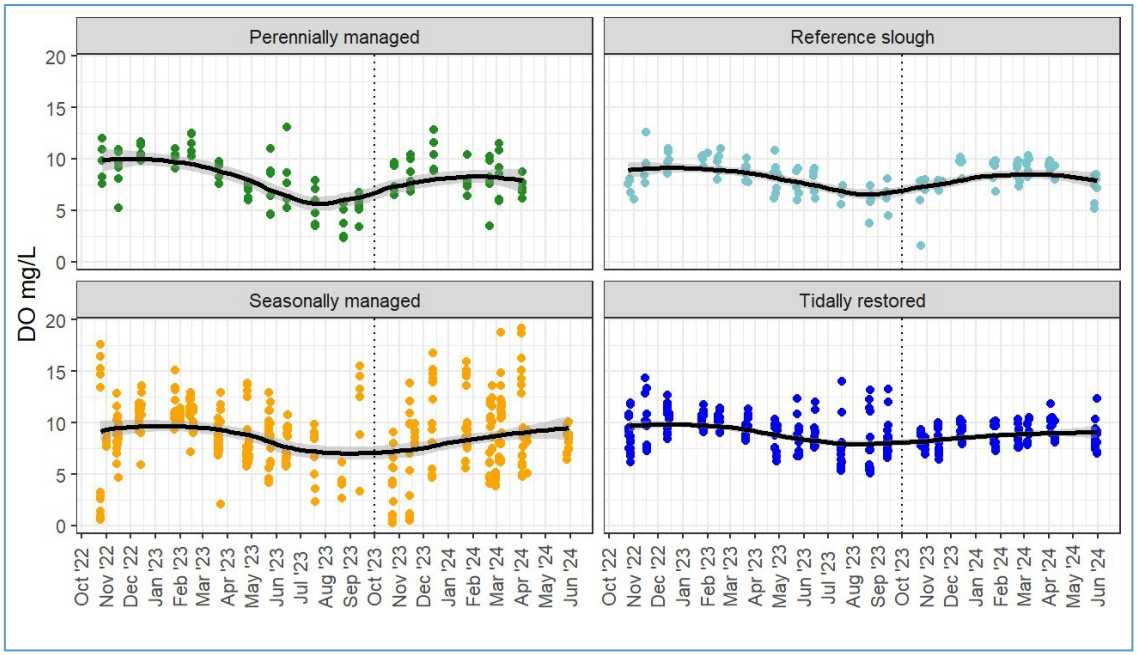


Figure 31. Point and LOESS regression plots of daytime dissolved oxygen trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Dotted vertical line delineates water years 2023 and 2024.

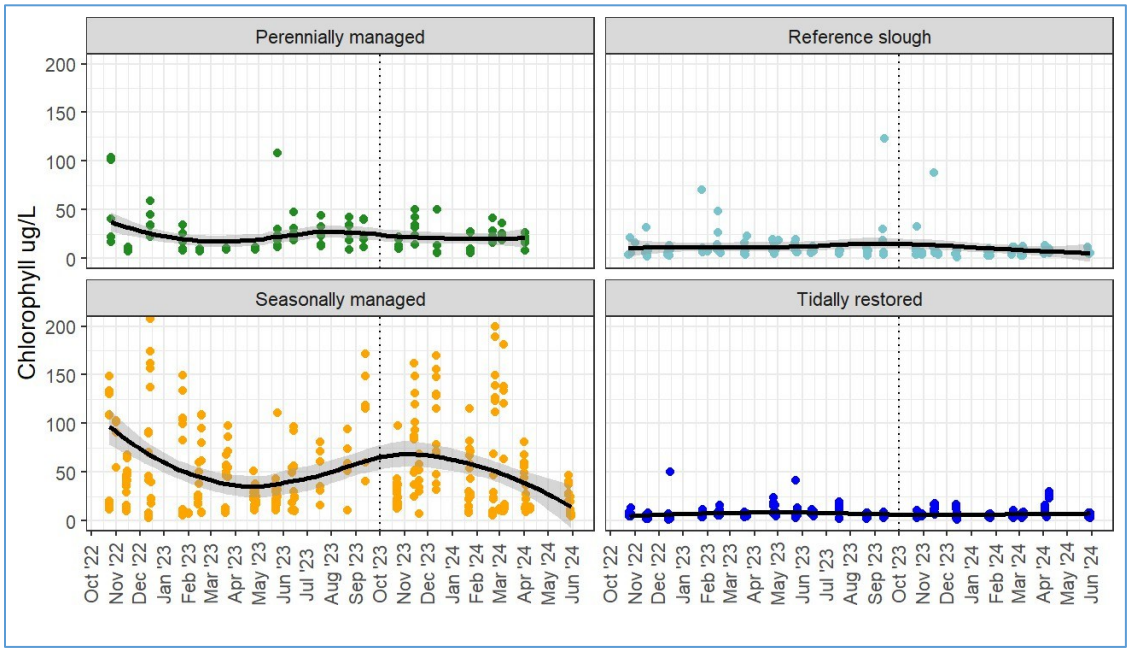


Figure 32. Point and LOESS regression plots of sonde chlorophyll-a trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 200 µg/l not shown (n=12 in seasonally managed wetlands) but are factored in LOESS regression trends. Dotted vertical line delineates water years 2023 and 2024.

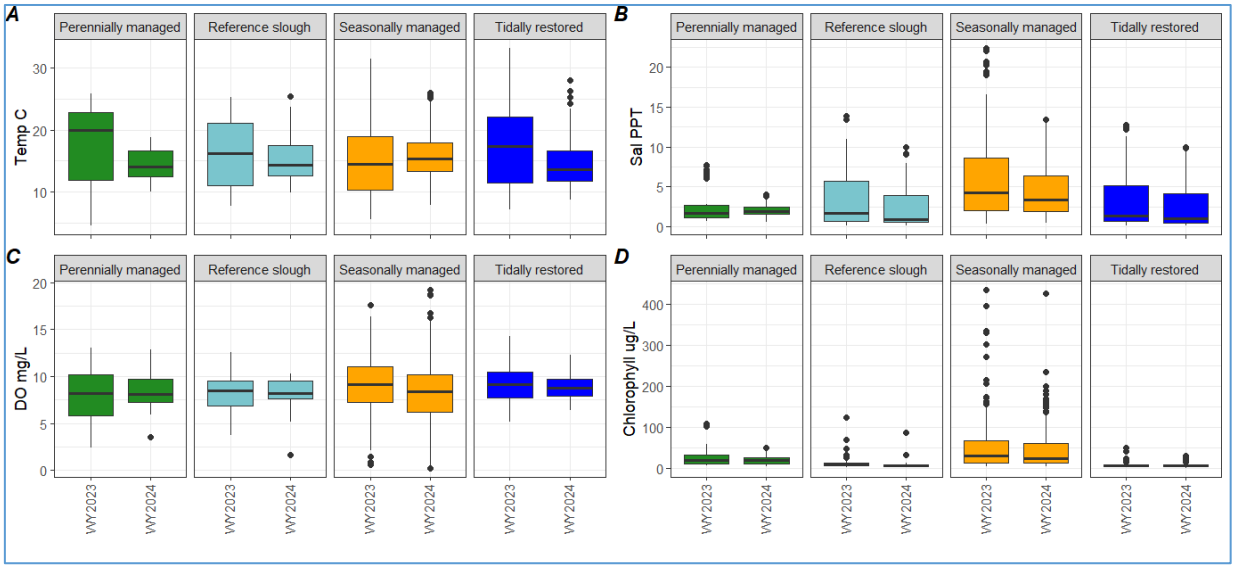


Figure 33. Box-and-whisker plots comparing distributions of (a) water temperatures, (b) salinities, (c) dissolved oxygen, and (d) chlorophyll concentrations across water years and treatments. Lines refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR.

Primary Production Rates

On average, seasonally managed wetlands supported higher gross primary production (GPP), net ecosystem production (NEP), and respiration (R) than other treatments (Figure 34 - Figure 37). However, there was high variation among seasonally managed wetlands and between quarterly trials, with the highest rates occurring in summer and fall. The perennially managed wetland supported slightly higher GPP and NEP than both tidal treatments, but R was similar between the two groups (Figure 37).

