Workplan for Monitoring and Assessment of Summer-Fall Suisun Marsh Salinity Control Gates Action, 2023

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Abbreviations

20mm	20-mm survey
BiOp	Biological Opinion
CDFW	California Department of Fish and Wildlife
CSTARS	UCD Center for Spatial Technologies and Remote Sensing
DWR	California Department of Water Resources
DCG	Delta Coordination Group
Delta	Sacramento-San Joaquin Delta
DSRS	Delta Smelt Resilience Strategy
DSM2	Delta Simulation Model 2
DOP	Directed Outflow Project
EDSM	Enhanced Delta Smelt Monitoring
EC	Electrical conductivity
EMP	DWR Environmental Monitoring Program
FLaSH	Fall low salinity habitat
FLoAT PWT	Flow Alteration Project Work Team
FMWT	Fall Midwater Trawl
IEP	Interagency Ecological Program
ITP	Incidental Take Permit
LSZ	Low salinity zone

MAST	Management, Analysis, and Synthesis Team
POD	Pelagic organism decline
PSU	Practical Salinity Unit
QAQC	Quality Assurance/Quality Control
SFE	San Francisco Estuary
STN	Summer townet survey
Suisun Bay	Suisun Bay and associated embayments
SMSCG	Suisun Marsh Salinity Control Gates
USFWS	U.S. Fish and Wildlife Service
UCD	University of California at Davis
Reclamation	U.S. Bureau of Reclamation
X2	The location of the near-bottom 2 PSU salinity isohaline measured in kilometers from the Golden Gate, following the River channel

Updates for 2023:

This workplan is very similar to the 2022 workplan, except that we will adjust our hypotheses to remove comparisons between the West Marsh and East Marsh. This data will also be used to evaluate effectiveness of the 100 TAF block of water, if used for additional SMSCG actions in 2023.

We will continue to leverage IEP's long-term monitoring surveys for water quality, phytoplankton, zooplankton, and fish. We will continue to collect water quality, phytoplankton, and zooplankton data at the same supplementary sites as in 2022. In 2021 and 2022, DWR funded a hyperspectral remote sensing survey of aquatic vegetation over the Delta and Suisun Marsh to establish no-action baseline data and will continue this monitoring in 2023.

Project Description

Study Concept/Abstract

The Suisun Marsh Salinity Control Gates (SMSCG) have the potential to provide an increase in low-salinity-zone habitat for endangered Delta Smelt (California Endangered Species Act listed as Endangered, Federal Endangered Species Act listed as Threatened), and to allow them to more frequently occupy Suisun Marsh, especially Montezuma Slough, one of their most important rearing habitats. Operation of the SMSCG in summer and fall to improve Delta Smelt habitat is called for in the Biological Opinion and Incidental Take Permit for the Central Valley Project and State Water Project. To support the adaptive management of the action, DWR is planning to monitor the change in water quality, phytoplankton, zooplankton, fishes, and aquatic vegetation resulting from the action. The monitoring plan will use data collected by the Interagency Ecological Program's (IEP) long-term monitoring programs when possible, supplemented with targeted sample collection where existing surveys lack spatial or temporal coverage. We will also be modeling the change in Delta Smelt habitat based on area of open water with appropriate temperature, salinity, and turbidity. Because wild Delta Smelt may not be captured in high enough numbers to test hypotheses on health or condition, we will use experimental enclosures of cultured Delta Smelt to test differences in smelt growth rate, health, and condition between regions of the estuary during years with the SMSCG action. We will use these data to make several comparisons: we will compare conditions in Suisun Marsh to conditions in Grizzly Bay and the Confluence, we will compare conditions during the action to conditions before and after the action, and we will compare conditions during the action to similar historical conditions. Monitoring during no-action years will be used as a baseline for comparison during action years. Results from this study will be used to adaptively manage the action in future years through discussions by the Delta Coordination Group.

Introduction

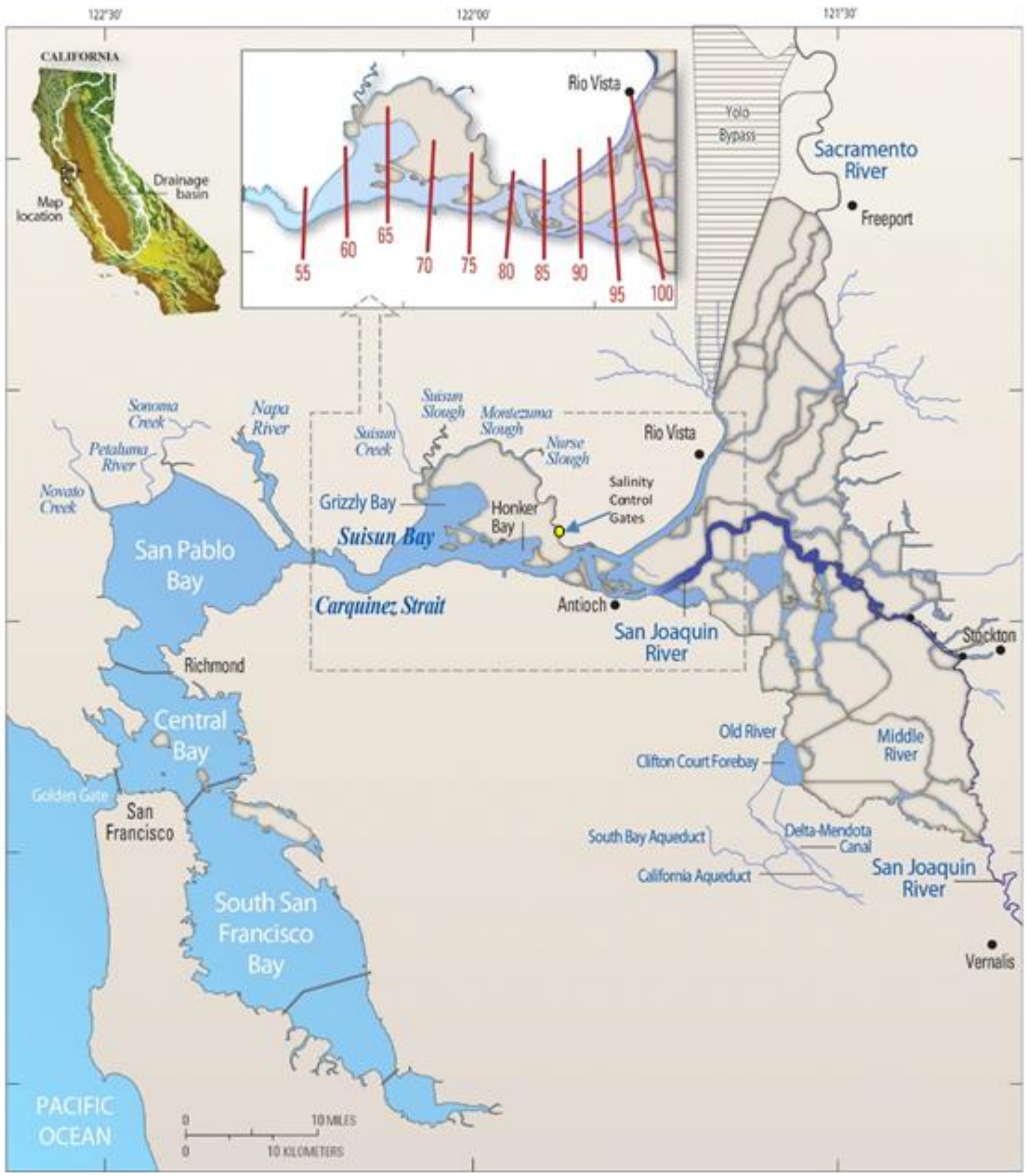
The following workplan describes the monitoring and evaluation of the operation of the Suisun Marsh Salinity Control Gates (SMSCG) in drier months (summer and fall) to improve salinity and habitat conditions for Delta Smelt as required by the Biological Opinion and Incidental Take permit for the Central Valley Project and State Water Project.

The concept of using the SMSCG to increase Delta Smelt habitat area began with the 2016 Delta Smelt Resiliency Strategy (DSRS) (California Natural Resources Agency 2016). The DSRS is a science-based approach to voluntarily address both immediate and near-term needs of Delta Smelt and promote their resiliency to future variations in habitat conditions. The Strategy included pilot operation of the SMSCG in summer to improve salinity and habitat conditions for Delta Smelt. The primary purpose of the action was to reduce salinities in Suisun Marsh, allowing Delta Smelt to access this important rearing area more frequently. Under the DSRS, a pilot action was successfully tested in 2018, when the SMSCG were operated in August and early September. Some of the initial results from that effort are described below. The following represents an update to our previous workplans (Sommer et al. 2018, 2019, Hartman et al. 2020), providing details of the proposed science activities for 2023.

Because of the success of the 2018 pilot action, a summer SMSGC action was included in the 2019 USFWS Biological Opinion for the long-term operations of the Central Valley Project and State Water Project (United States Fish and Wildlife Service (USFWS) 2019). Specifically, under the "Summer-Fall Habitat" Project component, the project description includes: *Suisun Marsh Salinity Control Gate (SMSCG) operations for up to 60 days (not necessarily consecutive) from June 1 through October 31 of Below Normal and Above Normal years. This action may also be implemented in Wet years if preliminary analysis shows expected benefits* (BiOp Table 2-1). This action is also included in the 2020 CDFW Incidental Take Permit (California Department of Fish and Wildlife (CDFW) 2020), where summer gate operations are required in Above Normal years, Below Normal years, and Dry years that follow Below Normal, Above Normal or Wet years (ITP Table 9A).

Along with the SMSCG actions, the summer-fall habitat action includes a 100 TAF block of water in Above Normal and Wet years for CDFW to deploy as they see fit to enhance summer-fall habitat or bank for the following year to facilitate a SMSCG action in a Dry water year.

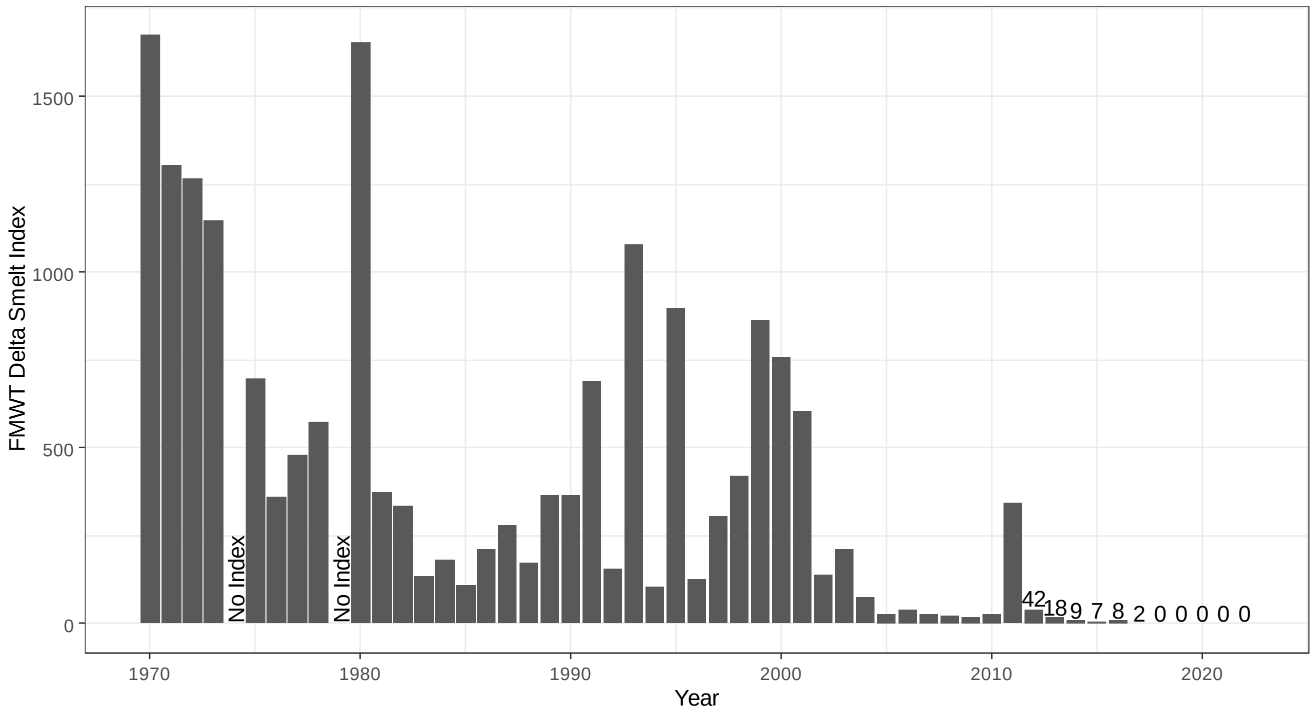
Figure 1 San Francisco Bay Estuary. Also shown are locations corresponding to different values of X2, which is the horizontal distance in kilometers from the Golden Gate up the axis of the estuary to where tidally averaged near-bottom salinity is 2 PSU (adapted from Jassby and others, 1995).



Delta Smelt

The Delta Smelt was listed as threatened under both the federal and state Endangered Species Acts in 1993 (California Department of Fish and Game et al. 1993, United States Fish and Wildlife Service 1993). Reclassification from threatened to endangered was determined to be warranted but precluded by other higher priority listing actions in 2010 (United States Fish and Wildlife Service 2010). The species status was changed from threatened to endangered under the State statute in 2009 (California Fish and Game Commission 2009). Subsequent declines in the Delta Smelt in concert with three other pelagic fishes (Figure 2) caused increased concern for avoiding jeopardy and achieving recovery of Delta Smelt. These declines are often referred to as the Pelagic Organism Decline (POD) (Sommer et al. 2007, Baxter et al. 2010).

Figure 2 Trends in abundance indices for Delta Smelt from 1967 to 2022 based on the Fall Midwater Trawl, a California Department of Fish and Game survey that samples the upper San Francisco Estuary. No index was calculated in 1974 or 1979.



Delta Smelt is a small (60–70 mm standard length) osmerid fish endemic to the upper SFE (Moyle 1992, Bennett 2005). Delta Smelt feed primarily on planktonic copepods, mysids, amphipods, and cladocerans (Slater and Baxter 2014). Many Delta Smelt complete the majority of their life cycle in the Low Salinity Zone (LSZ) of the upper estuary, where salinity is between 0.5 and 6 PSU, and then use the freshwater portions of the upper estuary primarily for spawning and rearing of larval and early post-larval fish (Figure 3) (Dege and Brown 2004, Bennett 2005). Juvenile and sub-adult Delta Smelt occur mostly in the LSZ, with a center of distribution around salinity 1-2 PSU (Swanson et al. 2000, Bennett 2005, Sommer et al. 2011), though appropriate turbidities and temperatures are also necessary (Nobriga et al. 2008).

Figure 3 Simple conceptual diagram of the Delta Smelt annual life cycle for the dominant Low Salinity Zone rearing and the upper Delta spawning life history (modified from Bennett, 2005).

