Sacramento Deep Water Ship Channel Food Study – Pre-Project Monitoring

Bureau of Reclamation and Cramer Fish Sciences

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Project Description

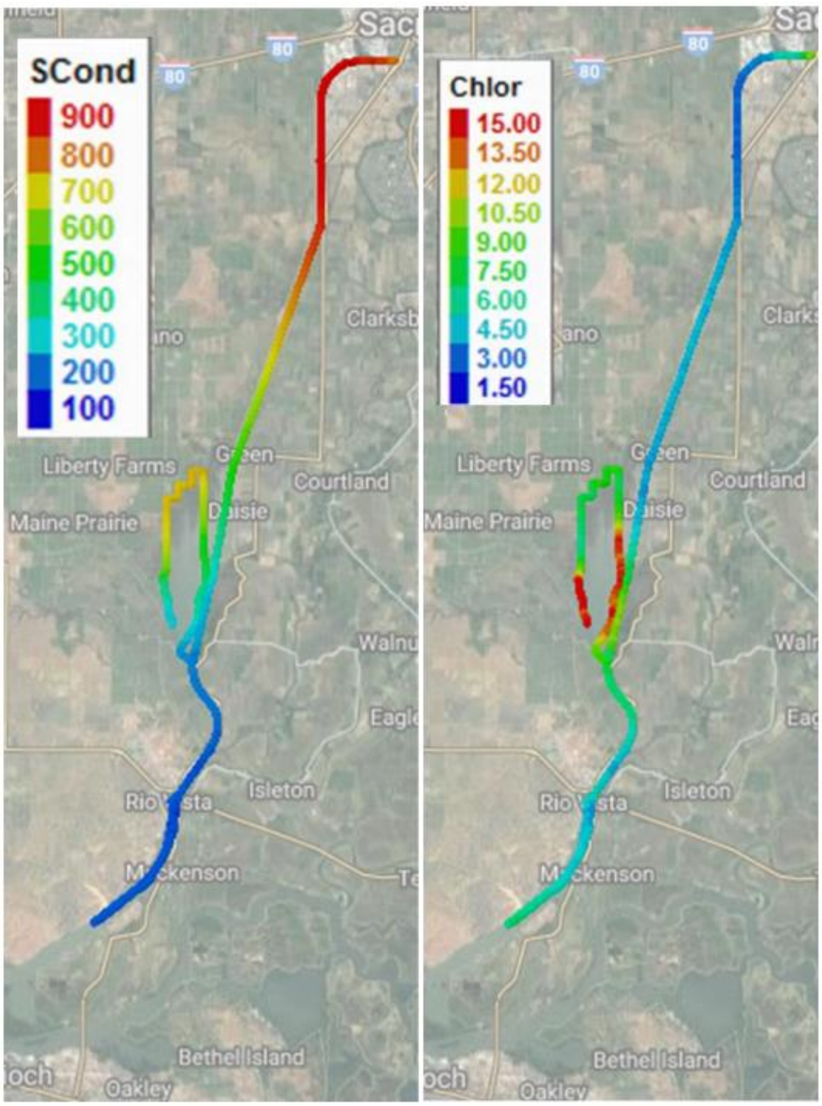
Succinct Study Concept

As part of its 200-year flood protection planning process, the City of West Sacramento is developing alternatives that include constructing or repairing infrastructure that would provide an opportunity to restore the historic hydraulic connection between the Sacramento Deepwater Ship Channel (SSC) and the Sacramento River (Thomas et al. 2019, 2020). A reconnected SSC has the potential to export primary and secondary production into the North Delta, potentially increasing food supply for pelagic fish including Delta Smelt (*Hypomesus transpacificus*). While the SSC presently has little net flow, it is still a dynamic system where tide, wind, and solar inputs can dramatically affect food web function. Describing these relationships and general pre-project food web patterns will support our understanding of how SSC flow and possible nutrient supplementation may alter present food web conditions. The purpose of the Sacramento Deep Water Ship Channel Food Study – Before-After Pre-Project Monitoring (Project) is to collect baseline data in advance of the reconnection. Using the Aquatic Habitat Sampling Platform (Platform), water quality, zooplankton, and fish communities will be sampled twice monthly from SSC Marker 62 (adjacent to Courtland on the Sacramento River) to the W.G. Stone Navigation Lock (~RM 87; **Error! Reference source not found.**). Sampling will occur in both SSC littoral and pelagic habitats during the day and at night.