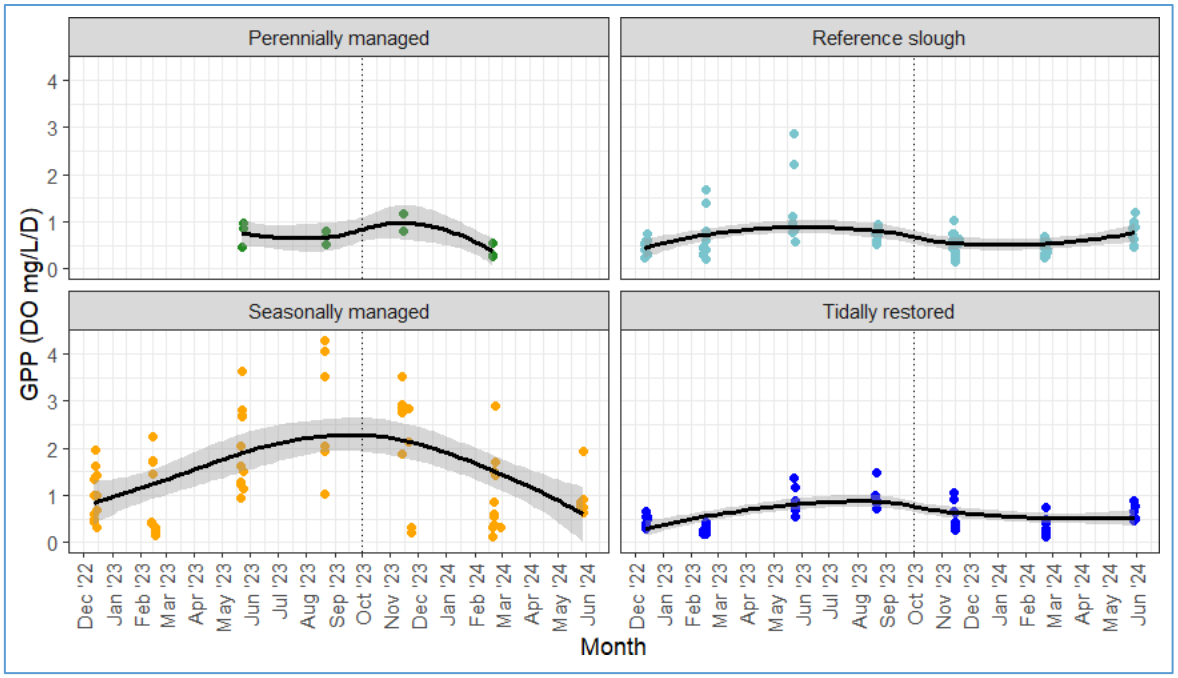


Figure 34. Point and LOESS regression plots depicting pelagic gross primary production in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh.

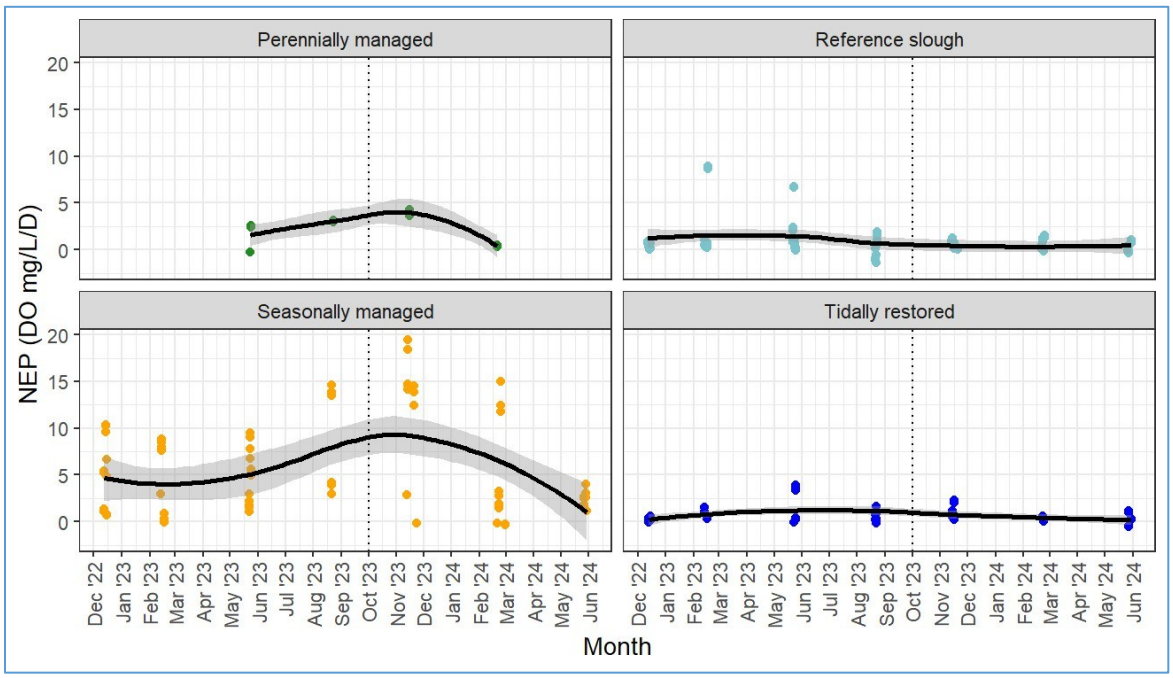


Figure 35. Point and LOESS regression plots depicting pelagic net ecosystem production rates in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh.



Figure 36. Point and LOESS regression plots depicting pelagic respiration rates in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh.