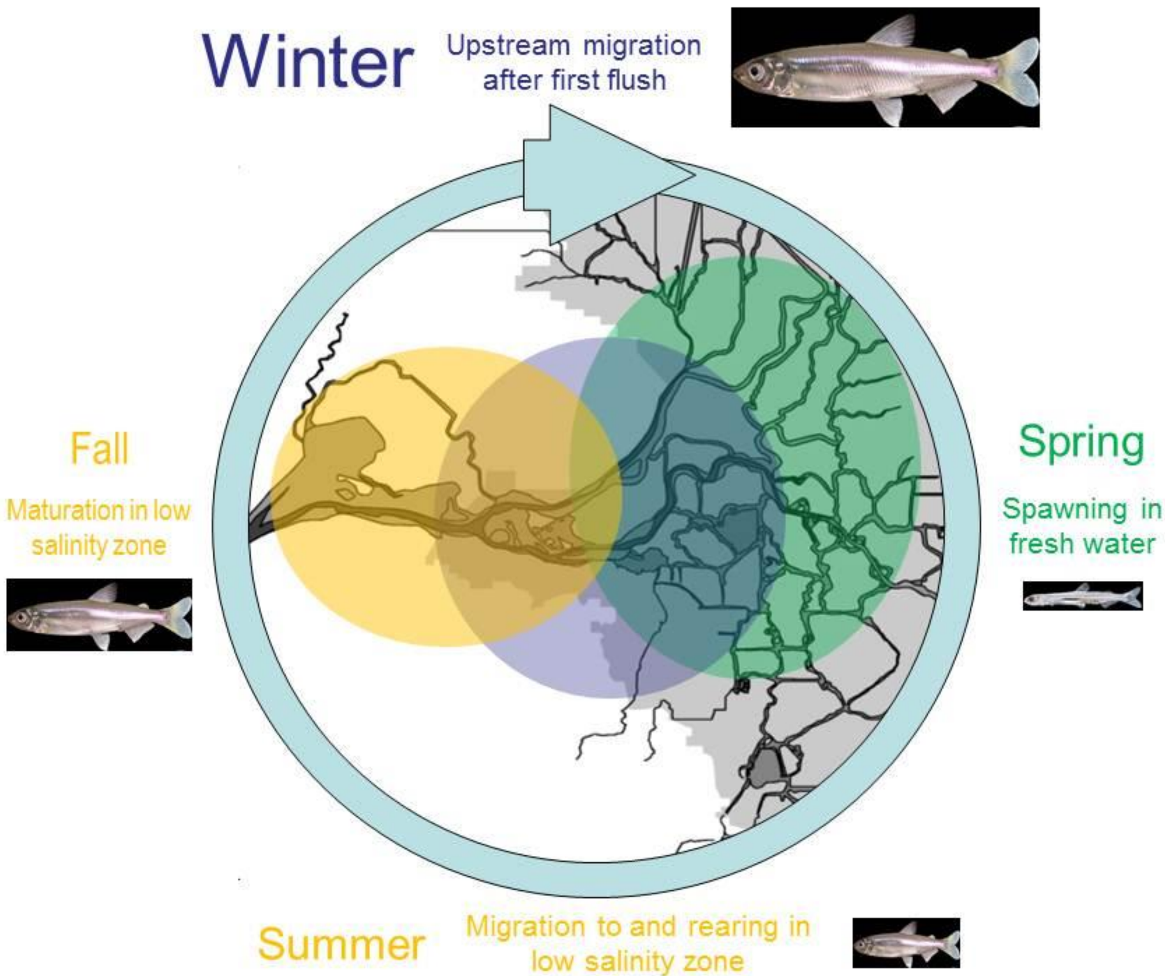
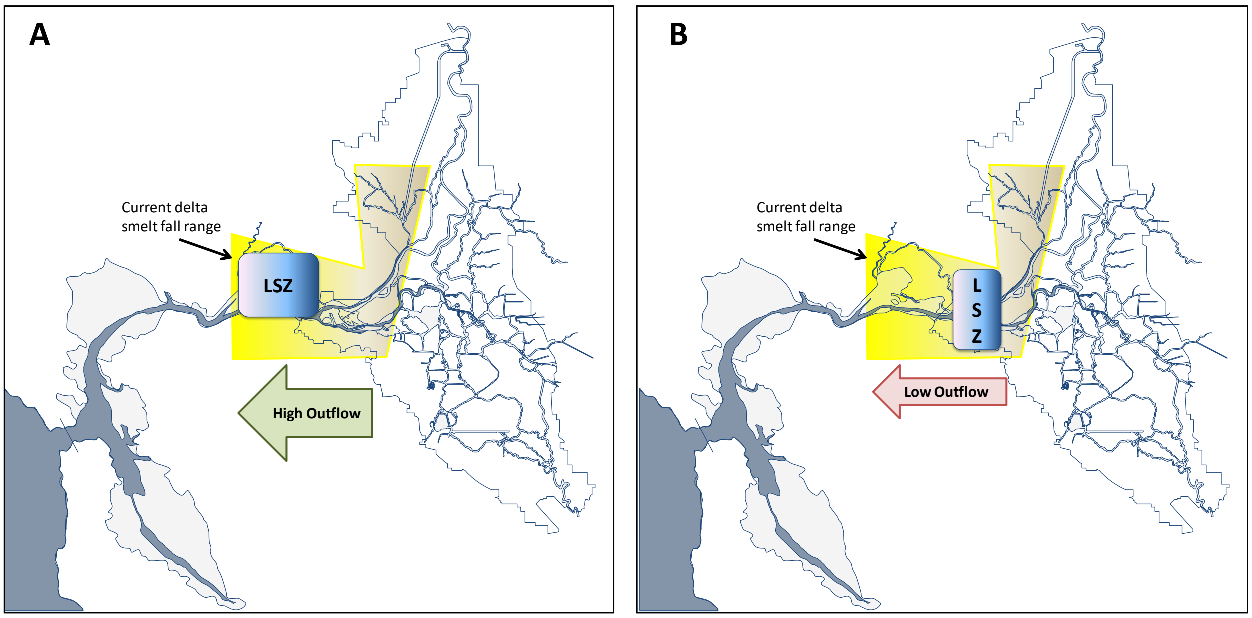


Figure 4 In the fall, Delta Smelt are currently found in a small geographic range (Shaded area) that includes the Suisun Bay, the River confluence, and the northern Delta, but most are found in or near the low salinity zone (LSZ). A: The LSZ overlaps the Suisun Bay under high outflow conditions. B: The LSZ overlaps the River confluence under low outflow conditions (from Reclamation, 2012).



Although abundance of Delta Smelt has been highly variable, there is a demonstrable long-term decline in abundance (Figure 2; (Sommer et al. 2007, Hobbs et al. 2017)). The decline of Delta Smelt has been intensively studied as part of an IEP effort to understand the POD (Sommer et al. 2007, Baxter et al. 2010). The POD investigators have concluded that the decline has likely been caused by the interactive effects of several causes, including both changes in physical habitat (e.g., salinity and turbidity fields) and the biotic habitat (i.e., food web)(Mac Nally et al. 2010, Thomson et al. 2010, IEP-MAST et al. 2015). Since the POD, Delta Smelt have been found in Montezuma Slough during most years by either the Fall Midwater Trawl or Enhanced Delta Smelt Monitoring Program (CDFW data, *ftp://ftp.wildlife.ca.gov/TownetFallMidwaterTrawl/* , USFWS data, *https://www.fws.gov/project/enhanced-delta-smelt-monitoring-program*), where they have had high foraging success (Hammock et al. 2017), indicating that both physical and biotic habitat in this region may be particularly suitable.

Conceptual Model

The IEP established a Management, Analysis and Synthesis Team (MAST) to develop a conceptual model for Delta Smelt Biology (IEP-MAST et al. 2015). In this workplan, we use the original framework of the Fall Low-Salinity Zone Habitat conceptual model (Brown et al. 2014), which includes stationary abiotic habitat components, dynamic abiotic habitat components, dynamic biotic habitat components, and Delta Smelt responses (i.e., recruitment; Figure 5). We use the IEP-MAST conceptual model (IEP-MAST et al. 2015) and subsequent literature (e.g. Moyle et al. 2016) to identify habitat components that likely are important to Delta Smelt in the summer and fall and to identify likely Delta Smelt biological responses. For a detailed description of the Delta Smelt MAST conceptual model, readers should refer to the original report (IEP-MAST et al. 2015). We put our conceptual model in the context of the fixed geography of the Suisun region because the SMSCG project is expected to affect only the Marsh and nearby areas. The idea that specific locations may be preferred by Delta Smelt has also received recent support in the literature (Merz et al. 2011, Bever et al. 2016, Hammock et al. 2017). Because the actions being considered in the workplan are very geographically specific, a more specific geographic conceptual model was developed for the SMSCG action than was used for the DS-MAST conceptual model (Figure 6). This new conceptual model was developed by the IEP Flow Alteration Project Work Team (FLoAT PWT). The FLoAT geographic conceptual model (Figure 6) focuses on the specific routes for additional flow being considered under the SMSCG and North Delta food web actions, and other potential flow augmentation actions.

Figure 5 Illustration showing estuarine habitat conceptual model (modified from Peterson 2003).

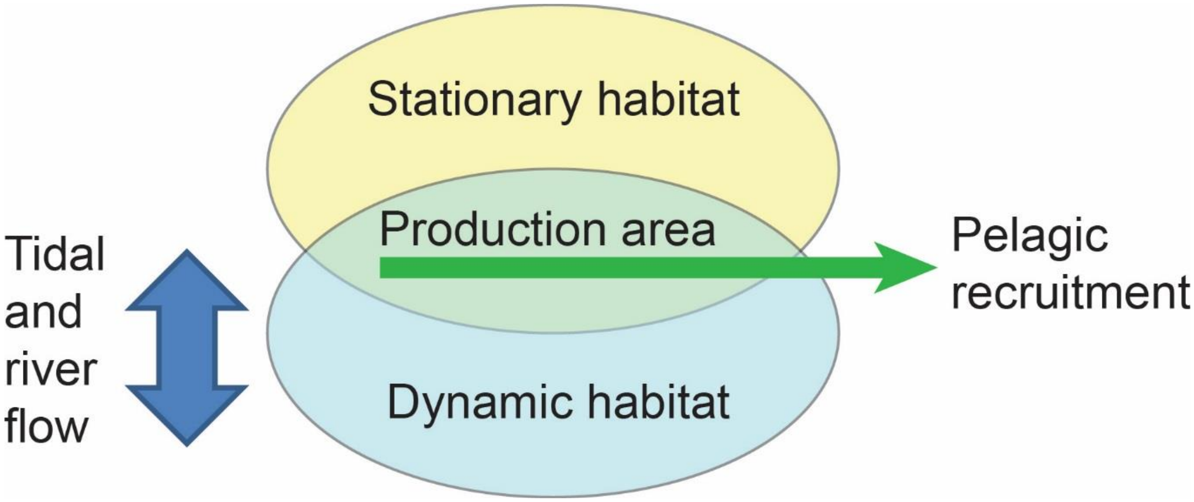
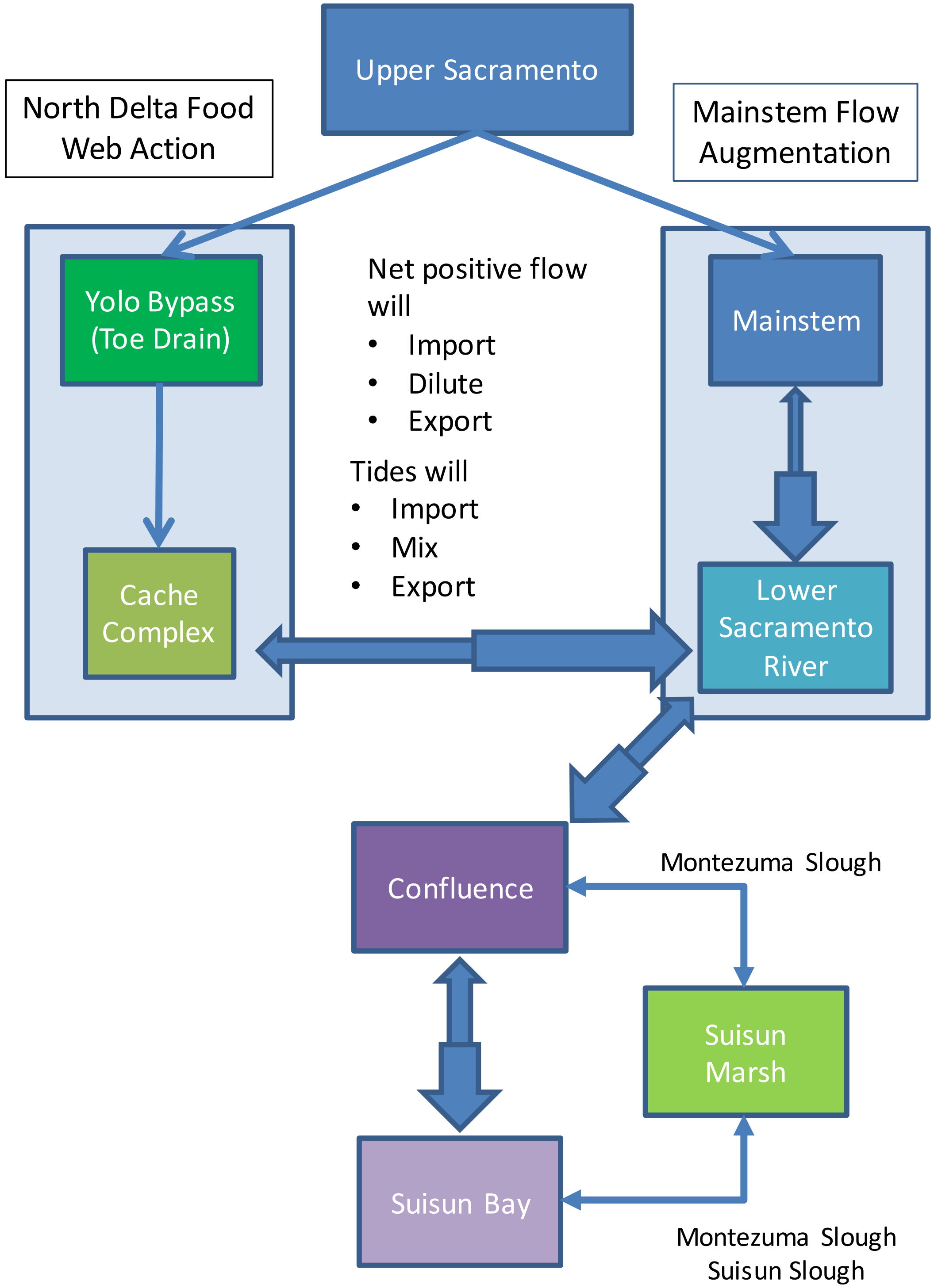


Figure 6 Box model for the geographic area of interest, and key upstream reaches developed by the IEP FLoAT Project Work Team.



The water flow in Suisun Marsh exhibits several patterns affected by tidal action, net river flow, local stream flow, and marsh inundation. At the eastern end of the Marsh water can enter through the eastern end of Montezuma Slough which connects to the confluence region (Figure 1), or from the west through Suisun Slough or the western end of Montezuma Slough at Grizzly Bay (Figure 1). Daily tidal cycles cause water in Montezuma Slough to travel a significant fraction of the slough length. When river discharge is high, net flow is westward through Montezuma Slough. During low river flow, tidal asymmetry between Suisun Bay and Montezuma Slough tends to create a small net eastward flow in Montezuma Slough, drawing in relatively saline water from the west (Fischer et al. 2013). As described in the Environmental Impact Report (EIR) for joint operations of the State Water Project and Central Valley Project, the SMSCG are currently operated in fall to freshen Marsh channels by opening gates during ebb tides and closing gates during flood tides.

The spatial extent of the action, particularly the impact of salinity on Grizzly Bay, is poorly understood. Several previous models disagree on whether the Gates' effect will extend into Grizzly Bay, so the northern edge of the Bay will be of particular interest for water quality monitoring.