Statement of Research Problem

Central Valley Project (CVP) operations are thought to contribute to the decline of Delta Smelt, an endemic fish listed as 'threatened' under the federal Endangered Species Act (ESA), by adversely affecting the extent and quality of its critical habitat. Under the Central Valley Project Improvement Act of 1992, Reclamation has the authority to fund activities with the potential to reduce CVP impacts on smelt and their critical habitat and to undertake actions to improve Delta habitat conditions.

Figure 1 Longitudinal variation in specific conductance and chlorophyll concentration in the main stem Sacramento River, Cache Slough Complex and Sacramento ship channel, July 26, 2012, showing three distinct water zones and persistent small phytoplankton blooms below the gates in the West Sacramento Port, believed due to nutrient inputs from leakage through the gate and groundwater inputs from the Sacramento River. Reproduced from Reclamation 2018.

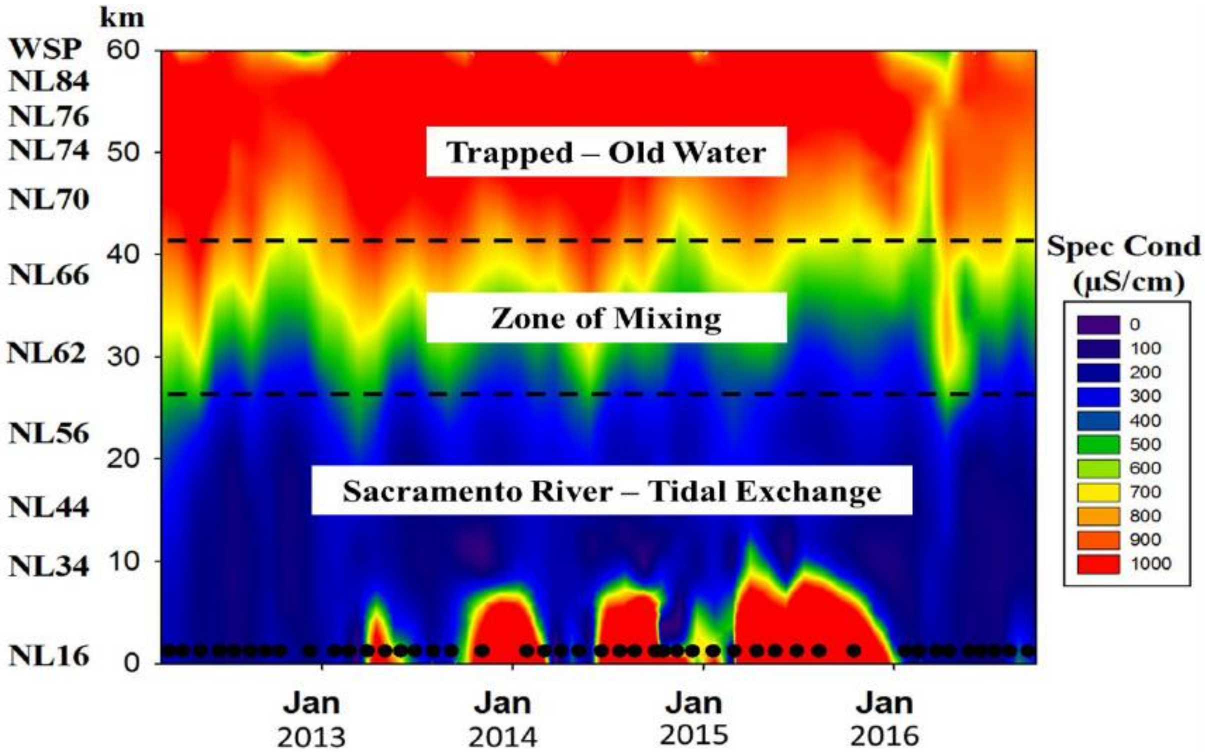


As in many estuaries, fish and other higher trophic level production in open waters (pelagic habitat) of the Delta region is fueled by phytoplankton. However, the Delta has notably low phytoplankton production and biomass

(Van Nieuwenhuyse 2007; Jassby 2008) resulting in food-limitation and low overall productivity compared to other systems (Kimmerer 2002). Consequently, increasing food resources (i.e., phytoplankton and zooplankton) is expected to have a beneficial effect on the entire system, including Delta Smelt. As a result, a goal for north Delta food resource management is to increase the standing stock of algal biomass.