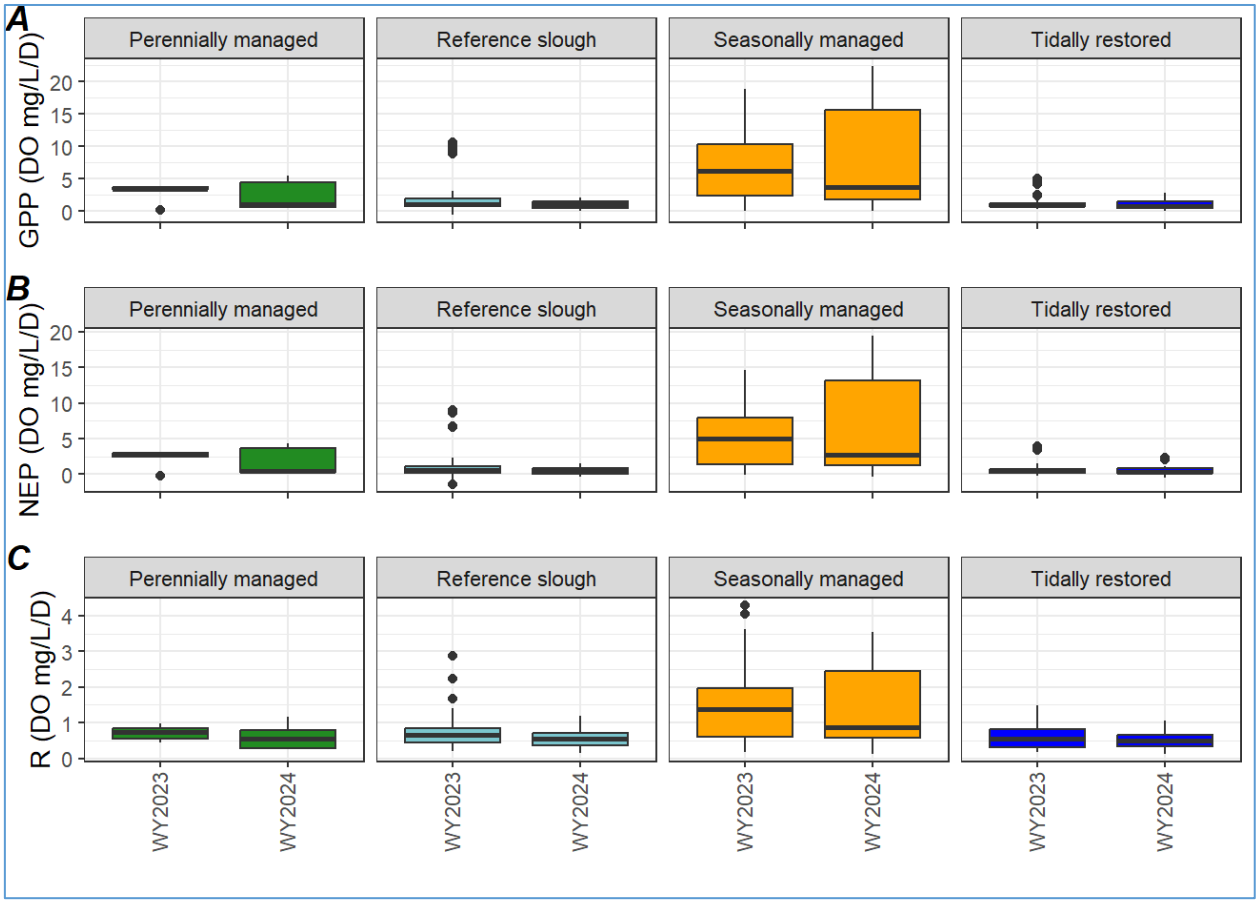


Figure 37. Box-and-whisker plots comparing rates of (a) gross primary production, (b) net ecosystem production, and (c) respiration across water years and treatments. Lines refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR.

RZA abundances were patchy and highly variable, although elevated densities were generally restricted to managed wetlands. Copepod abundances were higher in managed wetlands during the flooded months and on two occasions were high in reference sloughs (Figure 38). Cladocerans were restricted to only a few sites, but abundances were higher in managed wetlands during the winter and spring months and were sparse in all wetland treatments during the fall months (Figure 39). Both copepod and cladoceran abundances decreased in the perennially managed wetland after the first year of flooding (Figure 37); For copepods, this trend was mirrored in other treatments, while, for cladocerans, the trend was reversed in seasonally managed wetlands.

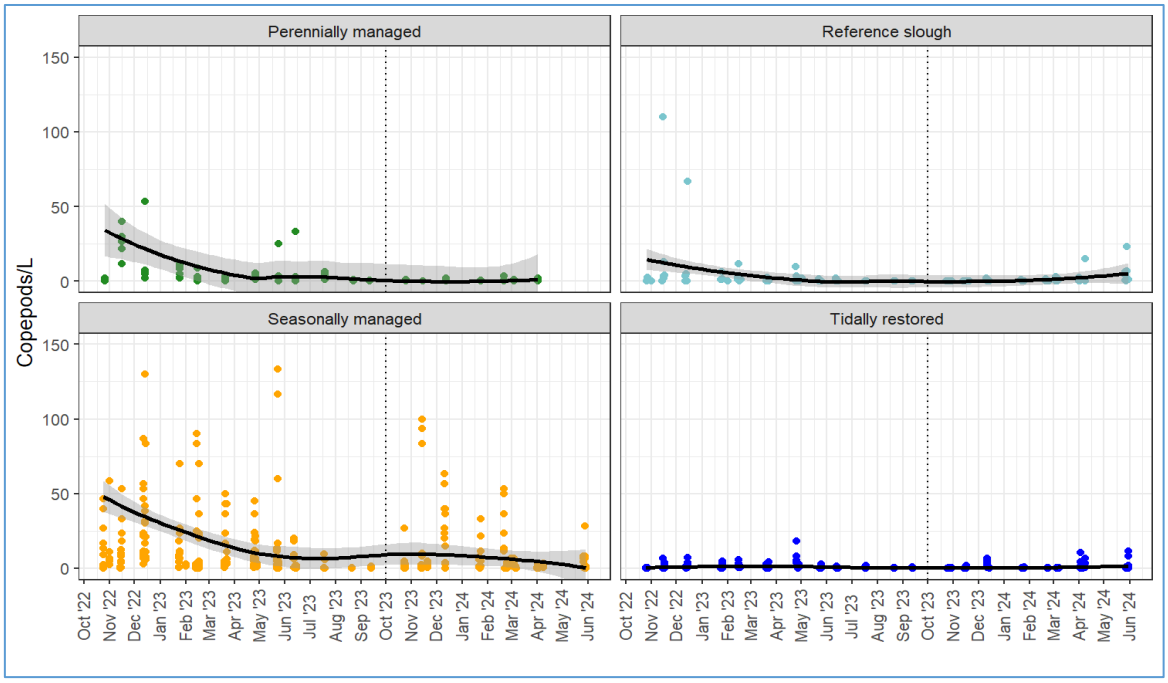


Figure 38. Point and LOESS regression plots of RZA copepod abundance trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 150 counts not shown (n = 1 in perennially managed, n=6 in seasonally managed) but are included in LOESS regression. Dotted vertical line delineates water years 2023 and 2024.

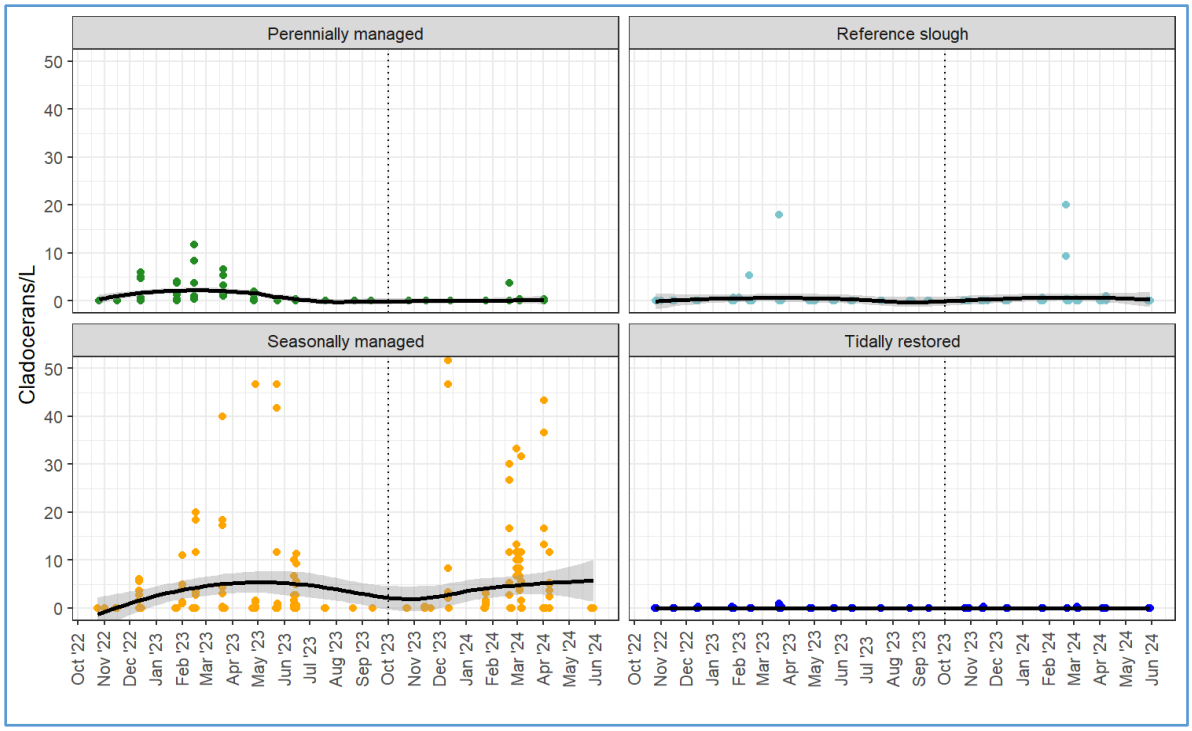


Figure 39. Point and LOESS regression plots of RZA cladoceran abundance trends in a perennially managed wetland, seasonally managed wetlands, tidally restored wetlands, and adjacent reference sloughs in Suisun Marsh. Observations above 50 counts not shown (n=8 in seasonally managed) but are included in LOESS regression. Dotted vertical line delineates water years 2023 and 2024.