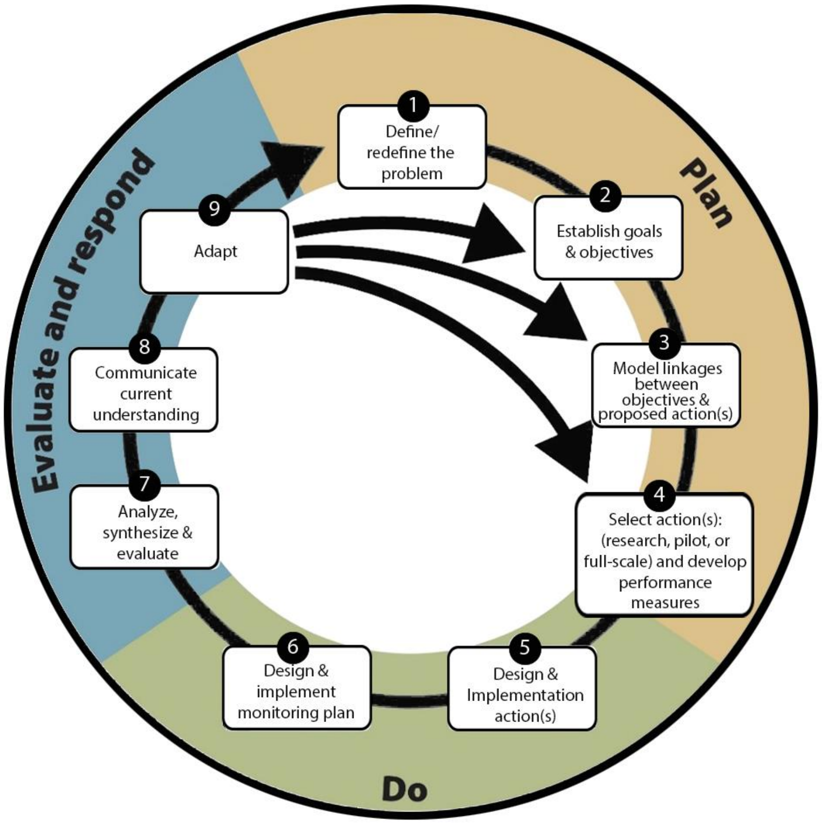
Adaptive Management Approach

The SMSG action, and the broader Summer-Fall Habitat Action, relies on an adaptive management approach to decide on the timing and extent of flow actions. DWR, US Bureau of Reclamation (Reclamation), CDFW, USFWS, and the state and federal water contractors have formed a Delta Coordination Group (DCG) to provide guidance on the SMSCG action and the rest of the Summer-Fall Habitat action. Monitoring in Suisun, as a part of the overall Delta Smelt Summer-Fall Habitat Action, will occur for at least the next ten years as required by the ITP, but the SMSCG action will only occur in a subset of these years, based on hydrodynamic conditions. The adaptive management planning and activities will be led by DWR and guided by management input from the Delta Coordination Group, IEP Science Management Team, and IEP's FLoAT PWT.

Each year, DWR will work with the Delta Coordination Group and Reclamation to produce a Summer-Fall Habitat Action Plan (action years only) and a science and monitoring plan (this document) to achieve desired habitat criteria and additional actions, as available, including monitoring, science, and food enhancement actions to enhance Delta Smelt habitat. The plan shall be developed based on a transparent structured decision-making process informed by previous monitoring as well as hydrologic, operational, and temperature forecasts using the best available modeling. Operations will maximize the number of days that Belden's Landing three-day average salinity is equal to, or less than, 4 PSU in all but dry years following below normal years. In a dry year following a below normal year, the Summer-Fall Action Plan shall be developed to maximize the number of days that Belden's Landing three-day average salinity is equal to, or less than, 6 PSU (as required by the ITP)(California Department of Fish and Wildlife (CDFW) 2020). As of March 1, 2023, the water year is forecasted to be "Above Normal" meaning an action will occur, or a small chance of being "Wet" (no action). In either of these water year types CDFW has proposed using the 100 TAF block of water for additional SMSCG actions on top of the regulatory requirement (See Summer Fall Habitat Action Plan). The final decision will be made based on the May 1st 50% exceedance forecast, 2023.

All adaptive management strategies share a cyclical design including: 1) problem assessment, including development of conceptual and quantitative models; 2) design and implementation of actions; 3) monitoring of outcomes; 4) evaluation of action outcomes; and 5) adjustment of the problem assessment and models in response to learning from the previous actions (Figure 7). This process might result in the modification of previous actions or consideration of new actions to address the identified problems. The SMSCG action incorporate a similar adaptive management approach, using many of the same institutions and metrics. Below, we outline our hypotheses, which we will be testing on an annual basis using the monitoring outlined in this workplan. We will adapt our monitoring based on previous years' results until all of our hypotheses have been addressed. We will also use the results of the monitoring to assess the effectiveness of the action itself, and adjust the timing and implementation of the action over the course of the ten-year incidental take permit. A full review of the Summer-Fall Habitat Action will occur after four years to gauge overall effectiveness.

Figure 7 The adaptive management cycle, as described by the Delta Science Program.



Hypotheses/Predictions

The general hypothesis is that reducing salinity in Suisun Marsh is beneficial for the Delta Smelt population due to increased distribution, increased foraging opportunities, and increased habitat complexity. Although our predictions are intended to help evaluate the performance of management actions, they should not be considered as absolute metrics of success. For example, we fully expect that some of the predictions will not be confirmed, and that there will be some surprising results. Indeed, examination of predictions that were not confirmed represents one of the best ways we can learn from the project, allowing us to better understand ecological processes, and improve our subsequent actions and monitoring.

The evaluation of these hypotheses relies on multiple comparisons. These approaches are summarized below, along with example metrics that we plan to evaluate for each.

1. *Before-During-After:* Some environmental variables will change as a result of the action. Because this type of comparison is confounded by seasonal habitat changes (e.g., warm summer vs cooler fall), this limitation must be kept in mind when interpreting the results. *Example metrics: salinity, fish community.*
2. *Regional Comparisons:* Our approach will rely heavily on comparisons of differences between three geographic areas (see Figure 15): 1) Suisun Marsh – including Montezuma Slough and smaller sloughs branching off the main slough 2) Grizzly Bay – Including Honker Bay, and 3) River Region – Confluence to Rio Vista. This comparison allows us to evaluate whether areas of Suisun Marsh that were freshened by the action were superior to the River, where smelt habitat would have been confined if not for the SMSCG action, and whether these areas are superior to the region of the Marsh not freshened by the action. A limitation of this approach is that the comparison is not a useful way to identify what changes were triggered by the action. *Example metrics: turbidity, chlorophyll-a, zooplankton density, harmful algal blooms.*
3. *Comparison to Historical Years*: Since the estuary is relatively well-monitored, we can compare whether conditions under the SMSCG action were different than historical wetter years, and in drier years when there was no action. A limitation of this approach is that every water-year is different, making it difficult to directly compare one water-year to another. *Example metrics: habitat metrics such as salinity, temperature, turbidity, chlorophyll-a.*
4. *With/Without Action*: This approach is possible using only simulation models, which allow us to examine how different things might have been in 2018 (or other years) without the SMSCG action. *Example metrics: Area of low-salinity habitat.*

Here we describe the expected responses in two types of habitat components (Abiotic, Biotic) and for Delta Smelt. For each of the individual habitat components and fish responses, we describe our predictions (Table 1, Table 2) and summarize results from previous years' monitoring supporting our predictions.

Table 1 Predicted differences in metrics between the three regions during a no-action year. For the purposes of this analysis, we consider the "Grizzly Bay" to be Grizzly and Suisun bays, and the "River Region" to be the Confluence to Rio Vista (see Figure 15)

	Marsh	Grizzly Bay	River	How are we testing it?	2018 results
Habitat Conditions	—	—	—	—	—
Salinity	Lower	Higher	Lowest	Continuous sondes	Salinity dropped in August, stayed low through Sept.
Temperature	More variable than River	Lower than River or Marsh	Similar mean, lower variability	Continuous sondes	There was no difference in mean temp between regions in 2018.
Average Turbidity	Higher than River	Higher than River	Lower than Marsh	Continuous sondes, potential for remote sensing	Confirmed hypotheses
Food Web Responses	—	—	—	—	—
Average Phytoplankton Biomass	Higher than River	Similar to River	Lower	Chlorophyll from sondes and grab samples	Higher chlorophyll in Marsh
Diatom Biomass	Higher than River	Similar to River	Lower	Grab samples	Not evaluated in 2018
Average Microcystis Biomass	Lower than River	Lower than River	Higher than Marsh	Discrete observations (scale of 1-5)	Higher in River
Total Zooplankton biomass	Lower than River	Lower than River	Higher than Marsh	EMP, STN, FMWT, DOP, extra samples	Higher in River than Marsh

	Marsh	Grizzly Bay	River	How are we testing it?	2018 results
Aquatic Weeds	Lower than River, higher than Grizzly Bay	Lowest	Highest	Hyperspectral imagery	Not evaluated in 2018
Fish assemblage	More marine	Most Marine	Least marine	UCD, Bay Study, EDSM, Summer Townet, FMWT	Some differences in small versus large sloughs
Delta Smelt	—	—	—	—	—
DS growth, survival, in fall	Similar or higher than River	—	Lower than Marsh	DOP and/or enclosure studies	Not evaluated
DS health and condition	Similar or higher than River	—	Lower than Marsh	Enclosure studies	Not evaluated

Table 2 Predicted responses in the Marsh relative to Base conditions (i.e. similar historical years or modeling results for a no-action year). Predicted outcomes for the SMSCG Action assume a change in gate operations during summer or fall, including supplemental outflow to maintain compliance with Delta Water Quality Standards (D-1641).

	Similar historical years or modeled no action	Action year	How are we testing it?	2018 Results
Habitat Conditions	—	—	—	—
Salinity	Higher	Lower	Continuous sondes	Additional sondes to be installed in Grizzly Bay

	Similar historical years or modeled no action	Action year	How are we testing it?	2018 Results
Average Daily Net Delta Outflow	Lower	Higher	Modeling – DSM2	Outflow increased by 45.6 x 10^6 m^3
Surface area of the fall LSZ	Smaller	Larger	Modeling- SCHISM	LSZ area increased
Temperature	Neutral	Neutral	Continuous sondes, potential for remote sensing	Similar to previous years
Average Turbidity	Neutral	Neutral	Continuous sondes, potential for remote sensing	Not evaluated
Food Web Responses	—	—	—	—
Phytoplankton assemblage	More marine during late summer/fall	Less seasonal change	Summer Townet, FMWT samples	Not evaluated
Zooplankton assemblage	More marine during late summer/fall	Less seasonal change	Summer Townet, FMWT samples	Not evaluated
Zooplankton biomass	Lower biomass, esp. of freshwater species	Higher biomass, esp. Pseudodiaptomus and other freshwater species	Summer Townet, FMWT samples	Inconclusive
Aquatic Weeds	Lower	Higher	Hyperspectral imagery	Not evaluated
Fish assemblage	More marine during August in small sloughs	Less seasonal change.	UCD, EDSM, summer townet	—
Delta Smelt (DS) Responses	—	—	—	—
DS distribution	Eastward	Westward	IEP surveys	—

	Similar historical years or modeled no action	**Action year**	**How are we testing it?**	**2018 Results**
DS growth, survival, in fall	Lower	Higher	DOP and/or enclosure studies	—
DS health and condition	Worse	Better	Enclosure studies	—
DS Recruitment the next year	Worse	Better	IEP surveys	—
DS Population life history variability	Lower	Higher	DOP/IEP surveys	—

Abiotic Habitat

Salinity. The change in salinity during the action is the primary driver of all other effects of the action that are currently under consideration. Gate operation during the normal operational period has consistently shown predictable decreases in salinity throughout the Marsh that persist after gate operation ceases (DWR 1994, Sommer et al. 2020). Therefore, we predict salinity to decrease in the Marsh during the action.

Salinity changes in Grizzly Bay are uncertain, with modeling results disagreeing as to the extent of the impact. Specifically, the UnTRIM model developed by AnchorQEA for the 2018 action showed freshening of as much as 1-2 PSU at the Grizzly Bay monitoring site. An alternate model, DWR's SCHISM model, shows less freshening, confined to a narrower region and nearly always < 1 PSU at Grizzly Bay station. UnTRIM also indicates relatively slow recovery of salinity levels at places like Belden Landing at the cessation of tidal operations, on the scale of months whereas SCHISM shows the bulk of the relaxation happening in the first 10-14 days. Data collected by continuous sondes in Grizzly Bay did not show an effect of the action in 2018, but it was logistically difficult to install stations close to the shore, where the impact of the action is expected to be greatest. Due to these difficulties, three new continuous water-quality sondes were installed in Grizzly Bay in 2021 (see Water Quality Monitoring, below).

Three-dimensional modeling of the 2018 pilot action conducted by Anchor QEA using their UNTRIM model supported our prediction that the flow pulse combined with operation of the SMSCG would substantially improve habitat conditions for Delta Smelt (Figure 8). Although SMSCG operations concluded on September 6, modeling showed that the salinity benefits of the action continued for more than a month afterwards (Figure 9**Error! Reference source not found.**).

Modeled UnTRIM data from 2018 were compared to data collected by sondes and to high-speed mapping data collected by USGS. Analysis found UnTRIM was biased low as much as 2 PSU in some circumstances, so we have decided to use SCHISM for future modeling efforts (see Delta Smelt Habitat Area, below).

Figure 8 UnTrim modeling of average August 2018 habitat conditions in the Suisun Region with and without the SMSCG Action (left panels) and their net effect (right panel). The graph is summarized based on the percentage of time that habitat was <6 PSU

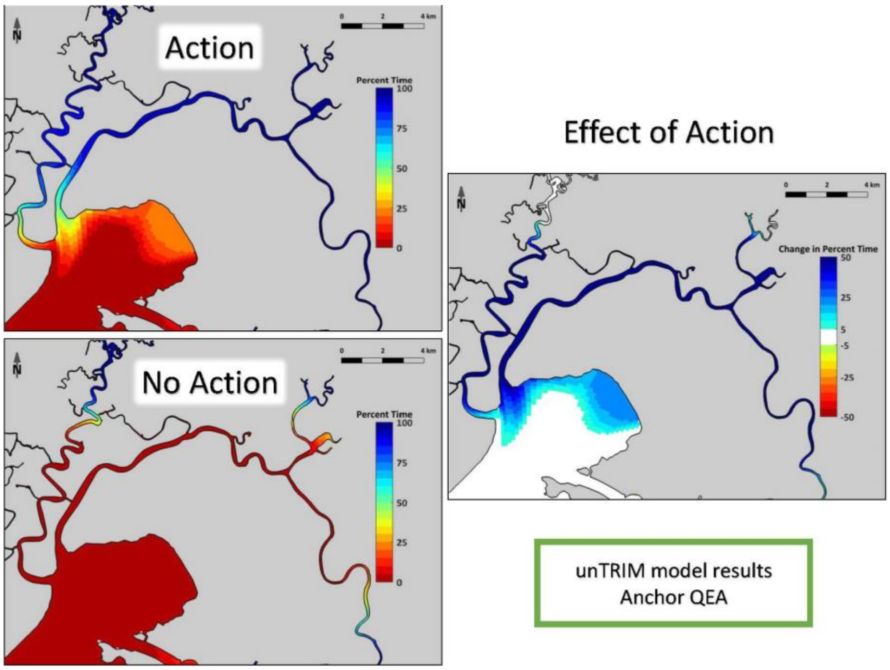
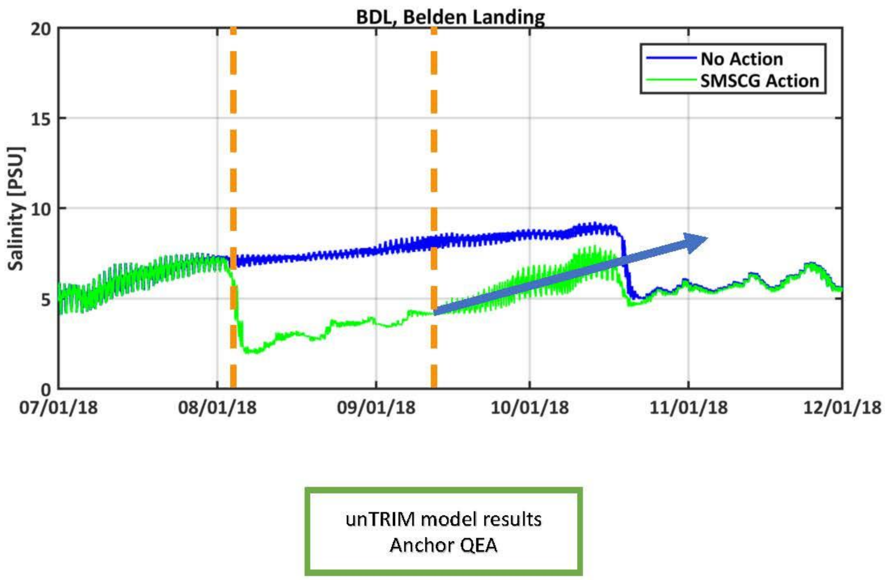


Figure 9 UnTrim modeling of average August 2018 salinities in the Suisun Region (at Belden's Landing) with and without the SMSCG Action. The arrow shows the "echo" as low salinity conditions persisted well past the gate operation period (bracketed with gold lines).