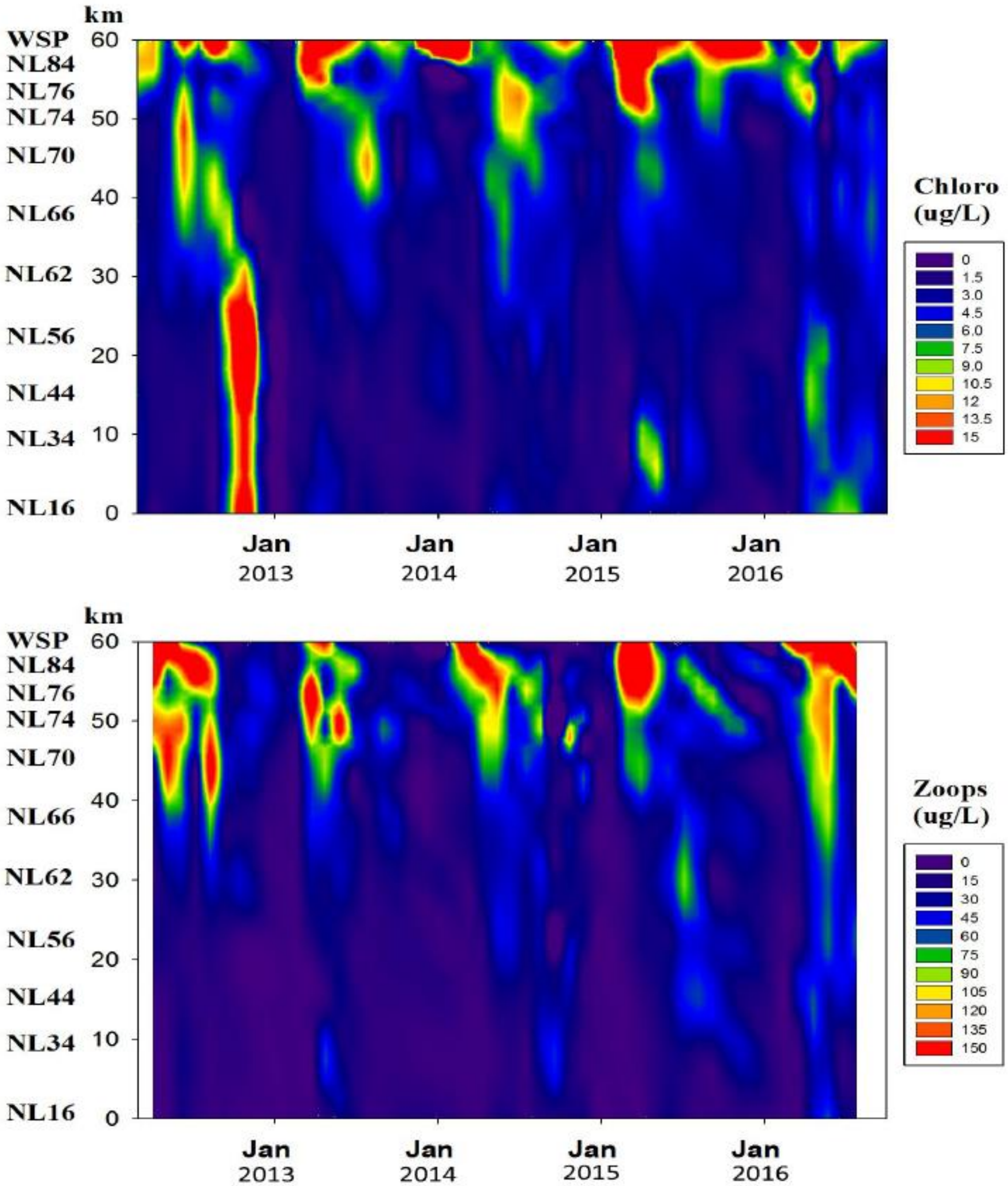
The Sacramento Ship Channel (SSC) represents an opportunity to enhance export of additional food web resources into the North Delta (Reclamation 2018). Water in the upper section of the SSC, termed "old water," experiences lentic conditions with little flushing or mixing (Figures 1 and 2). Seasonally, moderate blooms of phytoplankton and zooplankton are observed throughout the old water zone and more persistent blooms are observed below the gates in the West Sacramento Port (WSP; Figures 1 and 3), possibly due to nutrient inputs from leakage of Sacramento River water through the gates (especially during high flow periods). These observations, coupled with monthly nutrient, phytoplankton and zooplankton monitoring (collected by Reclamation since 2012), bioassay-scale experiments, and a series of ship channel nitrogen-addition experiments (conducted in 2019), all suggest that nitrogen additions to the system should enhance both primary (phytoplankton) and secondary (zooplankton) production and standing crops.