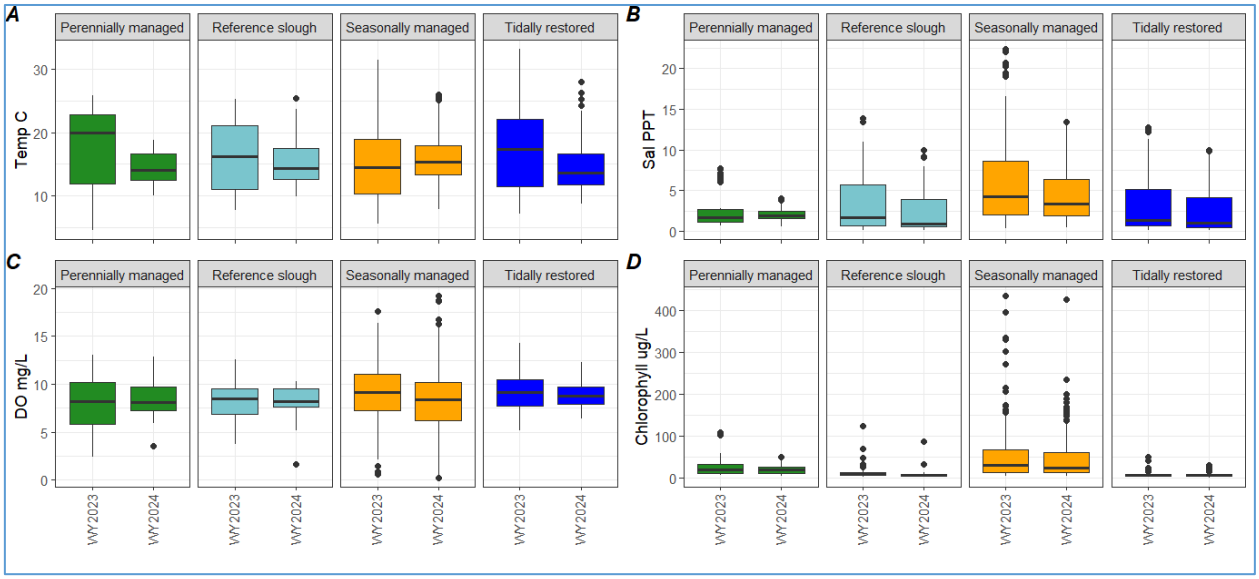


Figure 40. Box-and-whisker plots comparing (a) daytime dissolved oxygen, (b) chlorophyll-a concentrations, (c) copepod abundance, and (d) and cladoceran abundances across different treatment types and between water years. Plankton abundances are log-transformed. Lines refer to median observations. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR.

Among completed zooplankton net samples, zooplankton species composition was dominated by *Acanthocyclops* spp., *Eurytemora affinis*, and *Daphnia magna* (Figure 41, Figure 42). *Acanthocyclops* spp. were most abundant in several of the managed wetlands: Meins Landing, Potrero Pond, Miramonte Duck Club, and Denverton Duck Club (Figure 43). *Eurytemora affinis* were most abundant in Grizzly King, Denverton Duck Club, and Tule Red (a tidally restored site), while least abundant in Wings Landing and Montezuma Wetlands (Figure 43). *Daphnia magna* were most abundant in managed wetlands on the eastern end of Suisun Marsh: Potrero Pond, Meins Landing, and Denverton Duck Club (Figure 43). Denverton Duck Club (perennially managed) had decreased zooplankton abundances in the second year, while most seasonally managed wetlands had similar or higher abundances in the second year, except for Grizzly King.

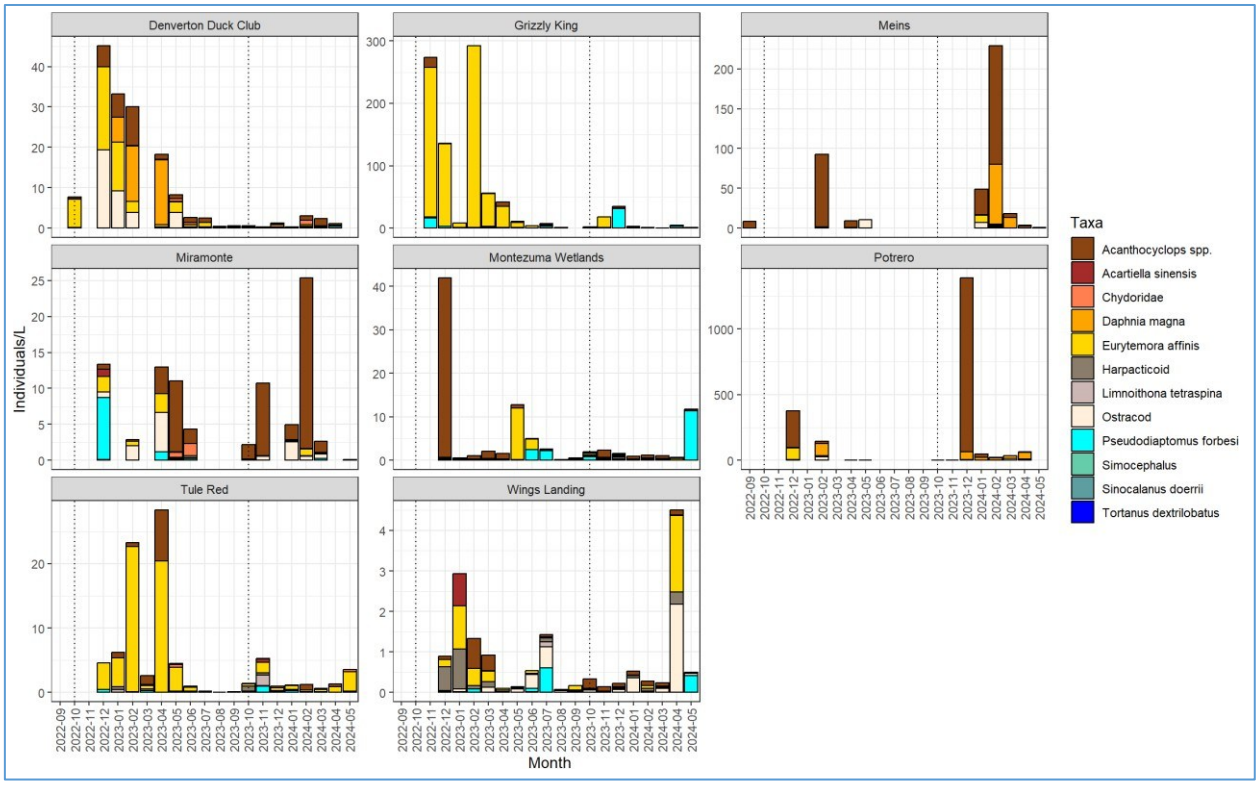


Figure 41. Stacked bar plots depicting density (size) and composition (color) of monthly zooplankton samples from different wetlands over the two-year study. Y-axis is scaled independently for each wetland (see Figure 8 for fixed-scale comparisons). Dotted vertical lines indicate the start of the water year. Note: data are incomplete as sample processing is still in progress at the time of writing.