Average Daily Net Delta Outflow. The action would result in a modest overall increase in Total Delta Outflow. Operations of the SMSCG in fall is known to result in a slight upstream shift in the salt field by directing more freshwater inflow into the Marsh rather than along the main open water region of the estuary (United States Fish and Wildlife Service (USFWS) 2019). Less flow along the main open water region of the estuary results in a slight upstream shift in the salt field (as indexed by X2). Modeling of the 2018 pilot project indicated that August 2-September operation of the SMSCG directed approximately 160 x 106 m3 (130 x 103 acre-feet) of low salinity water into Suisun Marsh. Delta outflow was augmented by an estimated 45.6 x 106 m3 (37 x 103 acre-feet) in order to maintain compliance with D-1641 and other water quality criteria. Therefore, <u>we predict an increase in Delta Outflow to offset upstream encroachment of salinity (X2) for any summer-fall operations of the SMSCG.</u>

Surface area of the fall Low Salinity Zone. Under the static summer-fall outflow regime that has been typical for the POD period (Brown et al. 2014), outflows throughout much of the fall are always low and salinity intrudes far to the east (X2

> 80 km), causing the LSZ to be constricted to the confluence of the deep Sacramento and San Joaquin river channels. When X2 is more seaward, the LSZ includes more of Suisun Bay and overall surface area is higher (Kimmerer et al. 2009). The extent and location of the LSZ may affect fish distribution and habitat attributes.

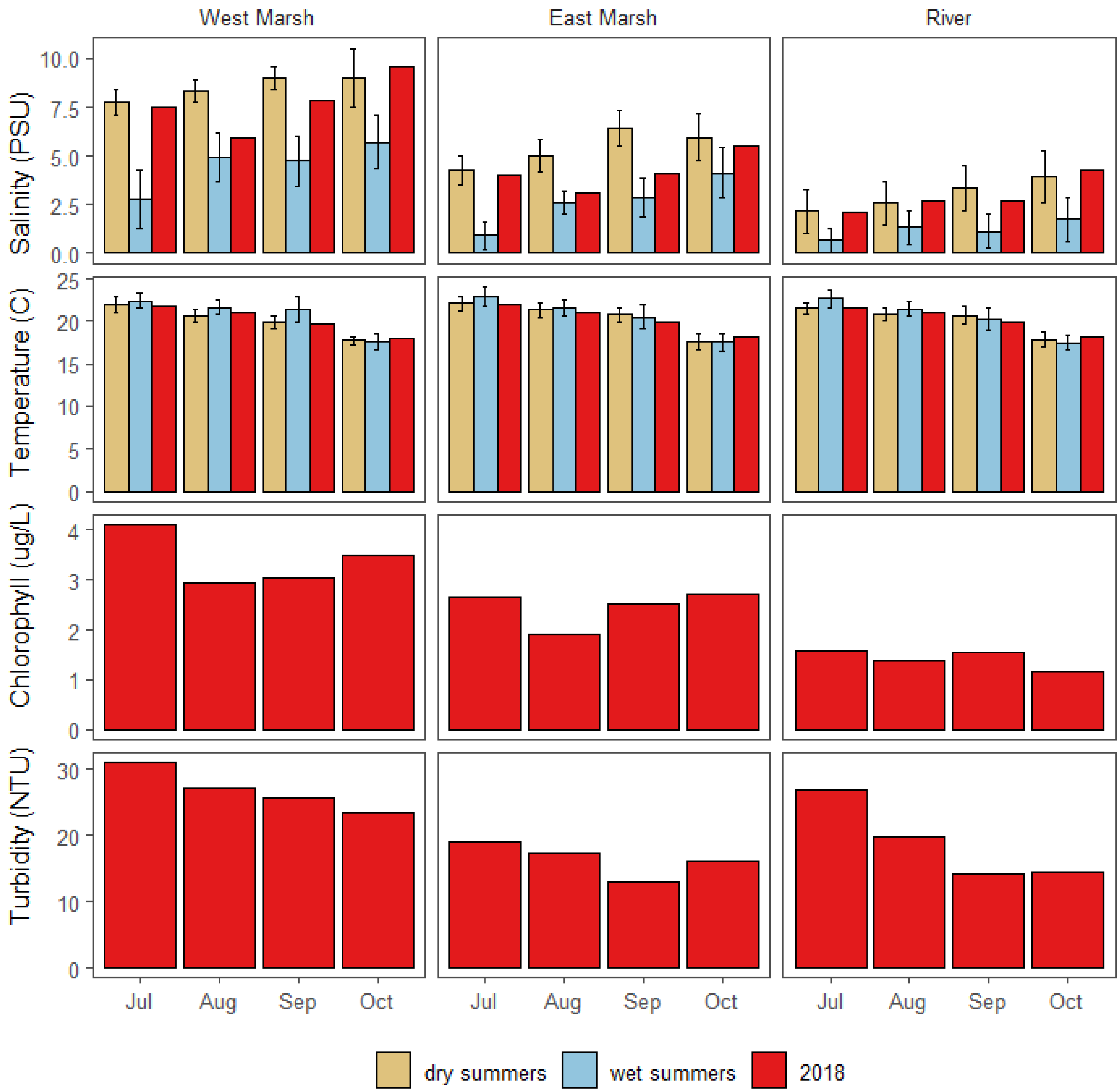
Based on modeling studies and results from the 2018 action, operation of the SMSCG in August will increase the amount of Delta Smelt habitat in the Suisun Marsh and Grizzly Bay (Sommer et al. 2020). The degree to which this will change depends substantially on water year types. In general, the degree of effect is greatest in drier water years and modest in above normal years. We predict SMSCG operations to result in a modest increase of the area of the LSZ in drier years and a very slight increase in above normal years. The action will also substantially increase the proportion of the LSZ that it located in Suisun Marsh (Eakin et al. 2020).

Temperature. Temperature is increasingly recognized as a key habitat variable affecting Delta Smelt (Sommer and Mejia 2013, Brown et al. 2014) with higher temperatures causing early spawning, a shortened maturation window (Brown et al. 2016b), and changes to behavior, (Davis et al. 2019b). Consistent increases in temperature may cause a shift in community structure towards more heat-tolerant non-native species (Davis et al. 2019a). There is currently little evidence for increasing water temperatures in the Delta, although with climate change such increases are expected over the course of the century (Wagner et al. 2011, Brown et al. 2016b, Dettinger et al. 2016). However, there is increasing concern that recent record warm years may be related to climate change. For example, Delta Smelt appear to have done relatively poorly despite wet conditions in 2017—record high summer temperatures are thought to have been a key factor (FLOAT-MAST 2020).

Our prediction is that the proposed SMSCG action will not have any effect on water temperatures, and water will be lower in Grizzly Bay than in Suisun Marsh or the Sacramento River. In 2018, water temperatures were similar in the Marsh as the River, which was somewhat unexpected, because the Marsh is closer to the cooling effect of the San Francisco Bay. However, further data analysis has indicated that channels in the interior of the Marsh are often warmer than Grizzly Bay or the River (FLOAT-MAST 2020). While many areas in Suisun Marsh have similar or higher temperatures when compared to the River region, high habitat complexity in Suisun Marsh could provide unique temperature refuges based on interactions between its tidal channels and the marsh plain (Enright et al. 2013). Such localized effects may not be detectable based on average LSZ temperature, but could nonetheless be a project benefit.

Turbidity. Turbidity has been found to be an important correlate to Delta Smelt occurrence during the summer (Nobriga et al. 2008) and fall (Feyrer et al. 2007). Turbidity increases feeding success in Delta Smelt and lowers predation risk (Hasenbein et al. 2013, Ferrari et al. 2014). In the SFE, turbidity is largely determined by the amount of suspended inorganic sediments in the water (Ganju et al. 2007, Schoellhamer et al. 2012). Strong turbulent hydrodynamics caused by strongly interacting tidal and riverine flows, bathymetric complexity, and high wind speeds continue to constantly resuspend large amounts of the remaining erodible sediments in large and open shallow bays of Suisun Bay. Suisun Bay thus remains one of the most turbid regions of the estuary. Turbidity dynamics in the deep channels of the river confluence and Sacramento River are driven more by riverine and tidal processes while wind and associated sediment resuspension has little if any effect (Ruhl and Schoellhamer 2004, Schoellhamer et al. 2016). This difference is also consistent with preliminary analyses by W. Kimmerer (SFSU, pers. com.) that suggest that turbidity in the LSZ is higher when fall X2 is further downstream and the LSZ overlaps Suisun Bay. In 2018, turbidity was higher in the Suisun Region ("Marsh") than the River (Figure 10). Hence, we expect to see that general pattern in turbidity levels in the SMSCG action period.

Figure 10 Monthly water quality results for three continuous monitoring locations: Sacramento River (Collinsville), East Suisun Marsh (National Steel) and West Suisun Marsh (Hunter Cut). The 2018 results (red bars) are shown in addition to the mean (+/- 1 SEM) of historical dry (brown bars: 2002; 2009; 2012) and wet (blue bars: 2005; 2006; 2017) summers. Standard deviations are also shown for the historical periods. Figure from Sommer et al. 2020.



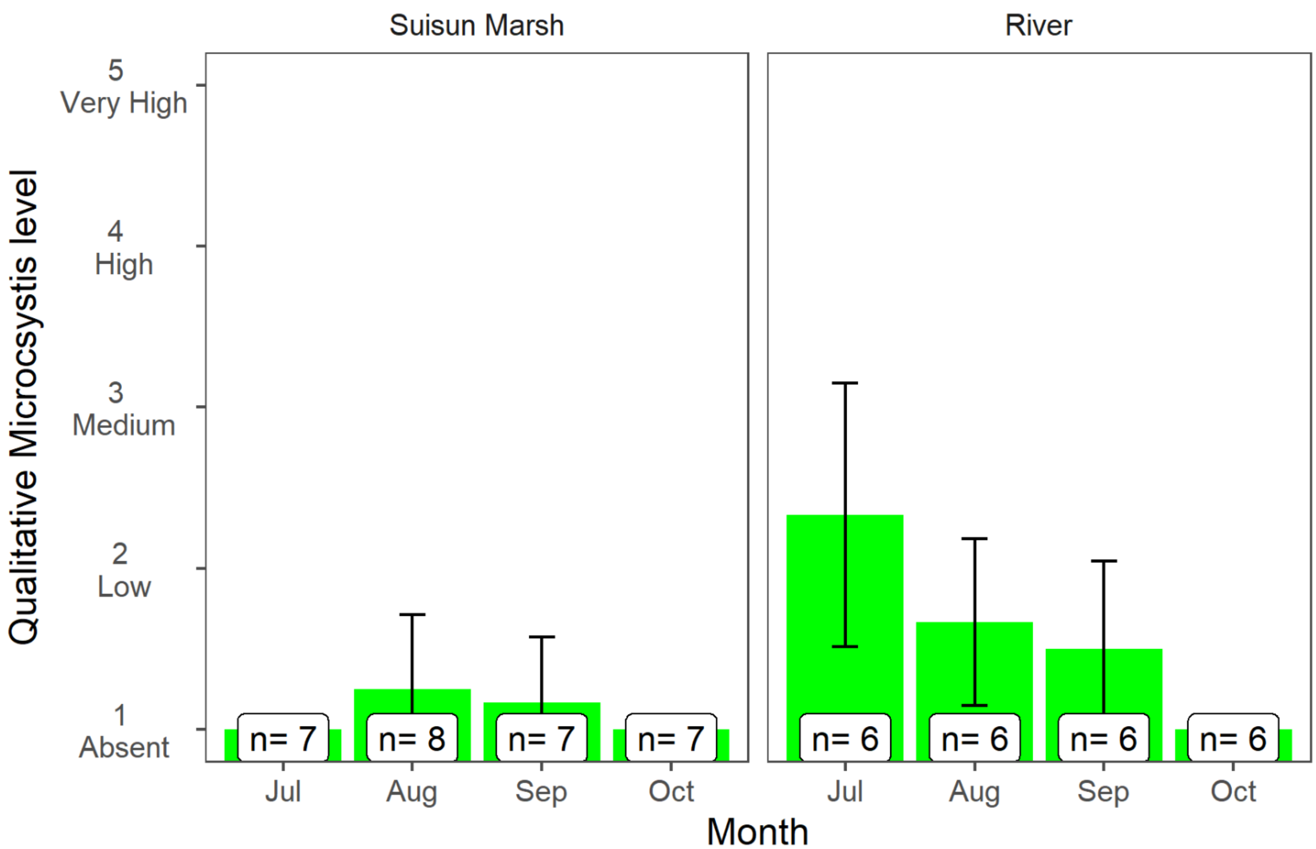
Biotic Habitat

Estuarine fishes seek areas with a combination of dynamic and stationary habitat components that are well suited to their particular life histories. In addition to abiotic habitat components, fish habitat also includes dynamic biological components such as food availability and quality and predator abundance.

Average phytoplankton and diatom biomass. Food availability for Delta Smelt relies on a strong base to the food web, including high phytoplankton biomass (particularly diatoms, considered one of the most nutritious forms of phytoplankton for copepods). Like the channels of the Cache Slough Complex, Marsh channels tend to have relatively higher levels of phytoplankton and zooplankton (Montgomery et al. 2015, Brown et al. 2016a). During the 2018 pilot action, chlorophyll-*a* was consistently at higher levels in the Marsh than in the River region (Figure 10, Sommer et al, 2020). We therefore predict that production of phytoplankton (including diatoms) will be greater in the Marsh than the River because of shallower depths and longer residence times. There might be a slight decrease in phytoplankton as flow is increased under the proposed action, but we do not expect that the change would be detectable given that flow will only increase slightly. We predict there will be a different community assemblage during action years versus no-action years due to the changed salinity regime, dominated by more salt-tolerant species and fewer harmful cyanobacteria in non-action years. The impact of the change in phytoplankton communities on higher trophic levels remains uncertain.

Microcystis. The biomass of *Microcystis* might be reduced slightly in the target regions under the proposed action as a result of increased Delta Outflow under the action but the change is unlikely to be detectable. Although the 2018 pilot action occurred during a period when *Microcystis* blooms typically occur, visual scores of algal colonies from the DFW Summer Townet Survey indicated that *Microcystis* remained at low levels throughout the action (Figure 11). There was no indication of a substantial change in presence during the action, but the Suisun region had significantly lower *Microcystis* presence than the river region (Sommer et al. 2020). Overall, we expect that Grizzly Bay, and the Marsh will have lower levels of *Microcystis* than the river since it is at the downstream end of its suitable habitat.