Figure 2 Longitudinal variation of specific conductance (saltiness) in the Sacramento ship channel, 2012-2016, demonstrating three distinct water zones. Reproduced from Reclamation 2018.



However, even with enhancement these food resources remain trapped in this zone with minimal advection to the tidal mixing zone where they could enter the north Delta. If the City of West Sacramento selects a flood control infrastructure alternative that allows for hydraulic reconnection between the ship channel and the Sacramento River, there would be an opportunity to export some of this food production to downstream reaches of the ship channel and the North Delta (Reclamation 2018). The proposed action posits that the reconnected ship channel has the potential to transport phyto- and zooplankton growing in the channel into the north Delta to improve food availability in the Liberty Island/Cache Slough region. Thus, in the SSC, there is the potential to control both water flow rates (diversions from Sacramento River) and nutrient concentrations (e.g., through nutrient additions) to enhance food resource export to the north Delta.

Figure 3 Longitudinal variation in chlorophyll concentration (top) and zooplankton biomass (bottom) in the main stem Sacramento River and ship channel, 2012-2016, demonstrating seasonal small blooms of phytoplankton and zooplankton throughout the old water zone and more persistent blooms below the gates in the West Sacramento Port. Reproduced from Reclamation 2018.



This proposed action hypothesizes that it may be possible to manipulate the SSC in a manner that would foster self-sustaining phytoplankton/zooplankton blooms and improve food conditions in these Delta Smelt habitats. Reconnecting the ship channel with the Sacramento River would alter many other environmental properties including hydraulic residence, specific conductance and possibly water clarity and could also introduce contaminants (e.g., rice herbicides and fungicides) discharged from the Colusa Basin Drain and other agricultural sources. Thus, the net direction and magnitude of the proposed action effect on Delta Smelt habitat is uncertain. This management question calls for comparing baseline data collected prior to the proposed action to future habitat conditions to document the presence and direction of an effect. To do this, it is critical to develop a database of current "pre-project" habitat conditions. Because species richness, productivity, and food web dynamics vary across differing environmental gradients, baseline pre-project SSC physical and biological data are needed to understand seasonality, weather (e.g., temperature, wind), and habitat (littoral, pelagic) along the stream continuum.

Research Objectives

It is hypothesized that manipulating SSC nutrients would allow Reclamation to grow up standing phytoplankton and zooplankton stocks and pulse these food resources (via reoperation of SSC lock) into the north Delta to create self-sustaining phytoplankton/zooplankton blooms. Increasing food resources in the food-limited North Delta is expected to have beneficial effects on the entire system, including ESA-listed Delta Smelt. The current Project is an initial step in this broader effort and our objective is to support determination of effects of these actions on SCC food production. Because species richness, productivity, and food web dynamics vary across environmental gradients, baseline pre-project SSC physical and biological data are needed to understand seasonality, weather (e.g., temperature, wind), and habitat (littoral, pelagic) effects along the stream continuum. We plan to collect pre-project data that supports testing hypotheses on proposed action effects. Research performed during this study will either directly answer the following postulated questions or provide the baseline data to be compared against in future research if and when the project is implemented (agricultural contaminants will be tracked under actions outside of this proposed research).

Research Questions

- How does fish community composition vary longitudinally and laterally (littoral vs pelagic) along the SSC?
- How does relative abundance of select fish and zooplankton taxa vary?
- How do fish and zooplankton communities differ between littoral and pelagic habitats?
- Is there a systematic relationship between measures of trophic state (chlorophyll a) and relative abundance of fish?
- What are present relationships between season, wind, water quality (e.g., temperature, dissolved oxygen, turbidity), nutrients, and phytoplankton standing stock along the SSC through the summer and fall period?
- How do habitat (littoral vs pelagic) and time (day vs night) affect these relationships?

Finally, by performing this research we will collect the baseline data necessary to ultimately evaluate how restored hydraulic connectivity between the SSC and Sacramento River will affect phytoplankton standing stock.