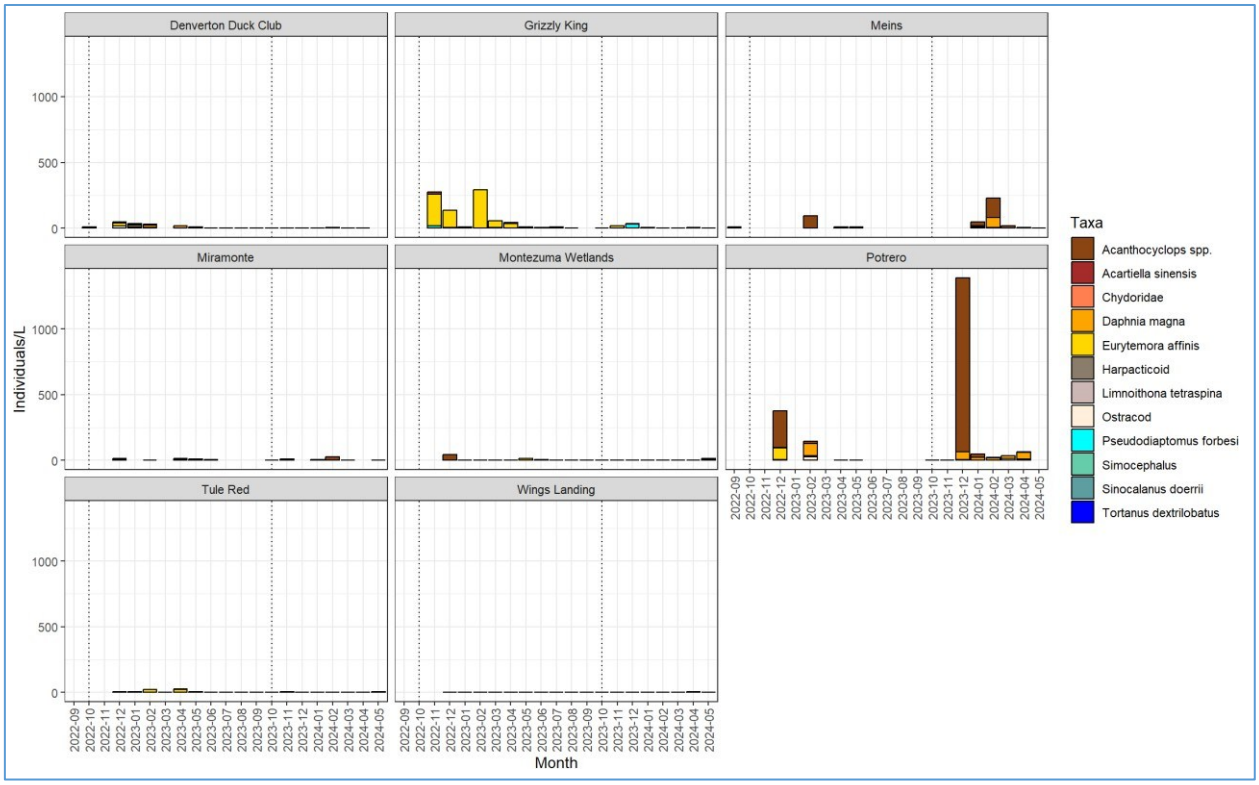


Figure 42. Fixed-scale stacked bar plots depicting density (size) and composition (color) of monthly zooplankton samples from different wetlands over the two-year study. Y-axis is fixed for comparison of total densities between wetlands (see Figure 7 for more detailed within-site trends). Dotted vertical lines indicate the start of the water year. Note: data are incomplete as sample processing is still in progress at the time of writing.

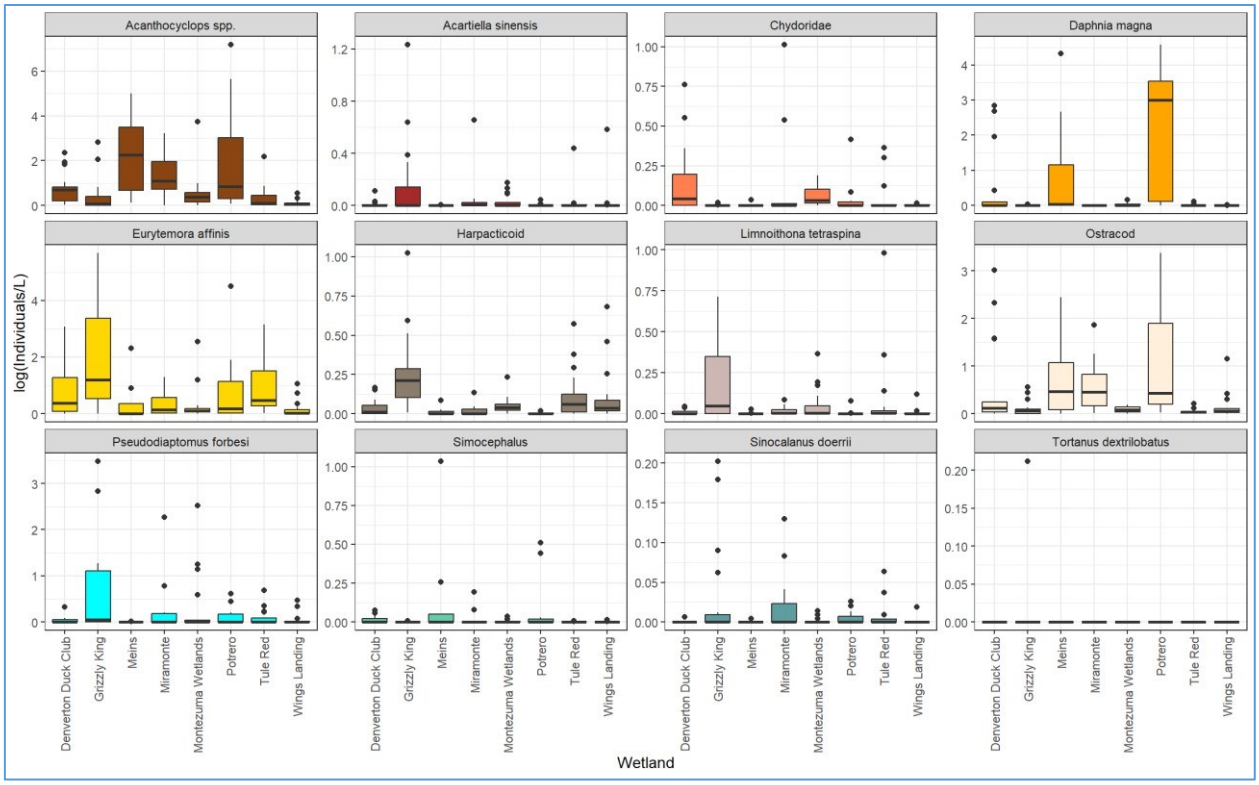


Figure 43. Box-and-whisker plots comparing zooplankton abundances in different wetlands for each taxon. Abundances are log-transformed with y-axes independently scaled for each taxon. Lines refer to median estimates across the two-year study period. Boxes refer to the interquartile range (IQR) while whiskers refer to 1.5 IQR. Points refer to outliers beyond 1.5 IQR. Note: data are incomplete as sample processing is still in progress at the time of writing.

Discussion

As data are still preliminary, some conclusions from this section could be subject to change as analyses develop.

Echoing previous studies, these results indicate that seasonally managed wetlands (when flooded) support higher plankton production than tidal channels and restorations, although they can present water quality trade-offs as well (Tung et al., 2021; Phillips et al., 2026). Seasonally managed wetlands promoted elevated salinities compared to other treatments, likely due to increased evaporation. Export of saline water from managed wetlands could cause localized impacts for fish in tidal habitats if they are already near key salinity thresholds. Although average DO was similar between treatments, low DO (<5 mg/L) was more frequently observed in seasonally managed

wetlands than others, likely due to increased decomposition driven by floods; this could also increase toxicity risks from exported water, especially in fall when decomposition is expected to be highest (Siegel et al, 2011). Negative exchange effects from managed wetlands could be exacerbated in low-volume sloughs due to decreased dilution rates. However, exported water could also have positive effects in sloughs when plankton in managed wetlands are abundant. Seasonally managed wetlands supported the highest phytoplankton concentrations among treatments, especially in fall and winter, when nutrients mobilized from floods and decomposing organic material are expected to be widely available (see Junk et al., 1989). Likewise, phytoplankton growth rates were higher in seasonally managed wetlands, but rates were highest in the summer despite lower concentrations, possibly due to increased water temperatures. Seasonally managed wetlands promoted higher zooplankton abundances, especially in winter, likely due to increased available food and increased water residence times (Phillips et al. 2026). Zooplankton abundances in managed wetlands were lowest in summer, possibly because of high recruitment of colonizing fish by this time (Platzer et al. in review).