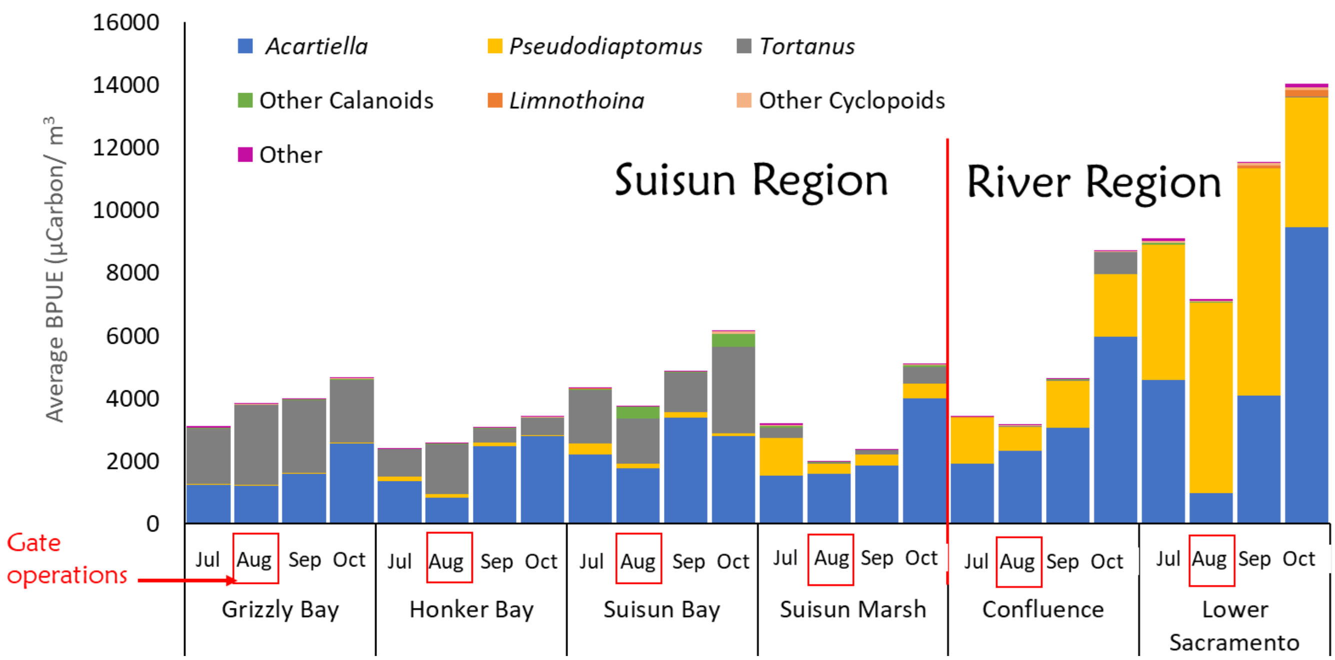
Figure 11 Presence of *Microcystis* colonies for monthly observations during 2018 in the River and Marsh regions as recorded by EMP, FMWT, and STN. Sample sizes and standard deviations are provided for each month. Figure from Sommer et al. 2020.



Zooplankton. Food resources for Delta Smelt (chiefly calanoid copepods) in the summer-fall LSZ vary considerably on many spatial and temporal scales. Overall, food quantity and quality may be higher for Delta Smelt if the LSZ is in Suisun Bay and Suisun Marsh than if it is in the river confluence. Previous research has found that, despite lower standing biomass of zooplankton as measured by IEP monitoring surveys, Delta Smelt captured in the Suisun region have greater foraging success (Hammock et al. 2017). During the 2018 action, the Marsh tended to have different zooplankton species than the upstream habitat, and the Suisun region had significantly lower biomass than the River region (Figure 12,(Sommer et al. 2020)). However, fresher conditions in the Marsh typically lead to increased zooplankton biomass, particularly the calanoid copepod

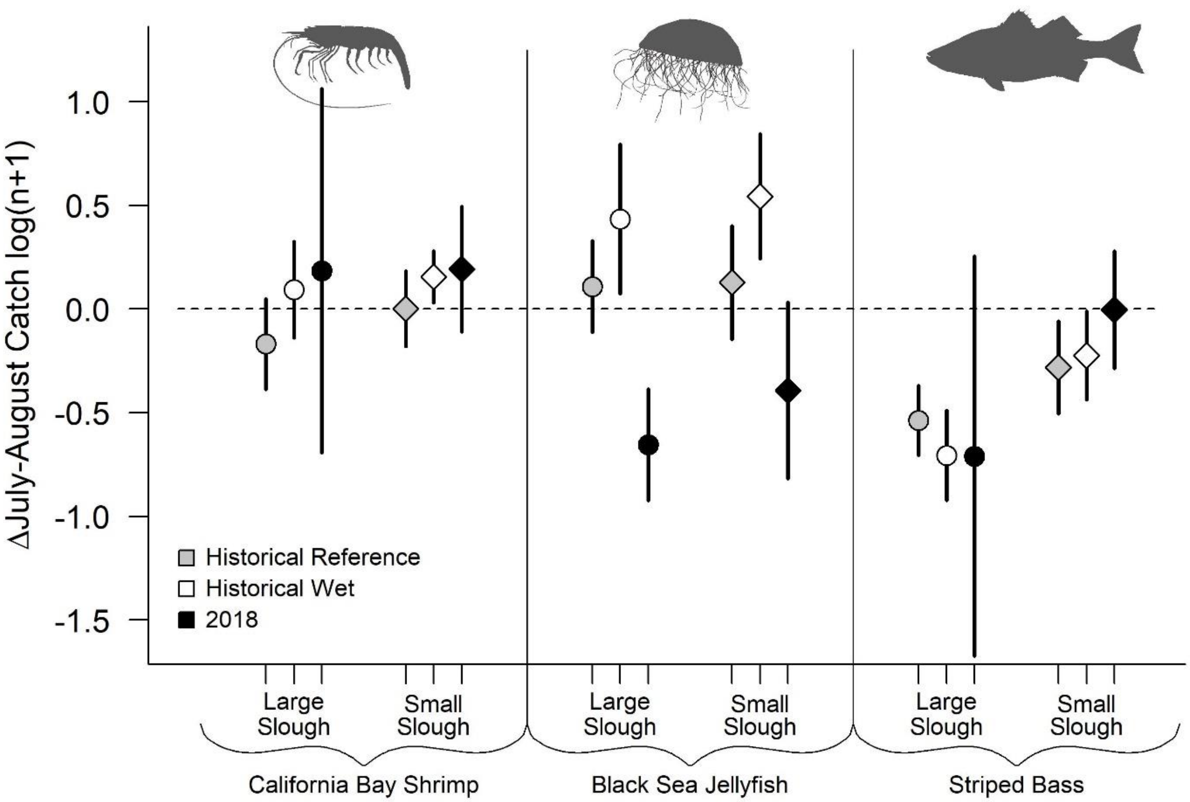
Pseudodiaptomus forbesi (Kimmerer et al. 2018, Hassrick et al. 2023). This pattern was not seen in 2018, but additional data collection may be necessary to see a response. Furthermore, increased overlap between the LSZ and marsh channels would provide zooplankton with additional terrestrial/wetland sources of carbon (Schroeter et al. 2015, Brown et al. 2016a, Young et al. 2016), and will provide fish with access to a wetland zooplankton production (Hammock et al. 2019). Therefore, we predict that Grizzly Bay and all of Suisun Marsh will continue to have lower zooplankton biomass than the river region. But we predict an increase in total zooplankton biomass and an increase in freshwater copepods and cladocera during the action.

Figure 12 Zooplankton biomass for different regions of the estuary during summer and fall 2018 based on CDFW collections in the Summer Townet Survey and Fall Midwater Trawl. Each of the colored bars represented different species of zooplankton. The gate operation period on the X-axis is bracketed with red boxes. Data courtesy of Christina Burdi (CDFW).



Fish Community. While overall fish community changes are not a primary goal of this action, we are using the opportunity to test hypotheses regarding changes to fish community as well. The fish community in Suisun Marsh changes seasonally based on recruitment patterns as well as physiological tolerances (Matern et al. 2002), so decreases in salinity in the summer are expected to shift the fish community towards a less salt-tolerant assemblage. Results from the UC Davis Suisun Marsh Survey in 2018 support our prediction that the SMSCG triggered some fish community changes. For example, there was a notable drop in jellyfish (not a fish, but still a pelagic competitor) coincident with SMSCG gate operations (Figure 13). There was also a shift in fish community between July and August during the gate action similar to historical wet years, even though 2018 was a dry year (Beakes et al. in review). In 2020, <u>we predict that Suisun Marsh and Grizzly Bay will have more salt-tolerant species than the river region. In years when a gate action occurs, we predict the East Marsh will have fewer salt-tolerant species than normal.</u> These changes may provide a different assemblage of predators and competitors for Delta Smelt.

Figure 13 Estimates of species-specific catch difference between July and August from reference years (gray), historical wet years (white), and 2018 (black). Catch difference for large- (circles) and small sloughs (diamonds) are plotted for three common species including California Bay Shrimp, Black Sea Jellyfish, and Striped Bass. Error bars encompass approximate 95% confidence intervals. Figure from Beakes et al. In review.



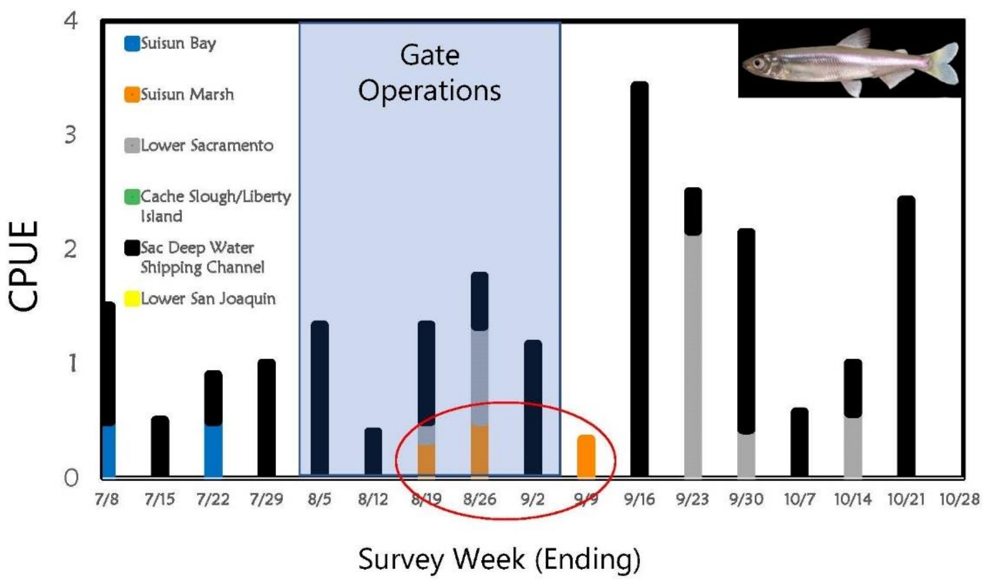
Aquatic vegetation. The SMSCG Action may facilitate the spread of invasive aquatic plant species in the Marsh. Operating the gates will increase the amount of fresh water transported from the Delta and into the Marsh. Much of the Delta is choked with invasive aquatic vegetation, and this vegetation disperses readily via floating seeds and vegetative fragments. This vegetation is at peak densities during the period the gates will be operated for this action. <u>Therefore, we predict that increasing the amount of water entering the marsh from the Delta could increase the risk of aquatic weed spread</u>. Alligatorweed, *Alternanthera* *philoxeroides,* is of particular concern because it arrived in the ecosystem in 2017 and is spreading rapidly. It is also salt-tolerant enough to invade much of the marsh.

Delta Smelt Responses

Delta Smelt will likely respond in several ways to outflow-related habitat changes such as SMSCG operations. Specifically, access to areas of greater bathymetric complexity such as those found in the Suisun Bay and Suisun Marsh likely offer multiple advantages to Delta Smelt (Bever et al. 2016), although many uncertainties regarding the mechanisms that link Delta Smelt responses to outflow conditions and the position of the LSZ remain. Note also that the responses of Delta Smelt may be muted depending on the status of the population and conditions in other seasons. For example, severely low adult abundance is likely to generate relatively low egg production. Even with good summer and fall survival, poor conditions in winter could affect adult maturation and winter and spring conditions can affect hatching and larval survival. The increase in the 2011 Delta Smelt abundance index compared to years in the 2000s (Figure 2) suggests that the Delta Smelt population was still resilient and able to respond to favorable conditions, but low population levels in recent years could substantially limit the efficacy of management actions. However, experimental releases of Delta Smelt in winter of 2022-2023 may provide hope that some fish will be present in the Marsh to benefit from the action.

Distribution. Prior to their spawning movements in the winter, Delta Smelt are commonly found in the LSZ (Feyrer et al. 2007, Sommer et al. 2011a). <u>We predict that the center of distribution of the Delta Smelt population, excluding the Cache Slough Complex will move westward into Suisun Marsh with the proposed action.</u> A more downstream distribution gives Delta Smelt access to a larger habitat area that overlaps with the more bathymetrically complex Suisun Bay with its deep channels, large shallow shoal areas, and connectivity with Suisun Marsh sloughs. In 2018, field sampling detected smelt in the Marsh during the action, but not before or after the action (Figure 22), though numbers were too low (seven fish caught in the Marsh) to make any conclusions as to the impact of the action on the observed pattern.

Figure 14 CPUE of Delta Smelt in the USFWS Enhanced Delta Smelt Monitoring Survey (EDSM) for different regions of the estuary. The period of gate operations is highlighted in blue. The circled area shows detection of Smelt in Suisun Marsh. Reports and data available at: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm



Health and condition. Distribution across a larger area with high turbidity, low contaminant levels, and low *Microcystis,* when the LSZ overlaps the Suisun Bay and Marsh, may help Delta Smelt avoid predators, increase feeding, and increase health and condition. Delta Smelt caught in Suisun Marsh have been found to have higher nutritional indices and morphometric condition factors (Hammock et al. 2015), with higher stomach fullness despite lower zooplankton biomass (Hammock et al. 2017). In addition, a larger habitat area may help Delta Smelt avoid areas with high concentrations of contaminants. <u>We predict that these metrics will improve with greater access to Suisun Marsh under the proposed action</u>.

Growth and survival. Distance from entrainment sites and locations where predators may congregate (e.g., artificial physical structures, scour holes in river channels, *Egeria* beds) may also help increase survival. Increased growth should result in greater size of adult Delta Smelt and greater fecundity of females in the following year, since number of eggs is related to length (Bennett 2005). Improved health and condition at the beginning of the spawning period may increase the likelihood of spawning success and frequency. Our prediction is that these metrics will improve with increased access to Suisun Bay and Marsh under the proposed action.

Recruitment in the next spring. Overall, our prediction is that improvements in abiotic and biotic habitat listed above will lead to increased distribution, abundance, and reproductive potential of the Delta Smelt population and greater recruitment in the following spring. Our prediction is that recruitment will improve with summer SMSCG operation due to increased survival, growth, health and condition. However, we acknowledge that such an effect will be difficult to detect because of overall low abundance of Delta Smelt and potential for conditions in other time periods to outweigh effects of the action.

Study Design

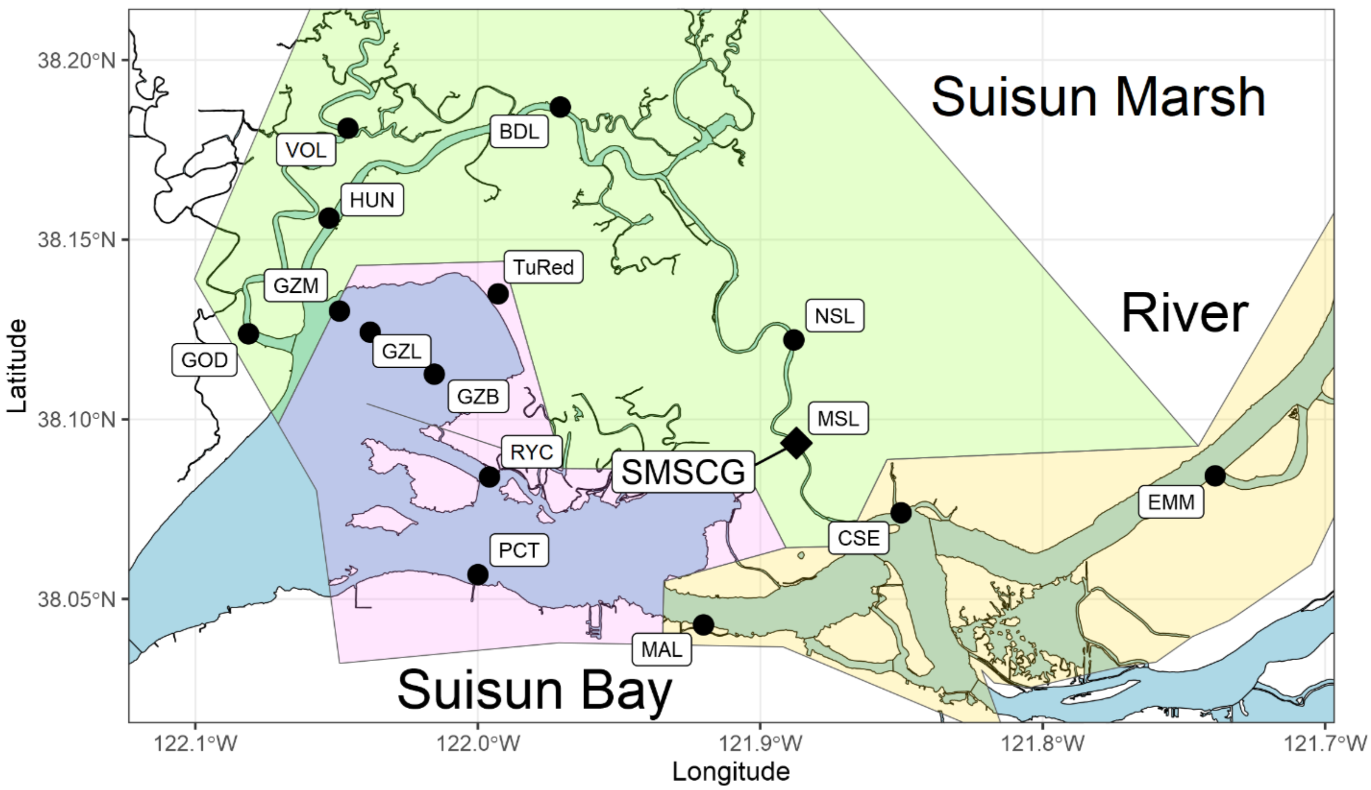
The monitoring and evaluation program for the SMSCG action will leverage existing routine monitoring surveys, supplementing them as necessary, to evaluate the predictions detailed in Table 1 and Table 2. Sampling locations are shown in Figure 15 and Figure 16, and the existing surveys that will inform the monitoring program for each of the predictions are listed in Table 5. Whether or not an action occurs in 2023, we will still be monitoring environmental conditions to provide a baseline for future years in which an action may occur. As with the predictions, the monitoring plan is organized by regions for predicted effects of the SMSCG action (Suisun Marsh, Grizzly Bay, and River Regions), and by time (Before-During-After; Historical). Below we summarize the key tools that will be used for the evaluation: Modeling, Monitoring, and Experimental Studies.