Study Design

Site Description

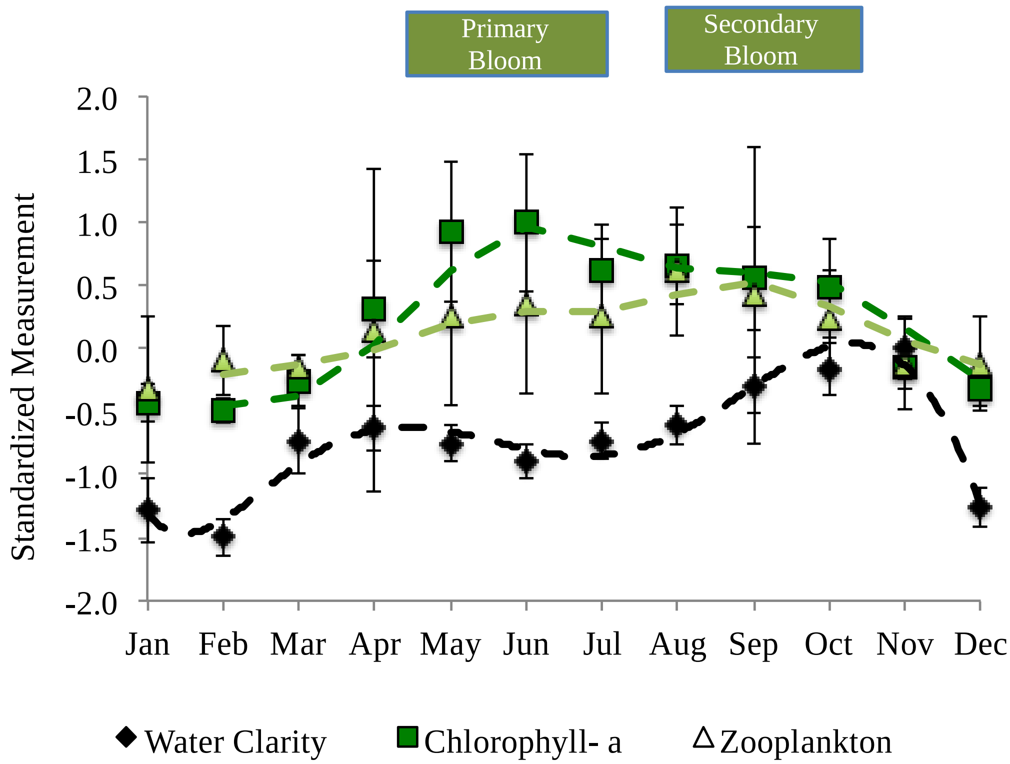
Sacramento Ship Channel

The Project will sample littoral (shallow; nearshore) and pelagic (open water) habitats from SSC Marker 62 (adjacent to Courtland on the Sacramento River) to The W.G. Stone Navigation Lock (~RM 87) to provide baseline data on food web dynamics across seasons, weather (e.g., temperature, wind), and habitats (littoral, pelagic). The SSC offers a longitudinal gradient of salinity, turbidity, water temperature, ammonium, phosphorus, nitrate, N:P ratio, phytoplankton and zooplankton abundances, and species composition (E. Van Nieuwenhuyse pers. Comm.). The SSC consists of three longitudinally distinct zones as illustrated by specific conductance (EC, Reclamation 2018). These zones include an area of trapped water in the upper section (lentic conditions), a zone of mixing in the mid-reach, and the lower zone that experiences tidal exchange twice a day (Figures 1 and 2). Seasonally, small blooms of phytoplankton and zooplankton are observed in the "old water" zone (Figure 3) and more persistent blooms below the gates in the West Sacramento Port (WSP; Figures 1 and 3). The Delta, including the SSC, has a Mediterranean climate with two distinct seasons, defined primarily by the precipitation regime: a cool, wet winter season (November through April) and a warm, occasionally foggy dry season (May through October). Historically, phyto- and zooplankton blooms persisted throughout the dry season (Figure 4; Merz et al. 2016). Preliminary data suggests that because the old water zone is largely isolated from mixing and tidal influences, wind may play a strong role in local food web dynamics (CFS 2020). The ship channel is bordered by shallow water with sandy or riprapped substrates that are not readily sampled by routine fish monitoring methods. Adjacent deeper areas of the ship channel are sampled routinely by the Summer Townet Survey, Fall Midwater Trawl, and Spring Kodiak Trawl.