While reference sloughs and tidally restored wetlands had lower salinities and fewer instances of low DO, these habitats supported comparatively low phytoplankton and zooplankton abundances. The lack of a flood pulse, coupled with higher tidal mixing, could limit phytoplankton growth, which, in turn, could limit zooplankton. There were occasional high abundances of phytoplankton and zooplankton observed in the reference sloughs, but these were often near managed-wetland outfalls in low-volume sloughs and could have been subsidized from the effluent. Tidally restored sites had no direct inputs from managed-wetland outfalls, so exchange effects were less likely to influence results. While plankton abundances were low overall in tidal restorations, there were a few occasions when they supported minor phytoplankton blooms that slightly increased zooplankton, especially in spring as temperatures began to warm.

Overall, these findings are consistent with the hypotheses, but unexpected trends were observed at the perennially managed wetland, Denverton Duck Club (DDC), and one of the seasonally managed wetlands, Miramonte Duck Club (MDC). It was predicted that DDC would respond to the initial fall flood pulse in the first year with high phytoplankton *and* zooplankton density that diminished thereafter, and that MDC would respond with high plankton densities for both years, but instead, both wetlands supported relatively few plankton after initial flooding. It is suspected that hydraulic connectivity to the slough channels at DDC and MDC wetlands were higher than other managed wetlands because these sites have more control structures that can move water at relatively high capacity; this could have resulted in low water-residence times that limited plankton accumulation (see Chappell et al. 2018). While this provides new insights into water management implications on plankton production, it also confounds

the examination on how perennial management affects plankton production in comparison to seasonal managed wetlands, when residence time is not a limiting factor. The effects of water management on plankton production may be highly variable depending on the site-specifics of a managed wetland (e.g., site elevation, hydrologic infrastructure, etc.). Still, when comparing DDC to tidal habitats, increased phytoplankton, primary production rates were found, and zooplankton abundances within DDC, suggesting that perennially managed wetlands offer moderate benefits to plankton production possibly due to increased residence times relative to open-tidal habitats. Because DDC also had fewer instances of low DO than most managed wetlands, perennial management could offer intermediate outcomes between seasonally managed wetlands and open-tidal habitats by slightly increasing plankton abundances while minimizing risks to water quality.

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Supplemental Tables

Table S1. Post-hoc contrasts for *Pseudodiaptomus forbesi* comparing biomass between years within each region.

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2017 - Year2018	River	0.752	0.241	2064.063	3.121	0.04763
Year2017 - Year2019	River	0.621	0.224	2064.017	2.772	0.12434
Year2017 - Year2020	River	1.258	0.223	2064.012	5.633	<0.00001
Year2017 - Year2021	River	1.240	0.222	2064.011	5.593	<0.00001
Year2017 - Year2022	River	2.000	0.223	2064.008	8.979	<0.00001
Year2017 - Year2023	River	-0.002	0.327	2064.133	-0.007	1.00000
Year2017 - Year2024	River	0.440	0.321	2064.194	1.373	0.90817
Year2017 - Year2025	River	1.173	0.298	2064.224	3.932	0.00281
Year2018 - Year2019	River	-0.131	0.205	2064.131	-0.641	0.99937
Year2018 - Year2020	River	0.506	0.205	2064.127	2.472	0.24604
Year2018 - Year2021	River	0.488	0.203	2064.166	2.404	0.28211
Year2018 - Year2022	River	1.248	0.204	2064.146	6.118	<0.00001
Year2018 - Year2023	River	-0.754	0.315	2064.149	-2.397	0.28613
Year2018 - Year2024	River	-0.312	0.308	2064.197	-1.015	0.98457
Year2018 - Year2025	River	0.420	0.284	2064.231	1.480	0.86518
Year2019 - Year2020	River	0.637	0.184	2064.034	3.463	0.01594
Year2019 - Year2021	River	0.619	0.182	2064.021	3.402	0.01957
Year2019 - Year2022	River	1.379	0.183	2064.015	7.526	<0.00001
Year2019 - Year2023	River	-0.623	0.302	2064.117	-2.064	0.49865
Year2019 - Year2024	River	-0.181	0.294	2064.204	-0.613	0.99954
Year2019 - Year2025	River	0.552	0.270	2064.242	2.045	0.51195
Year2020 - Year2021	River	-0.018	0.181	2064.016	-0.100	1.00000
Year2020 - Year2022	River	0.742	0.183	2064.029	4.064	0.00165
Year2020 - Year2023	River	-1.260	0.302	2064.151	-4.179	0.00102
Year2020 - Year2024	River	-0.818	0.294	2064.189	-2.782	0.12119
Year2020 - Year2025	River	-0.085	0.269	2064.225	-0.316	1.00000
Year2021 - Year2022	River	0.760	0.181	2064.005	4.210	0.00089
Year2021 - Year2023	River	-1.242	0.300	2064.168	-4.135	0.00123
Year2021 - Year2024	River	-0.800	0.293	2064.243	-2.730	0.13777
Year2021 - Year2025	River	-0.067	0.268	2064.289	-0.250	1.00000
Year2022 - Year2023	River	-2.002	0.301	2064.165	-6.648	<0.00001
Year2022 - Year2024	River	-1.560	0.294	2064.258	-5.310	<0.00001
Year2022 - Year2025	River	-0.827	0.269	2064.306	-3.073	0.05492
Year2023 - Year2024	River	0.442	0.378	2064.043	1.169	0.96290
Year2023 - Year2025	River	1.175	0.360	2064.048	3.266	0.03047
Year2024 - Year2025	River	0.733	0.353	2064.000	2.075	0.49067

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2017 - Year2018	Suisun Bay	1.963	0.242	2064.030	8.119	<0.00001
Year2017 - Year2019	Suisun Bay	0.326	0.228	2064.016	1.428	0.88731
Year2017 - Year2020	Suisun Bay	3.017	0.235	2064.021	12.845	<0.00001
Year2017 - Year2021	Suisun Bay	2.283	0.240	2064.035	9.501	<0.00001
Year2017 - Year2022	Suisun Bay	2.762	0.238	2064.076	11.627	<0.00001
Year2017 - Year2023	Suisun Bay	1.113	0.357	2064.093	3.122	0.04750
Year2017 - Year2024	Suisun Bay	1.549	0.323	2064.223	4.792	0.00006
Year2017 - Year2025	Suisun Bay	1.644	0.357	2064.128	4.608	0.00015
Year2018 - Year2019	Suisun Bay	-1.638	0.203	2064.091	-8.052	<0.00001
Year2018 - Year2020	Suisun Bay	1.053	0.211	2064.118	4.995	0.00002
Year2018 - Year2021	Suisun Bay	0.320	0.217	2064.148	1.473	0.86813
Year2018 - Year2022	Suisun Bay	0.799	0.214	2064.235	3.732	0.00607
Year2018 - Year2023	Suisun Bay	-0.850	0.341	2064.071	-2.492	0.23628
Year2018 - Year2024	Suisun Bay	-0.414	0.306	2064.236	-1.354	0.91447
Year2018 - Year2025	Suisun Bay	-0.319	0.341	2064.114	-0.936	0.99092
Year2019 - Year2020	Suisun Bay	2.691	0.195	2064.028	13.807	<0.00001
Year2019 - Year2021	Suisun Bay	1.957	0.201	2064.042	9.718	<0.00001
Year2019 - Year2022	Suisun Bay	2.436	0.198	2064.089	12.298	<0.00001
Year2019 - Year2023	Suisun Bay	0.788	0.332	2064.104	2.375	0.29832
Year2019 - Year2024	Suisun Bay	1.223	0.295	2064.263	4.140	0.00120
Year2019 - Year2025	Suisun Bay	1.318	0.332	2064.148	3.972	0.00239
Year2020 - Year2021	Suisun Bay	-0.734	0.209	2064.004	-3.514	0.01335
Year2020 - Year2022	Suisun Bay	-0.254	0.206	2064.029	-1.238	0.94810
Year2020 - Year2023	Suisun Bay	-1.903	0.336	2064.125	-5.659	<0.00001
Year2020 - Year2024	Suisun Bay	-1.468	0.300	2064.248	-4.884	0.00004
Year2020 - Year2025	Suisun Bay	-1.373	0.337	2064.163	-4.079	0.00155
Year2021 - Year2022	Suisun Bay	0.479	0.212	2064.011	2.264	0.36468
Year2021 - Year2023	Suisun Bay	-1.170	0.340	2064.140	-3.438	0.01736
Year2021 - Year2024	Suisun Bay	-0.734	0.305	2064.266	-2.408	0.27978
Year2021 - Year2025	Suisun Bay	-0.639	0.340	2064.185	-1.877	0.62989
Year2022 - Year2023	Suisun Bay	-1.649	0.338	2064.183	-4.873	0.00004
Year2022 - Year2024	Suisun Bay	-1.213	0.303	2064.321	-4.007	0.00207
Year2022 - Year2025	Suisun Bay	-1.118	0.339	2064.237	-3.302	0.02718
Year2023 - Year2024	Suisun Bay	0.435	0.402	2064.067	1.082	0.97678
Year2023 - Year2025	Suisun Bay	0.531	0.430	2064.031	1.234	0.94891
Year2024 - Year2025	Suisun Bay	0.095	0.402	2064.019	0.237	1.00000
Year2017 - Year2018	Suisun Marsh	1.793	0.323	2064.063	5.557	<0.00001
Year2017 - Year2019	Suisun Marsh	0.362	0.294	2064.047	1.231	0.94964
Year2017 - Year2020	Suisun Marsh	2.512	0.295	2064.039	8.530	<0.00001
Year2017 - Year2021	Suisun Marsh	2.647	0.295	2064.045	8.977	<0.00001
Year2017 - Year2022	Suisun Marsh	3.483	0.294	2064.044	11.866	<0.00001
Year2017 - Year2023	Suisun Marsh	-0.066	0.348	2064.194	-0.189	1.00000