Site Description

The geographic focus of this workplan is on Suisun Marsh, Grizzly/Suisun Bay, and the lower Sacramento River. However, we also include the low salinity zone (LSZ, or area with a salinity 0.5 to 6 PSU) and freshwaters in the North Delta upstream of the LSZ to put Delta Smelt habitat needs into a broader context consistent with recent reports and conceptual models (Brown et al. 2014, IEP-MAST 2015) (Figure 1). The geographic boundaries of the LSZ are dynamic both seasonally and annually: periods of high outflow push the LSZ seaward while drier periods with low outflow draw the LSZ further inland. Therefore, we also consider fresher and more brackish waters to the extent needed to understand both Smelt responses and the role of the LSZ.

This workplan focuses on the months of the action (June-October) and the months immediately before and after the action. However, IEP monitoring and other studies have been ongoing in the SFE for many years providing the opportunity to put the current workplan into a broader temporal context.

Figure 15 Water Quality monitoring stations. The three regions used for major comparisons are outlined. Additional data collected in Grizzly Bay will help better understand the spatial extent of the SMSCG influence.



Modeling

Water cost

We will use modeling to calculate the predicted water cost of the action when the water year forecasts are developed in the spring. This analysis will allow us to determine the most efficient timing and pattern of gate operations, as well as forecast the water supply impact of the summer gate operation. The objective of the water-cost analysis is to find a model scenario with the gates tidally operated that has equivalent salinity to a model scenario that is representative of gate in open position. First, DWR's Delta Simulation Model 2 (DSM2) is run with the preliminary hydrologic forecast and assumed operations, to model summer conditions without gate operation. A second DSM2 scenario is run with tidally operated gates tidally to quantify how different summer water quality would be in the interior Delta with the gate operation. DSM2 is then run iteratively with the gates operating tidally modeling incremental increases to Delta Outflow either by increasing flow to Freeport or by decreasing exports at the Delta Export Facilities. The increase in outflow is assumed constant through the summer operation period. The difference in salinity between the base open run and each tidal run is summed for the control period over which degradation to water quality is to be mitigated. Finally, the water-cost is determined by finding the intercept of zero sum of differences from the regression of the sums versus the decreased export rates.

This analysis will be run on various operational scenarios to maximize the time period where Belden's Landing salinity is below the target value (4 PSU, except dry years preceded by dry years, when it will be 6 PSU).

Delta Smelt Habitat Area

After the action, we will model 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 and a flexible coordinate system in the vertical (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) and (Ateljevich et al. 2015). Model applications for some proposed SMSCG operations have also been included in the documentation of the Incidental Take Permit for the SWP (DFW 2020).

Modeling assumptions and boundary conditions for the present study generally conform to the methods described by Ateljevich et al. (2014). For the present project, the mesh was modified to incorporate more marsh channels and marsh plains than previous versions of the Bay-Delta SCHISM mesh. The standard Bay-Delta SCHISM configuration incorporates approximations of numerous hydraulic structures in the Delta, including the SMSCG, Delta Cross Channel, and Clifton Court Forebay. All hydraulic structures are modeled as radial gates using standard 1D approximations similar to those used in DSM2 (See Water Cost, above).

We will use the SCHISM model to produce two metrics of smelt habitat area. First, the spatial area of habitat below 6 PSU. Second, the area below 6 PSU that also has a Secchi disk depth of 0.5m or less (higher turbidity) and water temperature of 23.9°C or lower. Temperature and turbidity may be interpolated from discrete water quality monitoring stations and/or data collected from continuous sondes. In light of improvements in the continuous turbidity monitoring network close to Suisun Bay and Marsh, modelers will, explore whether it is possible to translate the current index from Secchi depth to turbidity in order to take advantage of better temporal resolution in continuous turbidity sensor data.

Water Quality Monitoring

The LSZ, Suisun Marsh, and lower Sacramento River region are already relatively well-monitored by routine and long-standing IEP surveys such as the Environmental Monitoring Program (http://www.water.ca.gov/iep/activities/emp.cfm), which collects water quality, phytoplankton, zooplankton and benthic invertebrate samples on a monthly basis. DWR's water quality monitoring team maintains a number of water quality stations in the LSZ and Suisun region (Table 3, Figure 15). In 2021, three new sondes were placed in Grizzly Bay, as per the requirements in the 2020 ITP (section 9.1.3.3), one at the mouth of Montezuma Slough, one in the eastern region of Grizzly Bay, and one at the Tule Red restoration site.

The sondes will be serviced during site visits that will occur every two weeks or monthly, depending on local water quality conditions and sonde servicing requirements. Sondes are serviced following DWR's Real-Time Monitoring Standard Operating Procedure (DWR 2019), which closely follows the methods described in (Wagner et al. 2006) (hereafter, the “Wagner Method”). During each visit, a series of Quality Assurance/Quality Control (QAQC) readings are collected to quantify all sensor operations or changes due to biofouling. A set of readings are recorded before the existing sonde is disturbed. The existing sonde is removed from the water and a freshly laboratory-calibrated sonde is installed. A water sample is collected and the just-removed sonde’s readings are recorded and compared with a laboratory-calibrated reference sonde both immersed in the same sample water. The just-removed sonde’s sensors are carefully cleaned to remove any biological or chemical fouling, and another set of comparison readings are recorded. Before departing the station, a set of sensor readings from the newly-installed sonde are recorded. Finally, back in the laboratory, the removed sonde is thoroughly cleaned and sensor readings are recorded while the sonde is immersed in a set of reference standards. Using the field and laboratory readings within the Wagner Method QAQC framework, sensor changes due to the environment can be separated from changes in the sensors themselves, and the data collected between maintenance visits can be assigned QAQC data quality ratings, flagged as anomalous, etc.

When sondes are serviced, a discrete water sample is collected and sent to DWR’s Bryte laboratory for analysis of chlorophyll-a and nutrients.

Table 3 Water quality monitoring stations.All stations collect data every 15 minutes for salinity, temperature, dissolved oxygen, and turbidity. Stations marked with an asterisk also have ph, and chlorophyll and phycocyanin fluorescence. Asterisked stations also have samples for nutrient and chlorophyll-*a* analysis are collected every two weeks or monthly.

STATION	Owner	Region	LOCATION
CSE*	DWR	River	Montezuma Slough at Collinsville
EMM	USBR	River	Sacramento River at Emmenton
MAL	DWR	River	Sacramento River at Mallard Island
MSL*	DWR	Marsh	Montezuma Slough near SMSCG Facility
NSL*	DWR	Marsh	Montezuma Slough at National Steel
BDL*	DWR	Marsh	Montezuma Slough at Belden’s Landing
HUN*	DWR	Marsh	Montezuma Slough at Hunter Cut
GZL*	DWR	Grizzly Bay	Grizzly Bay Piling
GZB*	DWR	Grizzly Bay	Grizzly Bay Buoy
RYC	DWR	Grizzly Bay	Ryer Island
PCT	DWR	Grizzly Bay	Port Chicago

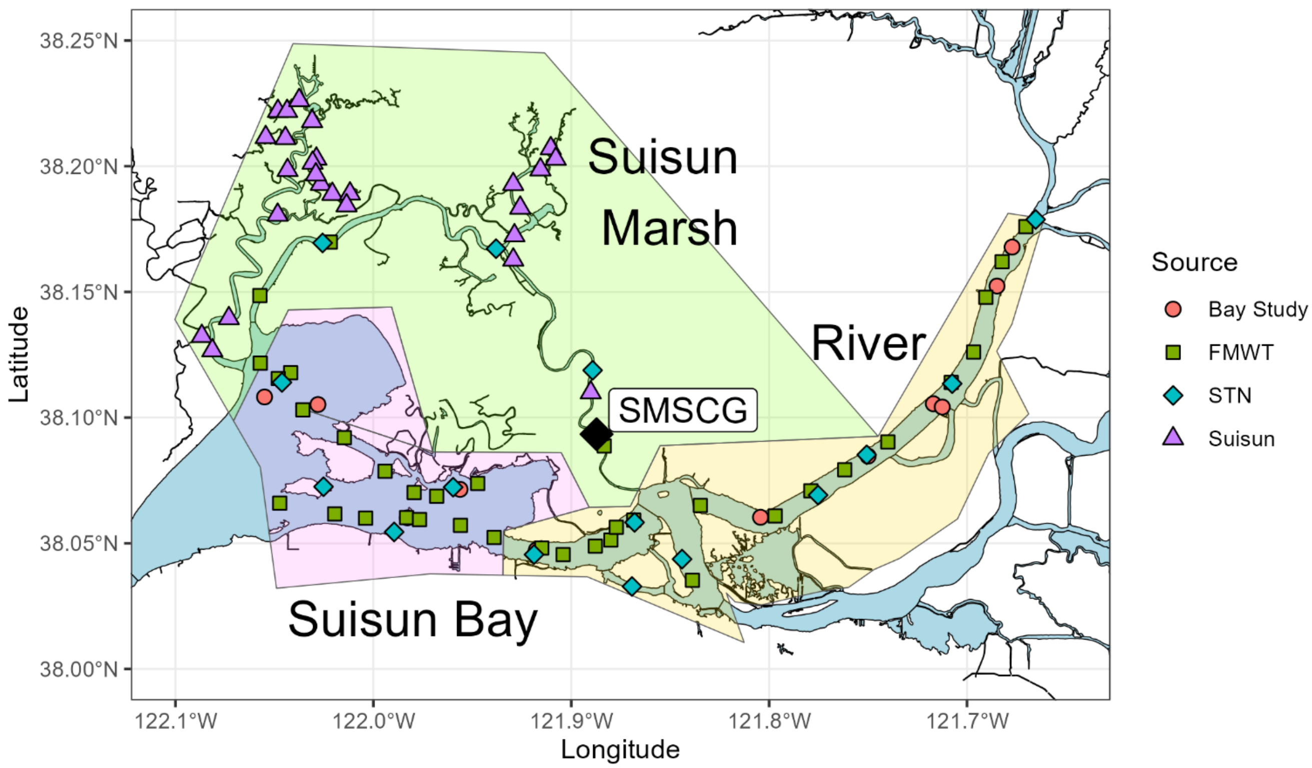
STATION	Owner	Region	LOCATION
GZM*	DWR	Grizzly Bay	Mouth of Montezuma
TRB*	DWR	Grizzly Bay	Tule Red Restoration Site near breach

Biological Monitoring

Fish

Fish monitoring will rely entirely on existing surveys conducted by IEP, specifically the California Department of Fish and Wildlife (CDFW) Summer Townet Survey (STN), San Francisco Bay Study, and Fall Midwater Trawl Survey (FMWT), as well as the UC Davis Suisun Marsh Survey and the USFWS Enhanced Delta Smelt Monitoring Program (EDSM). Because we are relying entirely on existing monitoring programs, each of which has limited sampling in our area of interest, statistical analysis of community composition may not be possible until multiple action years are combined. The recently published *data set* and associated *R package ('deltafish')* that integrates data from all of these fish surveys will facilitate analysis of responses to this management action by the fish communities. Each survey is described in brief below. Please refer to survey web sites for full details.

Figure 16 Sampling sites for IEP's long-term fish monitoring surveys. FMWT = Fall Midwater Trawl. STN = Summer Townet Survey, Bay Study = CDFW San Francisco Bay Study, Suisun = UC Davis Suisun Marsh Fish Survey.



The California Department of Fish and Wildlife operates the Summer Townet Survey (https://www.wildlife.ca.gov/Conservation/Delta/Townet-Survey), which collects zooplankton and juvenile fish samples at all stations shown in Figure 16, every two weeks in June, July, and August. The townet consists of a fixed D-frame sled on runners with an 18-foot net. The main net body is 11 ft. long with 1/2" stretch, knotted, nylon, mesh tapering down to a 7 ft. cod-end with a section of woven mesh with approximately 8 holes per inch. A zooplankton net (modified Clarke-Bumpas net, 160 micron mesh) is attached to the top of the net frame to sample mesozooplankton prey availability during one of the fish tows at each station. Two 10 minute stepped oblique tows are performed at each station. A third tow is conducted if any fish are captured during the first two tows. All fishes and several invertebrate species are counted and measured.

In September, the Townet Survey is replaced by the Fall Midwater Trawl, (https://www.wildlife.ca.gov/Conservation/Delta/Fall-Midwater-Trawl), which operates on a monthly basis and also collects zooplankton samples in addition to fish sampling at a subset of its fish sampling stations. The midwater trawl net has mouth dimensions of 12 ft x 12 ft. Net mesh sizes graduate in nine sections from 8-inch stretch-mesh at the mouth to 0.5-inch stretch-mesh at the cod-end. All four corners of the net mouth are connected to planing doors that hold the net mouth open when being towed through the water. At each station a 12-minute stepped-oblique tow is conducted. All fishes and several invertebrate species are counted and measured. At stations where zooplankton is collected, a mesozooplankton net (modified Clarke-Bumpas net, 160 micron mesh) and a macrozooplankton (mysid) net attached to a steel frame is sampled by a stepwise-oblique tow immediately before or after fish sampling.

UC Davis conducts the Suisun Marsh Fish Sampling Program, a year-round monthly survey of the Suisun Marsh Region (https://watershed.ucdavis.edu/project/suisun-marsh-fish-study). This survey conducts beach seines and otter trawls at 21 sites in nine sloughs throughout the Marsh (Figure 16). Trawling is conducted using a 5.3 m long otter trawl with a 1.5 m X 4.3 m opening, with 35 mm stretch mesh in the body and 6 mm stretch mesh in the cod end. The trawl is towed at 4 km/hr for 5 minutes in small sloughs and 10 minutes in large sloughs. Beach seines are only conducted in upper Suisun and Denverton sloughs using a 10 m beach seine with 6 mm stretch mesh.