The North Delta

The North Delta is a key area supporting native fish habitat, including Delta Smelt, and has been identified in the Delta Smelt Resiliency Strategy (DSRS) Over the past century, the extent of engineered levees in the San-Francisco Estuary (Bay-Delta) has dramatically reduced seasonally and tidally inundated shallow water habitat and overall habitat complexity of the system (Brown and Michniuk 2007). Most Delta levees are riprapped on the waterside and devoid of riparian vegetation or natural aquatic features (e.g., gently sloped banks, shallow benches, alcoves, fine-textured soils etc.). It has been hypothesized that channelization of estuary waters, installation of rock revetment, and removal of shaded riverine aquatic (SRA) and riparian habitat along the waters' edge have adversely affected native fish species through a number of pathways, including limiting food production (Baxter et al. 2010; Bennett and Moyle 1996; Feyrer et al. 2007; Hellmair et al. 2018).

Figure 4 Relationship between primary productivity and zooplankton biomass for 15 zooplankton stations monitored prior to the invasion of the overbite clam (1978-1985), demonstrating persistent blooms throughout the dry season (May-Oct). Lines represent locally weighted scatterplot smoother (Lowess). Means are standardized for comparison and presented as Z scores. Reproduced from Merz et al. (2016).



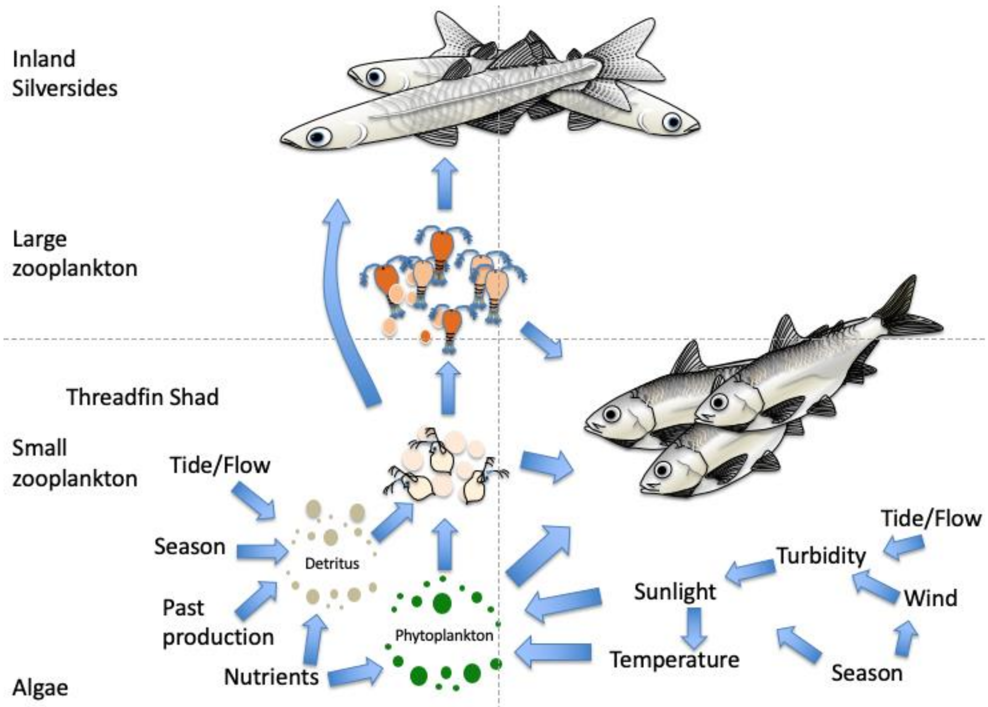
The Estuary Food Web

The Estuary food web has been altered by a series of species invasions (Winder and Jassby 2011; Kratina et al. 2014). The introduced suspension-feeding overbite clam (*Potamocorbula amurensis*), which spread throughout the entire Estuary following its introduction around 1986 (Nichols et al. 1990; Alpine and Cloern 1992; Winder and Jassby 2011), is a major driver of pelagic food web dynamics. Filter-feeding activity of this invasive clam greatly reduced phytoplankton production (Kimmerer et al. 1994). Substantial abundance, composition, and timing changes have simultaneously occurred in the zooplankton community and been attributed to clam predation (Kimmerer et al. 1994; Orsi and Ohtsuka 1999; Winder and Jassby 2011; Merz et al. 2016). Zooplankton abundance declines have been partially compensated by the non-native cyclopoid copepod *Limnoithona tetraspina*, introduced in 1993 (Bouley and Kimmerer 2006; Winder and Jassby 2011) but, while young Delta Smelt larvae consume *L. tetraspina*, unless resources are limited, late juvenile and older Delta Smelt do not. Further, due to *L. tetraspina*'s relatively small size, its utility as a food source is in question (Lott 1998; Bouley and Kimmerer 2006; Baxter et al. 2010; Hennessy 2011; Slater and Baxter 2014). Increased discharge of ammonium to the Estuary, largely from treated domestic sewage effluent, has also been linked to food-limited conditions and to reduced fish abundance (Dugdale et al. 2007, 2012, 2013; Glibert 2010, 2012; Glibert et al. 2011).