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2017 - Year2024	Suisun Marsh	0.794	0.344	2064.272	2.305	0.33955
Year2017 - Year2025	Suisun Marsh	1.375	0.340	2064.093	4.040	0.00182
Year2018 - Year2019	Suisun Marsh	-1.432	0.245	2064.111	-5.837	<0.00001
Year2018 - Year2020	Suisun Marsh	0.719	0.246	2064.073	2.923	0.08384
Year2018 - Year2021	Suisun Marsh	0.854	0.246	2064.071	3.466	0.01579
Year2018 - Year2022	Suisun Marsh	1.689	0.245	2064.060	6.904	<0.00001
Year2018 - Year2023	Suisun Marsh	-1.859	0.307	2064.100	-6.049	<0.00001
Year2018 - Year2024	Suisun Marsh	-0.999	0.303	2064.162	-3.295	0.02777
Year2018 - Year2025	Suisun Marsh	-0.419	0.299	2064.044	-1.401	0.89756
Year2019 - Year2020	Suisun Marsh	2.151	0.206	2064.017	10.416	<0.00001
Year2019 - Year2021	Suisun Marsh	2.285	0.207	2064.010	11.044	<0.00001
Year2019 - Year2022	Suisun Marsh	3.121	0.205	2064.014	15.226	<0.00001
Year2019 - Year2023	Suisun Marsh	-0.428	0.277	2064.189	-1.543	0.83487
Year2019 - Year2024	Suisun Marsh	0.432	0.273	2064.272	1.585	0.81324
Year2019 - Year2025	Suisun Marsh	1.013	0.268	2064.064	3.786	0.00496
Year2020 - Year2021	Suisun Marsh	0.135	0.208	2064.005	0.649	0.99931
Year2020 - Year2022	Suisun Marsh	0.970	0.206	2064.019	4.711	0.00009
Year2020 - Year2023	Suisun Marsh	-2.578	0.278	2064.162	-9.281	<0.00001
Year2020 - Year2024	Suisun Marsh	-1.718	0.273	2064.222	-6.290	<0.00001
Year2020 - Year2025	Suisun Marsh	-1.138	0.268	2064.043	-4.242	0.00078
Year2021 - Year2022	Suisun Marsh	0.835	0.206	2064.009	4.046	0.00177
Year2021 - Year2023	Suisun Marsh	-2.713	0.278	2064.143	-9.756	<0.00001
Year2021 - Year2024	Suisun Marsh	-1.853	0.274	2064.217	-6.774	<0.00001
Year2021 - Year2025	Suisun Marsh	-1.273	0.269	2064.043	-4.738	0.00008
Year2022 - Year2023	Suisun Marsh	-3.548	0.277	2064.156	-12.826	<0.00001
Year2022 - Year2024	Suisun Marsh	-2.689	0.272	2064.242	-9.879	<0.00001
Year2022 - Year2025	Suisun Marsh	-2.108	0.267	2064.044	-7.893	<0.00001
Year2023 - Year2024	Suisun Marsh	0.860	0.329	2064.050	2.613	0.18159
Year2023 - Year2025	Suisun Marsh	1.440	0.325	2064.083	4.426	0.00035
Year2024 - Year2025	Suisun Marsh	0.581	0.321	2064.075	1.807	0.67770

Table S2. Post-hoc contrasts for *Limnoithona* comparing biomass between years within each region.

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2017 - Year2018	River	0.752	0.241	2064.063	3.121	0.047628
Year2017 - Year2019	River	0.621	0.224	2064.017	2.772	0.124335
Year2017 - Year2020	River	1.258	0.223	2064.012	5.633	<0.00001
Year2017 - Year2021	River	1.240	0.222	2064.011	5.593	<0.00001
Year2017 - Year2022	River	2.000	0.223	2064.008	8.979	<0.00001

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2017 - Year2023	River	-0.002	0.327	2064.133	-0.007	1.000000
Year2017 - Year2024	River	0.440	0.321	2064.194	1.373	0.908171
Year2017 - Year2025	River	1.173	0.298	2064.224	3.932	0.002805
Year2018 - Year2019	River	-0.131	0.205	2064.131	-0.641	0.999367
Year2018 - Year2020	River	0.506	0.205	2064.127	2.472	0.246045
Year2018 - Year2021	River	0.488	0.203	2064.166	2.404	0.282114
Year2018 - Year2022	River	1.248	0.204	2064.146	6.118	<0.00001
Year2018 - Year2023	River	-0.754	0.315	2064.149	-2.397	0.286126
Year2018 - Year2024	River	-0.312	0.308	2064.197	-1.015	0.984569
Year2018 - Year2025	River	0.420	0.284	2064.231	1.480	0.865177
Year2019 - Year2020	River	0.637	0.184	2064.034	3.463	0.015938
Year2019 - Year2021	River	0.619	0.182	2064.021	3.402	0.019568
Year2019 - Year2022	River	1.379	0.183	2064.015	7.526	<0.00001
Year2019 - Year2023	River	-0.623	0.302	2064.117	-2.064	0.498647
Year2019 - Year2024	River	-0.181	0.294	2064.204	-0.613	0.999542
Year2019 - Year2025	River	0.552	0.270	2064.242	2.045	0.511947
Year2020 - Year2021	River	-0.018	0.181	2064.016	-0.100	1.000000
Year2020 - Year2022	River	0.742	0.183	2064.029	4.064	0.001647
Year2020 - Year2023	River	-1.260	0.302	2064.151	-4.179	0.001018
Year2020 - Year2024	River	-0.818	0.294	2064.189	-2.782	0.121188
Year2020 - Year2025	River	-0.085	0.269	2064.225	-0.316	0.999997
Year2021 - Year2022	River	0.760	0.181	2064.005	4.210	0.000890
Year2021 - Year2023	River	-1.242	0.300	2064.168	-4.135	0.001225
Year2021 - Year2024	River	-0.800	0.293	2064.243	-2.730	0.137775
Year2021 - Year2025	River	-0.067	0.268	2064.289	-0.250	1.000000
Year2022 - Year2023	River	-2.002	0.301	2064.165	-6.648	<0.00001
Year2022 - Year2024	River	-1.560	0.294	2064.258	-5.310	<0.00001
Year2022 - Year2025	River	-0.827	0.269	2064.306	-3.073	0.054921
Year2023 - Year2024	River	0.442	0.378	2064.043	1.169	0.962895
Year2023 - Year2025	River	1.175	0.360	2064.048	3.266	0.030475
Year2024 - Year2025	River	0.733	0.353	2064	2.075	0.490672
Year2017 - Year2018	Suisun Bay	1.963	0.242	2064.03	8.119	<0.00001
Year2017 - Year2019	Suisun Bay	0.326	0.228	2064.016	1.428	0.887308
Year2017 - Year2020	Suisun Bay	3.017	0.235	2064.021	12.845	<0.00001
Year2017 - Year2021	Suisun Bay	2.283	0.240	2064.035	9.501	<0.00001
Year2017 - Year2022	Suisun Bay	2.762	0.238	2064.076	11.627	<0.00001
Year2017 - Year2023	Suisun Bay	1.113	0.357	2064.093	3.122	0.047503
Year2017 - Year2024	Suisun Bay	1.549	0.323	2064.223	4.792	0.000062
Year2017 - Year2025	Suisun Bay	1.644	0.357	2064.128	4.608	0.000150