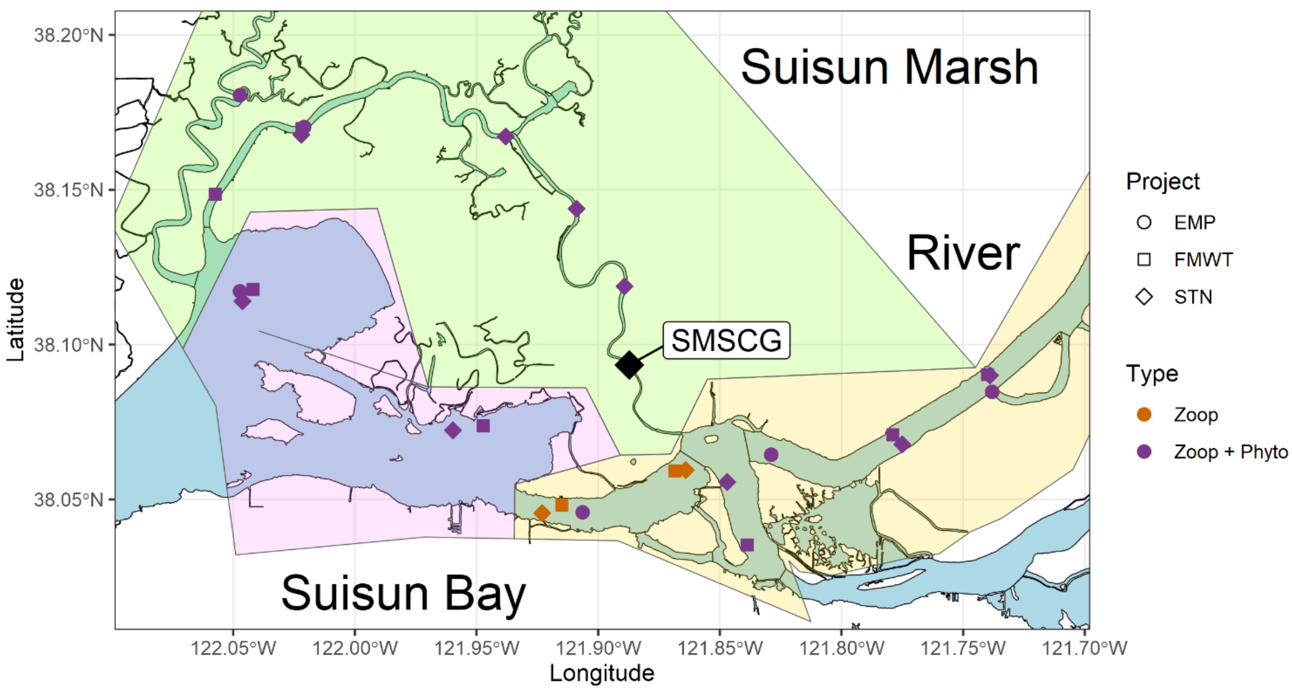
The San Francisco Bay Study (Bay Study) samples with two trawl nets at each station (https://wildlife.ca.gov/Conservation/Delta/Bay-Study). The otter trawl, which has identical dimensions to the UC Davis otter trawl, samples demersal fishes, shrimp, and crabs. The otter trawl is towed against the current at a standard engine rpm for 5 minutes then retrieved. The midwater trawl, which has identical dimensions and methods to the FMWT midwater trawl, samples pelagic fishes. Fish, caridean shrimp, and brachyuran crabs are identified, measured, and counted.

The Enhanced Delta Smelt Monitoring Program (EDSM) was initiated by the U.S. Fish and Wildlife Service in 2016 to provide estimates of Delta Smelt distribution and abundance (https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm). EDSM conducts stratified random sampling via Kodiak trawls (July-March) and larval gear (may-June). Over the course of a week, field crews sample between 18 and 37 random sites, with at least two samples in Suisun Marsh (sites are randomly selected, so not shown on sampling figure). A minimum of two tows are conducted at each site. All fish collected are identified (in the field when possible, in the lab for early life stages), measured, enumerated, and recorded. In addition to fish information, environmental data are collected for each sampling event. Full details on methods and data are available on their Environmental Data Initiative data package (United States Fish and Wildlife Service et al. 2019).

Zooplankton

Zooplankton will be monitored primarily using four existing IEP surveys, including the CDFW STN and FMWT (described above), as well as the DWR/CDFW Environmental Monitoring Program (EMP). Previous years also included the USBR Directed Outflow Project (DOP), but this survey is not being conducted in 2023. Additional sampling is conducted specifically for this management action to increase the spatial and temporal resolution of data in the area of interest. See Table 4 for the list of stations and sampling schedule and Figure 17 for a map of all fixed stations.

Figure 17 **Phytoplankton and Zooplankton sampling locations**



Zooplankton sampling by STN and FMWT are described in the previous section. EMP conducts water quality, phytoplankton, and zooplankton sampling on a monthly basis throughout the upper estuary at 17 stations (Figure 15). At each station, they collect a 10-minute stepped oblique trawl using the same zooplankton sled used by FMWT (see above). Additionally, they collect microzooplankton using a vertically-integrated pump sample (https://wildlife.ca.gov/Conservation/Delta/Zooplankton-Study). Two of these stations are not fixed, but instead follow the salinity field and sample where the bottom salinity reaches 2 PSU and 6 PSU, respectively.

The DOP (https://www.usbr.gov/mp/bdo/directed-outflow.html), established in 2017, collects data on water quality, phytoplankton, zooplankton, and fish (Schultz 2019). Like EDSM, DOP conducts stratified random sampling instead of sampling at fixed stations, and DOP coordinates some of its fish monitoring with

EDSM. DOP collects zooplankton in three regions relevant to this action: Suisun Bay, Suisun Marsh, Lower Sacramento River. This survey collects three zooplankton samples per week per region from April to November, paired with EDSM. Instead of the oblique tows used by the other zooplankton surveys, DOP concurrently collects pairs of samples from each location, one from near the top of the water column and one from near the bottom. Analysis suggests that this combination of top and bottom tows provides comparable results to oblique tows (Schultz 2019). Zooplankton are sampled using a 50-cm diameter bongo net frame towed for seven minutes. One of the bongo cylinders is outfitted with 500-micron mesh for macro-zooplankton, the other cylinder is outfitted with 150-micron mesh for meso-zooplankton. The survey is currently being re-designed, so while these data will be used for historical comparisons, they will not be collected in 2023.

Additional sampling was initiated in 2020 to increase the number of stations in key regions and/or increase the frequency of sampling during the time period of interest (Table 4, Figure 15). The goal was to achieve sampling every two weeks during July to October. In the Eastern Marsh, one new station was added (“Mont”), and sampling at STN stations 609 and 610 was extended into September and October. In the Western Marsh, the frequency of sampling of EMP NZS42 and FMWT 606 was increased from monthly to every two weeks. Also, FMWT 605, which previously only sampled fish, now includes zooplankton sampling every two weeks. In the River region, the frequency of sampling for a set of FMWT stations (513, 704, 706, 802) was increased from monthly to every two weeks. Other areas will be monitored for potential side effects of the SMSCG action, including Honker Bay and Grizzly Bay, so sampling of some FMWT stations in these areas will be increased to every two weeks (508, 519, 602).

All four surveys have similar zooplankton processing methods. In brief, samples are concentrated in the laboratory by pouring them through a sieve screened with 150-micron mesh wire and reconstituted to organism densities of 200-400 per milliliter. The sample is stirred to distribute the animals homogeneously and a 1-milliliter subsample is extracted with an automatic pipette and placed in a Sedgewick-Rafter cell (slide). All animals on a slide are identified and counted under a compound microscope to the lowest possible taxonomic classification. This procedure is repeated until 6% of the sample, or between 5 and 20 slides, are analyzed.

We will be evaluating the mesozooplankton collected by the 160-micron mesh nets only. Analysis of 2018 data found that the data collected with a 500-micron mesh (Mysid) net were too highly variable to reach any conclusions about the effects of the action. We will, therefore, not collect extra mysid samples in future years.

Phytoplankton

To monitor phytoplankton, several types of data will be used. Water quality stations distributed throughout the area will collect algal pigment fluorescence data every 15 minutes (Figure 15, Table 3). Water samples will be collected from these stations every two weeks or monthly for laboratory analysis of chlorophyll-*a* and used to calibrate the continuous fluorescence data (Figure 15, Table 3). This chlorophyll-*a* concentration data serves as a proxy for phytoplankton abundance. Phytoplankton community composition sampling was initiated in 2020 and currently includes 13 sampling sites, which are a subset of zooplankton stations (Table 4,Figure 17). There are six fixed stations within Suisun Marsh and three in the River region, as well as one fixed station within each Grizzly Bay and Honker Bay and the existing “floating” stations at 2 PSU and 6 PSU. Samples will be collected as 60-mL water samples preserved with Lugol’s iodine solution. Taxonomic analysis will be conducted by BSA Environmental Services, Inc. (Beachwood, OH), following the same methods and procedures as the EMP phytoplankton samples. These samples augment existing IEP phytoplankton community composition data that is collected monthly by EMP at all their fixed stations (see descriptions of EMP above).

Table 4 stations and general timing for biweekly phytoplankton and zooplankton sampling. EMP = stations with monthly phytoplankton and zooplankton sampling that could augment or replace some of the other samples, depending on relative timing. Phyto = subset of zooplankton stations to sample for phytoplankton. Stations and/or sampling dates specific to the SMSCG action monitoring are denoted with an asterisk.

Region	Phyto	EMP	July Week 1	July Week 3	August Week 1	August Week 3	September Week 1	September Week 3	October Week 1	October Week 3
River	Y	NZ064	STN 706	STN 706	STN 706	STN 706	FMWT 706	FMWT 706*	FMWT 706	FMWT 706*
River	Y	—	STN 704	STN 704	STN 704	STN 704	FMWT 704	FMWT 704*	FMWT 704	FMWT 704*
River	Y	NZ060	STN 801	STN 801	STN 801	STN 801	FMWT 802	FMWT 802*	FMWT 802	FMWT 802*
River	N	—	STN 513	STN 513	STN 513	STN 513	FMWT 513	FMWT 513*	FMWT 513	FMWT 513*
River	N	NZ054	STN 508	STN 508	STN 508	STN 508	FMWT 508	FMWT 508*	FMWT 508	FMWT 508*
Marsh	Y	—	STN 609	STN 609	STN 609	STN 609	STN 609*	STN 609*	STN 609*	STN 609*
Marsh	Y	—	MONT*	MONT*	MONT*	MONT*	MONT*	MONT*	MONT*	MONT*
Marsh	Y	—	STN 610	STN 610	STN 610	STN 610	STN 610*	STN 610*	STN 610*	STN 610*
Marsh	Y	—	FMWT 605*	FMWT 605*	FMWT 605*	FMWT 605*	FMWT 605*	FMWT 605*	FMWT 605*	FMWT 605*
Marsh	Y	NZ032	STN 606	STN 606	STN 606	STN 606	FMWT 606	FMWT 606*	FMWT 606	FMWT 606*
Marsh	Y	NZS42	EMP NZS42*	EMP NZS42*	EMP NZS42*	EMP NZS42*	EMP NZS42*	EMP NZS42*	EMP NZS42*	EMP NZS42*
Bay	Y	—	STN 519	STN 519	STN 519	STN 519	FMWT 519	FMWT 519*	FMWT 519	FMWT 519*

Region	Phyto	EMP	July Week 1	July Week 3	August Week 1	August Week 3	September Week 1	September Week 3	October Week 1	October Week 3
Bay	Y	NZ028	STN 602	STN 602	STN 602	STN 602	FMWT 602	FMWT 602*	FMWT 602	FMWT 602*
Floating	Y	EZ02	EMP EZ02	—	EMP EZ02	—	EMP EZ02	—	EMP EZ02	—
Floating	Y	EZ06	EMP EZ06	—	EMP EZ06	—	EMP EZ06	—	EMP EZ06	—

Microcystis

Microcystis monitoring is conducted by many of the IEP surveys, including STN, FMWT, and EMP. Visual assessment of *Microcystis* abundance is made concurrently with the zooplankton and fish sampling. An ordinal score is recorded based on the density of *Microcystis* colonies. The range of the scale is 1-5, with 1 being "absent" and 5 being "very high" (Figure 18).

Aquatic vegetation

To assess the potential impact of the SMSCG action on aquatic weed spread, we are contracting with the UC-Davis Center for Spatial Technologies and Remote Sensing to perform annual hyperspectral surveys of the full legal Delta and Suisun Marsh. They generate maps with areas classified by vegetation type (Figure 19). They also conduct field surveys of vegetation throughout the Delta and Suisun Marsh, which allows them to ground truth the hyperspectral imagery and determine the species composition of the vegetation. To date, Suisun Marsh has been imaged in 2018, 2019, 2021, and 2022 and DWR currently plans to fund this monitoring through at least 2023.

Figure 18 Ordinal scale for scoring *Microcystis* abundance from visual surveys.

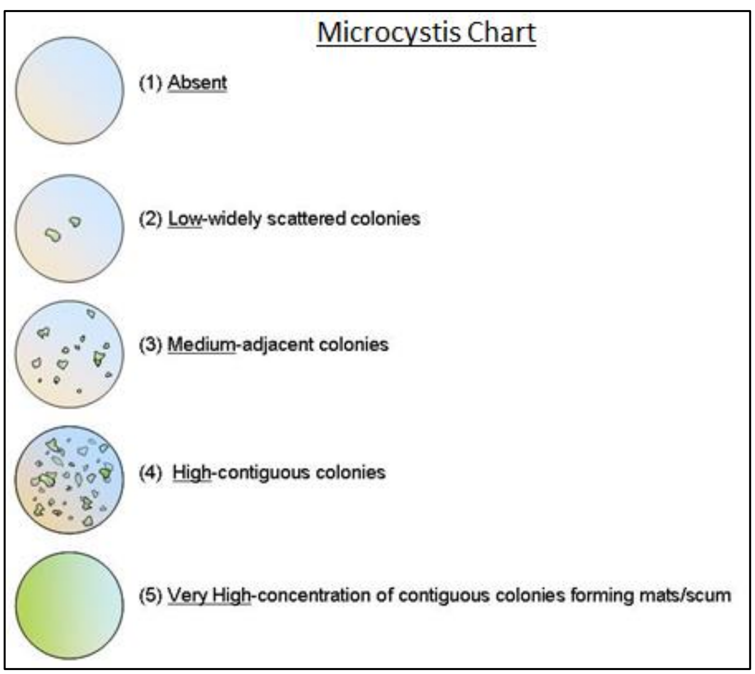
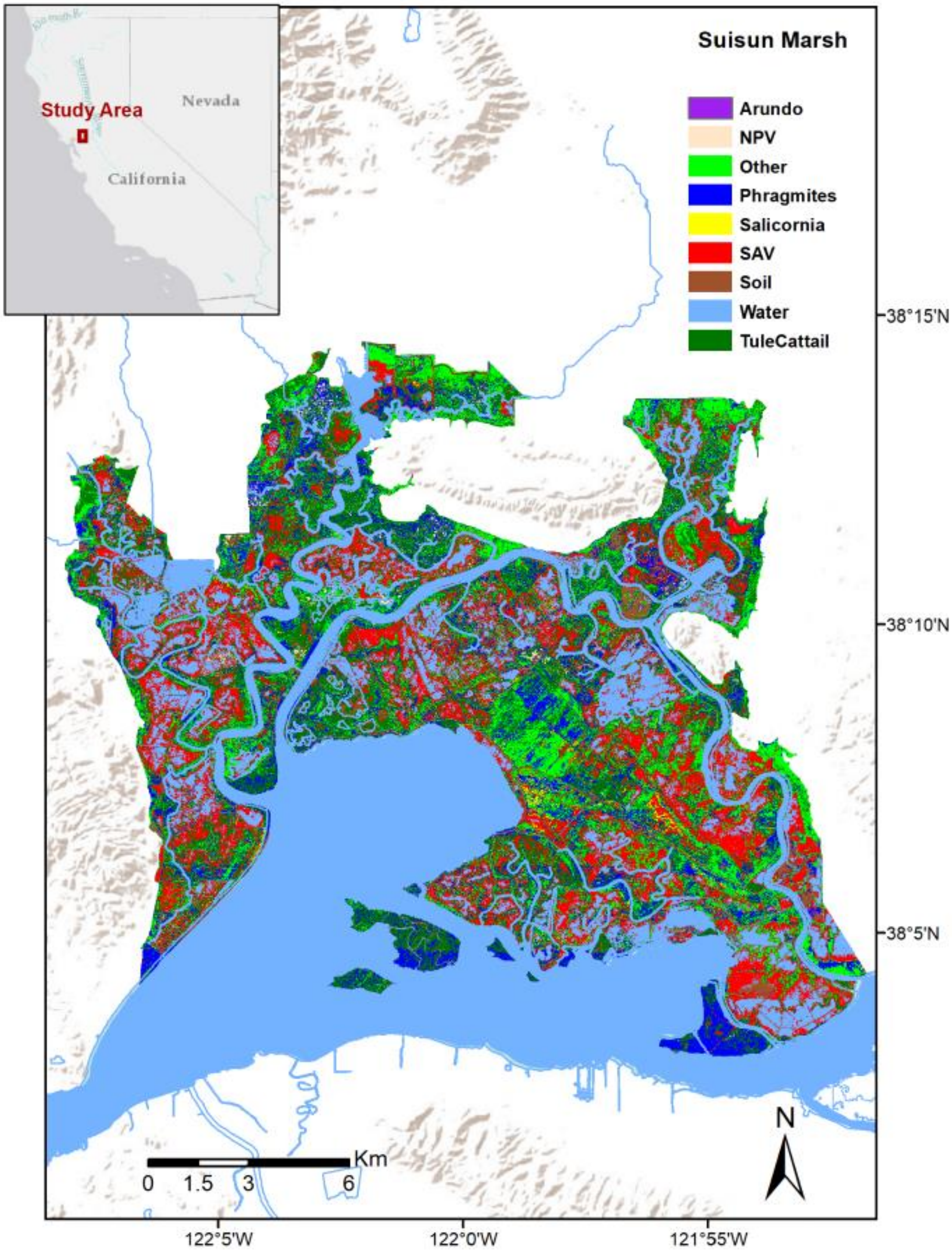


Figure 19 Classification map based on hyperspectral imagery collected in April 2019.