During the past several decades of environmental changes, species introductions, and Estuary food web alteration, Delta Smelt abundances have declined. Once the most abundant fish sampled in Delta trawl surveys (Stevens and Miller 1983; Moyle and Herbold 1989; Stevens et al. 1990), Delta Smelt catches were reduced to such a low level as to justify its listing as threatened under the Endangered Species Act in 1993. This continued long-term decline in Delta Smelt abundance coincides with declines in phytoplankton and native zooplankton production, suggesting zooplankton availability and quality may have played a role (Sommer et al. 2007; Winder and Jassby 2011; Slater and Baxter 2014; Stompe et al. 2020).

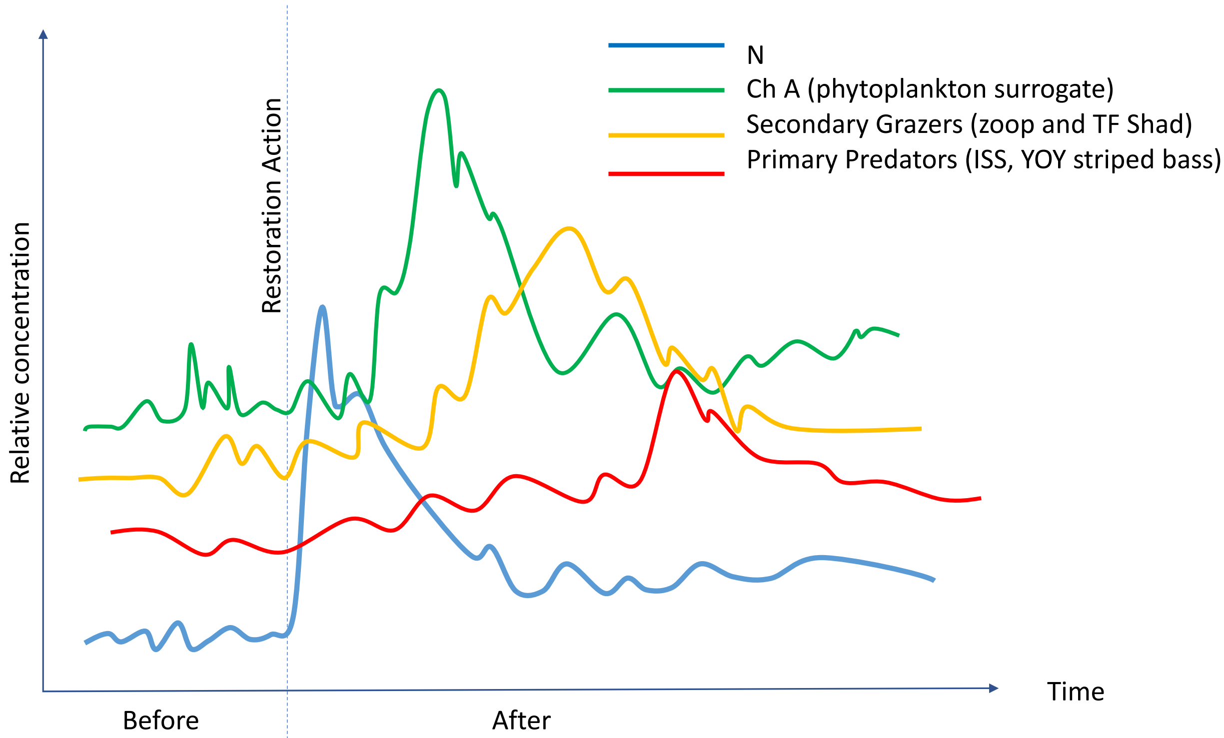
This study will collect baseline data on fish and zooplankton abundance paired with simultaneous data collected on abiotic conditions. As incidences of Delta Smelt observation are expected to be low, data analysis will focus on the two common invasive species as representatives of individual trophic level response to potential actions in the SSC (**Error! Reference source not found.**). Although Threadfin Shad *Dorosoma petenense* are considered omnivorous, over 40% (46-66%) of their diet can include phytoplankton, suggesting they are a good representative of primary consumers (Miller 1967; Kelley 1966). Inland Silverside *Menidia beryllina* is a euryhaline, zooplanktivorous, annual fish species, representing a secondary consumer that could rapidly respond to variation in food web changes (Chizinski et al. 2007). These species are also consistent with data collected during a pilot study of nutrient supplementation in the SSC conducted in 2019 (CFS 2020).