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2018 - Year2019	Suisun Bay	-1.638	0.203	2064.091	-8.052	<0.00001
Year2018 - Year2020	Suisun Bay	1.053	0.211	2064.118	4.995	0.000023
Year2018 - Year2021	Suisun Bay	0.320	0.217	2064.148	1.473	0.868133
Year2018 - Year2022	Suisun Bay	0.799	0.214	2064.235	3.732	0.006072
Year2018 - Year2023	Suisun Bay	-0.850	0.341	2064.071	-2.492	0.236282
Year2018 - Year2024	Suisun Bay	-0.414	0.306	2064.236	-1.354	0.914467
Year2018 - Year2025	Suisun Bay	-0.319	0.341	2064.114	-0.936	0.990922
Year2019 - Year2020	Suisun Bay	2.691	0.195	2064.028	13.807	<0.00001
Year2019 - Year2021	Suisun Bay	1.957	0.201	2064.042	9.718	<0.00001
Year2019 - Year2022	Suisun Bay	2.436	0.198	2064.089	12.298	<0.00001
Year2019 - Year2023	Suisun Bay	0.788	0.332	2064.104	2.375	0.298320
Year2019 - Year2024	Suisun Bay	1.223	0.295	2064.263	4.140	0.001198
Year2019 - Year2025	Suisun Bay	1.318	0.332	2064.148	3.972	0.002391
Year2020 - Year2021	Suisun Bay	-0.734	0.209	2064.004	-3.514	0.013349
Year2020 - Year2022	Suisun Bay	-0.254	0.206	2064.029	-1.238	0.948099
Year2020 - Year2023	Suisun Bay	-1.903	0.336	2064.125	-5.659	<0.00001
Year2020 - Year2024	Suisun Bay	-1.468	0.300	2064.248	-4.884	0.000039
Year2020 - Year2025	Suisun Bay	-1.373	0.337	2064.163	-4.079	0.001548
Year2021 - Year2022	Suisun Bay	0.479	0.212	2064.011	2.264	0.364680
Year2021 - Year2023	Suisun Bay	-1.170	0.340	2064.14	-3.438	0.017356
Year2021 - Year2024	Suisun Bay	-0.734	0.305	2064.266	-2.408	0.279781
Year2021 - Year2025	Suisun Bay	-0.639	0.340	2064.185	-1.877	0.629891
Year2022 - Year2023	Suisun Bay	-1.649	0.338	2064.183	-4.873	0.000042
Year2022 - Year2024	Suisun Bay	-1.213	0.303	2064.321	-4.007	0.002073
Year2022 - Year2025	Suisun Bay	-1.118	0.339	2064.237	-3.302	0.027178
Year2023 - Year2024	Suisun Bay	0.435	0.402	2064.067	1.082	0.976782
Year2023 - Year2025	Suisun Bay	0.531	0.430	2064.031	1.234	0.948910
Year2024 - Year2025	Suisun Bay	0.095	0.402	2064.019	0.237	1.000000
Year2017 - Year2018	Suisun Marsh	1.793	0.323	2064.063	5.557	<0.00001
Year2017 - Year2019	Suisun Marsh	0.362	0.294	2064.047	1.231	0.949639
Year2017 - Year2020	Suisun Marsh	2.512	0.295	2064.039	8.530	<0.00001
Year2017 - Year2021	Suisun Marsh	2.647	0.295	2064.045	8.977	<0.00001
Year2017 - Year2022	Suisun Marsh	3.483	0.294	2064.044	11.866	<0.00001
Year2017 - Year2023	Suisun Marsh	-0.066	0.348	2064.194	-0.189	1.000000
Year2017 - Year2024	Suisun Marsh	0.794	0.344	2064.272	2.305	0.339552
Year2017 - Year2025	Suisun Marsh	1.375	0.340	2064.093	4.040	0.001816
Year2018 - Year2019	Suisun Marsh	-1.432	0.245	2064.111	-5.837	0.000000
Year2018 - Year2020	Suisun Marsh	0.719	0.246	2064.073	2.923	0.083844

Contrast	Region	Estimate	SE	df	t.ratio	p.value
Year2018 - Year2021	Suisun Marsh	0.854	0.246	2064.071	3.466	0.015789
Year2018 - Year2022	Suisun Marsh	1.689	0.245	2064.06	6.904	<0.00001
Year2018 - Year2023	Suisun Marsh	-1.859	0.307	2064.1	-6.049	<0.00001
Year2018 - Year2024	Suisun Marsh	-0.999	0.303	2064.162	-3.295	0.027765
Year2018 - Year2025	Suisun Marsh	-0.419	0.299	2064.044	-1.401	0.897557
Year2019 - Year2020	Suisun Marsh	2.151	0.206	2064.017	10.416	<0.00001
Year2019 - Year2021	Suisun Marsh	2.285	0.207	2064.01	11.044	<0.00001
Year2019 - Year2022	Suisun Marsh	3.121	0.205	2064.014	15.226	<0.00001
Year2019 - Year2023	Suisun Marsh	-0.428	0.277	2064.189	-1.543	0.834873
Year2019 - Year2024	Suisun Marsh	0.432	0.273	2064.272	1.585	0.813238
Year2019 - Year2025	Suisun Marsh	1.013	0.268	2064.064	3.786	0.004956
Year2020 - Year2021	Suisun Marsh	0.135	0.208	2064.005	0.649	0.999307
Year2020 - Year2022	Suisun Marsh	0.970	0.206	2064.019	4.711	0.000092
Year2020 - Year2023	Suisun Marsh	-2.578	0.278	2064.162	-9.281	<0.00001
Year2020 - Year2024	Suisun Marsh	-1.718	0.273	2064.222	-6.290	<0.00001
Year2020 - Year2025	Suisun Marsh	-1.138	0.268	2064.043	-4.242	0.000776
Year2021 - Year2022	Suisun Marsh	0.835	0.206	2064.009	4.046	0.001770
Year2021 - Year2023	Suisun Marsh	-2.713	0.278	2064.143	-9.756	<0.00001
Year2021 - Year2024	Suisun Marsh	-1.853	0.274	2064.217	-6.774	<0.00001
Year2021 - Year2025	Suisun Marsh	-1.273	0.269	2064.043	-4.738	0.000080
Year2022 - Year2023	Suisun Marsh	-3.548	0.277	2064.156	-12.826	<0.00001
Year2022 - Year2024	Suisun Marsh	-2.689	0.272	2064.242	-9.879	<0.00001
Year2022 - Year2025	Suisun Marsh	-2.108	0.267	2064.044	-7.893	<0.00001
Year2023 - Year2024	Suisun Marsh	0.860	0.329	2064.05	2.613	0.181593
Year2023 - Year2025	Suisun Marsh	1.440	0.325	2064.083	4.426	0.000345
Year2024 - Year2025	Suisun Marsh	0.581	0.321	2064.075	1.807	0.677702

Attachments

Attachment A: Summer Fall Habitat Action Monitoring and Science Plan
(Separate Document)

Attachment B: 2024 Summer Fall Habitat Action Plan (Separate Document)

Attachment C: Memo: Decommissioning Real-Time Water Quality Monitoring Stations GZM and GZB (Separate Document)