Outstanding monitoring needs

This workplan has been discussed and reviewed by the large team of interagency collaborators contributing to data collection, as well as the IEP FLOAT PWT. Many of these reviewers suggested additional monitoring as important for evaluating the SMSCG Action. This section documents those suggestions. This additional monitoring will not be implemented this year. However, discussions about the importance and feasibility of incorporating this work in future years is ongoing.

Fish community composition

There are concerns that the current approach for monitoring the response of the fish community to the SMSCG Action provides insufficient sampling and suffers from confounding effects. Monitoring is currently accomplished using a combination of existing IEP surveys, including the CDFW Summer Townet Survey (STN), San Francisco Bay Study, and Fall Midwater Trawl Survey (FMWT), as well as the UC Davis Suisun Marsh Survey and the USFWS Enhanced Delta Smelt Monitoring Program (EDSM) (see Biological Monitoring, above for details).

First, collaborators at USBR expressed concern that sampling by existing surveys in key areas of the marsh is too low for evaluating the effects of the action on fishes. For example, there are few fixed stations in the eastern portions of Montezuma Slough, and those stations are only sampled every two weeks or monthly. The amount of data obtained from these stations may be too low to capture changes in the community, particularly if the duration of the action is short. While it is true that the number of fixed stations in key areas is somewhat limited, there are supplemental data available from the randomly-selected EDSM sites. In previous years, evaluation of this action relied heavily on these weekly EDSM data. Also, the data collected in a single year may be insufficient to detect patterns in the community, but data combined across multiple years increases statistical power. Logistically, increasing the amount of sampling would be impossible at this time because any additional sampling would require ESA delta smelt take, a very limited resource, and there are currently insufficient staff to conduct the surveys. Ultimately, Delta Smelt are so rare that additional sampling probably still would not provide sufficient data on their response to the action, and data on the rest of the fish community is of secondary importance. Monitoring changes in the environmental conditions favorable for Delta Smelt will need to largely serve as a surrogate for Delta Smelt abundances. The idea of expanded sampling targeting Delta Smelt may be re-examined if experimental releases of

Delta Smelt are successful in increasing catch of smelt by EDSM on a regular basis.

Second, combining data sets from different surveys results in potential confounding spatially and/or temporally. There is risk of spatial confounding because the UC-Davis Suisun Marsh Survey samples primarily in small sloughs while most other surveys sample primarily in large sloughs. In this case, it could be difficult to determine whether differences in fish communities are due to differences in surveys, habitats, or both. Similarly, there is risk of temporal confounding because surveys occur at different times. For example, the Summer Town Net survey occurs June to August and Fall Midwater Trawl occurs August to at least October. Creating a rigorous monitoring design using a combination of different surveys comes with unique challenges, and these confounding effects are an issue. However, spatial and temporal overlap in subsets of stations across surveys can help evaluate the degree of the issue. For example, there are a few stations for the UC-Davis Suisun Marsh Survey that are done in large sloughs, and data from these stations could be compared with nearby stations from other surveys. For temporal confounding, there are surveys that occur all year (EDSM: weekly, UC-Davis: monthly) that could help to determine how much of an issue temporal confound between STN and FMWT is. In addition, the recently published data set and associated R package ('deltafish') that integrates data from all of these fish surveys will facilitate analysis of responses to this management action by the fish communities. Analyzing data from a mix of surveys is not easy, but if the limitations of the approach are kept in mind during both analysis and interpretation, it should be possible, as has been done by Stompe et al. (2020) and Polanksy et al. (2019).

Delta Smelt Enclosure studies

Enclosures will only be deployed this year if the SMSCG action occurs. Enclosures may be used in future years to assess how the action impacts smelt survival, health, and condition. See the Smelt Enclosures Study workplan for full details.

Since wild Delta Smelt have become increasingly rare, we will use hatchery fish placed in novel enclosures to provide supplemental information about fish responses to different regions and management actions. As part of the effort to evaluate potential management uses of Delta Smelt (Lessard et al. 2018), UC Davis, DWR, and FWS have developed floating enclosures that could be used to house cultured Delta Smelt. These enclosures were successfully tested in 2019 at Belden's Landing and the Sacramento River (near Rio Vista) to obtain baseline data during a no-action year to enable comparisons with future years in which SMSCG actions occur.

Table 5 Data sources with current status of data collection

Variable	Suisun Marsh Region (Montezuma Sl, Grizzly Bay, Honker Bay)	River Region (Mainstem from Confluence area to Rio Vista)
Abiotic Habitat	—	—
Average Daily Net Delta Outflow	Dayflow	Dayflow
San Joaquin River Contribution Outflow	Dayflow	Dayflow
Surface area of the LSZ	SCHISM Modeling	SCHISM Modeling
Turbidity, Salinity, Temperature	*Discrete:* Biweekly, existing STN/FMWT stations + 3 additional stations. (*n = 8*)	*Discrete:* Biweekly, STN/FMWT stations, from confluence up Sac River to Station 711 (*n = 5)*
	Continuous: Existing Stations (GOD, HUN, BDL, NSL, MSL, HON, TYC, PTC) + 3 new stations in Grizzly Bay	*Continuous:* Existing stations PTC MAL, CSE, RVB, LIS
Biotic Habitat	—	—
Chlorophyll-*a*	*Continuous:* Existing Stations (GOD, HUN, BDL, NSL, MSL, HON, TYC, PTC) new stations in Grizzly Bay	*Continuous:* Existing stations PTC, MAL, CSE, RVB, LIS
Phytoplankton Community	EMP/DOP plus up to 6 additional stations	EMP/DOP plus up to 3 additional stations
Microcystis abundance	STN/FMWT/EMP	STN/FMWT/EMP
Zooplankton abundance	STN/FMWT/EMP/DOP	STN/FMWT/EMP/DOP

Variable	Suisun Marsh Region (Montezuma Sl, Grizzly Bay, Honker Bay)	River Region (Mainstem from Confluence area to Rio Vista)
Delta Smelt Responses	—	—
DS growth, survival, and fecundity	STN/FMWT/EDSM (otoliths-growth) Enclosures	STN/FMWT/EDSM (otoliths-growth) Enclosures
DS health and condition	STN/FMWT/EDSM Enclosures	STN/FMWT/EDSM Enclosures
DS Recruitment the next year	STN/FMWT/EDSM	STN/FMWT/EDSM
DS Population life history variability	STN/FMWT/EDSM (otoliths)	STN/FMWT/EDSM (otoliths)
DS behavior	Enclosures	Enclosures

Data analysis and synthesis

As noted in the predictions, we will rely on four basic approaches to evaluate the data described in the previous section: 1) Comparisons to historical data; 2) Regional comparisons; 3) Comparisons for Before, During, and After the SMSCG Action; and 4) Modeled simulations of habitat components with and without the SMSCG Action. Each of these approaches are described briefly, below. In addition, we provide examples of which of the four approaches will be used on data sets described above (Table 6). Data limitations may prevent us from conducting full statistical analyses on each component, but the combined analyses will allow us to use a weight-of-evidence approach to evaluate the effectiveness of the action.

1. Historical Comparisons: A primary approach will be to evaluate the predictions as compared to years when the action was not conducted (e.g. 1987-2017). This analysis will be performed using visual comparisons of data from 2020 with previous dry summers and wet summers, identified through hierarchical cluster analyses (as in Sommer et al. 2020).
2. Regional Comparisons: A key assumption in our conceptual model is that habitat conditions with be different in the Marsh, Grizzly Bay, and River regions. To compare these regions, we will perform a series of generalized

linear models on various environmental parameters versus regions. For continuous parameters (salinity, temperature, turbidity, and chlorophyll), we will include a lag term to account for temporal autocorrelation or perform an autoregressive-moving-average model.

3. Comparisons Before-During-After: An additional part of the analysis will include looking at before the action period (e.g., May-June), during the action period (e.g., July-Sept), and after the action (e.g., October). The latter approach is particularly important for selected new water quality sensors and newer zooplankton stations for which there is no historical record. For parameters such as temperature that have clear seasonal patterns, we will compare the difference in observed water temperature from the historical average before, during, and after gate operation, rather than absolute temperature. This analysis will be combined with the regional analyses using generalized linear models with time period as a categorical predictor variable.
4. Simulation Modeling: Interannual and seasonal variability are confounding factors that will affect our ability to interpret summaries from Approach #1 and #3 above. However, simulation modeling provides an approach to understand how conditions might be different with and without the SMSCG Action. As described above, a key element of this work will be SCHISM modeling to provide a high- resolution evaluation of how habitat conditions changed under the action.

Table 6 Example planned analyses. Some of these analyses may be difficult to test statistically without multiple years of data.

Variable	Historical Comparisons	Regional Comparison	Before-During-After Comparison	Modeled With/Without Project
Abiotic Habitat	—	—	—	—
Average Daily Net Delta Outflow	X		X	X
Surface Area of LSZ	X	X	X	X
Turbidity, Salinity, Temperature	X	X	X	X
Biotic Habitat	—	—	—	—
Chlorophyll-*a*	X	X	X	
Phytoplankton Community Composition	X	X	X	
Microcystis	X	X	X	
Zooplankton Biomass	X	X	X	
Fish Community	X	X	X	
Delta Smelt (DS) Responses	—	—	—	—
DS Distribution	X	X	X	
DS Growth, Survival, and Fecundity	X	X	X	
DS Health and Condition	X	X	X	
DS Recruitment the Next Year	X			
DS Population Life History Variability	X	X	X	

Budget

The following summarizes some of the approximate major costs for a typical year of a SMSCG action (Table 7). This includes the costs associated with operating and monitoring the SMSCG, but does not include cost of additional outflow water. The program will also be supported through in kind contribution of time by DWR PIs and IEP synthesis staff. All other costs included in fully-funded IEP sampling programs (EMP, STN, FMWT, EDSM, DOP, Bay Study, UCD Suisun Marsh).

Table 7 Approximate budget of the SMSCG action for years when the action occurs and years when it does not occur.

Cost	Approximate annual amount – Action year	Approximate annual amount – No Action Year
Gate and boat lock operations	$200,000	$0
Water quality monitoring	$100,000	$100,000
Phytoplankton analysis	$30,000	$30,000
Modeling Delta Outflow and area of Delta Smelt Habitat	$50,000	$50,000
Program management and data analysis	$250,000	$200,000
Total:	$630,000	$380,000

Sample Collection and Permitting

Since the project will rely on existing IEP fish sampling in the region (STN, FMWT, EDSM, UCD Suisun Marsh, Bay Study), the take authority is covered by each respective program. The project includes some additional zooplankton, water quality sondes, and benthic sampling. **No additional take for listed species is requested** for most of these activities as the entities carrying out the work already have sufficient incidental take coverage. Permits and CEQA analysis for the gate action itself is covered under the State Water Project EIR, BiOp and ITP.

Reporting

A range of deliverables will be provided to suit the needs of different audiences.

- An annual report summarizing all data collected for the action.

- A data package published on the Environmental Data Initiative data repository containing all the data collected as part of this study. (see Attachment 2: Data Management Plan).
- At least two presentations or posters at scientific conferences, including the IEP annual workshop.
- Short summaries and fact sheets to accompany technical report.

Data from this year may be used in peer-reviewed publications published in future years when a gate action occurs, but no manuscripts are planned for 2022 unless we find unexpected results.

Timeline

The timeline mapped out below is a projected timeline for the project in most years (Table 8) but may be adjusted pending water forecasts. The Biological Opinion and ITP both state that there will be up to 60 days of gate operations between June 1 and October 1 of most year types over the course of the 10-year ITP. Every year, the Delta Coordination Group will begin planning the action in March and develop a final Habitat Action Plan by May. Most years, we expect the action to begin in July or August rather than June, depending on Delta hydrology and salinity at Belden's Landing. Monitoring for the action will begin at least one month prior to the action and continue for one month after the action. Phytoplankton and zooplankton sample processing may not be completed until six months or more after the action, but we will have a preliminary report complete by February 28th of each year, to be updated with plankton data as it becomes available. The workplan will be re-assessed annually, with a more comprehensive review after four years.

Table 8 Timeline of planning, gate operation, and monitoring for years when gate actions occur.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Planning			Hydrologic forecast, DCG meeting	Develop Habitat Action Plan	Final Habitat Action plan, IEP workplan update						Hindcast modeling	Hindcast modeling
Operations		Nor	mal gate ops			Special	gate	ops		Nor	mal gate op	s

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sample collection						Plankton, fish, and water quality data						
Sample processing								Plankton sample processing				
Analysis		Write report on last year							Analyze results			

Coordination with IEP

A key part of the adaptive management of this project will be outreach and coordination of the work. As noted above, the primary vehicles for coordination will be the Delta Coordination Group and IEP FLoAT PWT. The former includes the major decision makers involved in the project, and the latter represents a public forum for all parties interested in the projects. Both groups will be reviewing this monitoring plan. In addition, project management will provide periodic briefings to the Suisun Environmental Coordination Advisory Team, which was designed specifically to help coordinate Suisun Marsh activities.

This project is highly consistent with the Restoring Native Species and Communities section of the IEP Science Strategy. Specifically, the "Flow modifications and benefits" topic for smelts. The approach is also consistent with the stated goal of the IEP Science Strategy to use a suite of methods (Monitoring, Experiments, Modeling) to answer management questions. Additionally, the project addresses the specific mandates in the ITP and Biological Opinion to increase science to understand Delta Smelt Habitat in the summer and fall, increase monitoring in Grizzly Bay, and implement a science and monitoring program surrounding the Summer-Fall Habitat Action.

As will be described below, the project relies heavily on existing data and samples collected by IEP in Suisun Marsh and the low salinity zone. Additional work requested of IEP includes: 1) Assistance with synthesis (IEP FLoAT PWT); 2) Operation of supplemental water quality sondes (DWR IEP Staff); 3) Collection and analysis of supplemental phytoplankton and zooplankton samples (CDFW IEP Staff).

The project will also coordinate with existing IEP monitoring and specific projects that are either already collecting data in the region, or have planned studies. Examples include:

- UC Davis Suisun Marsh Study (O'Rear)
- Directed Outflow Project (Schultz, USBR)
- Tule Red Shallows Benthic and Pelagic Collections (De La Cruz, USGS)
- Fish Restoration Program Monitoring (Sherman), particularly at the Tule Red restoration site.

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