Figure 5 Simplified conceptual pelagic food web model for the Sacramento Shipping Channel including critical drivers, linkages, and dominant primary (Threadfin Shad) and secondary consumer (Inland Silversides) fish species. Arrows indicate direction of driver and energy flow. Arrow size is relative to conceptual level of importance. Reproduced from CFS 2020.



Pre-project monitoring establishes a baseline from which to measure change following an enhancement action (Roni et al. 2010). It is a critical component of the other monitoring phases because questions posed by effectiveness and validation monitoring can only be answered if the pre-project condition is documented. If the proposed action results in an increase in phytoplankton production, then it is hypothesized that the subsequent response of higher trophic levels may be described by a simple predator–prey mathematical model based on Lotka-Volterra's equation (e.g., Hairston et al. 1960). In this scenario, increased phytoplankton production would be followed first by increased production of zooplankton and threadfin shad in turn followed by increased production of predators such as inland silversides and young of the year striped bass (Figure 6).

Figure 6 Assumed Lotka-Volterra-type response of pelagic food web post restoration action. In this instance, we assume N is limited in the food web. Figure demonstrates hypothetical response of each trophic level following N enhancement.



Methods

Gear Description

The Project will make use of the Single-Platform Aquatic Species Habitat Sampling System (Platform; US Patent 9,776,692; US Patent 10,259,541). The Platform is a large pontoon boat with a forward deployed net that funnels fish and zooplankton past cameras and discharges entrained organisms from the stern (Figure 6, 7). The Platform allows for continuous, efficient sampling of shallow and pelagic habitats that minimizes lethal take of sensitive organisms, while allowing abiotic and biotic conditions to be related directly to fish and zooplankton observations (Merz et al. *In Review*). The Platform is very effective for fish and zooplankton sampling because it moves through the water more quickly than standard trawling methods and has fewer complications than a beach seine when sampling through complex habitats. It has also been successfully used to monitor abiotic and food web responses to experimental nitrogen supplementation in the SSC as a pilot study for the present Project (CFS 2020).

Figure 7 Lateral and top views of the sampling Platform showing forward deployed net and funneling of fish through the live box and out the stern of the boat.

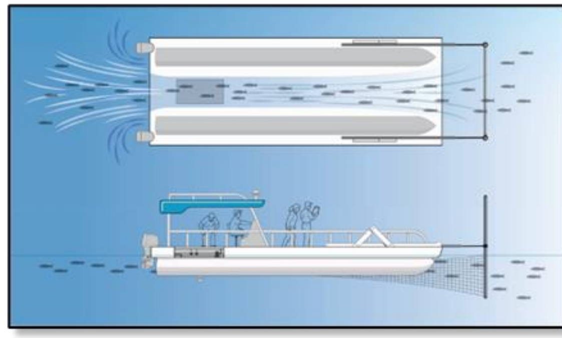


Figure 8 Tule perch in the Platform video chamber observed during June 2019 sampling at Sherman Island.

The Platform was developed to: 1) improve sampling representation and catch efficiency across aquatic habitats, 2) minimize or prevent lethal take of sensitive fish species, and 3) simultaneously collect additional biotic (e.g., zooplankton and larval fish) and abiotic data (e.g., water quality and depth) by combining new technologies that integrate fish sampling with key ecological attributes of occupied habitats. For example, while sampling fish, the Platform can simultaneously sample water chemistry, Chl *a*, and zooplankton communities for subsequent analysis, while providing a means to integrate eDNA collections. eDNA samples collected during Platform transects, and subsequently analyzed using metabarcoding and qPCR methodology, help to validate video fish observations, assess presence of fish species not observed directly in the Platform, and provides complimentary species occurrence data associated with Platform derived habitat data. The Platform enables the collection of spatially and temporally synchronized data using distinct spatial coordinates (via GIS) and time-stamp attributes. This integrated sampling feature is designed to save time and project resources by simultaneously collecting a broad suite of temporally and spatially coordinated data that represent multivariate environmental conditions experienced by targeted life stages and species of fishes being sampled. Overall, this approach provides an integrated, quantitative ecological context for comparing and evaluating empirical fish data, a critical feature not provided by conventional fish sampling methods.

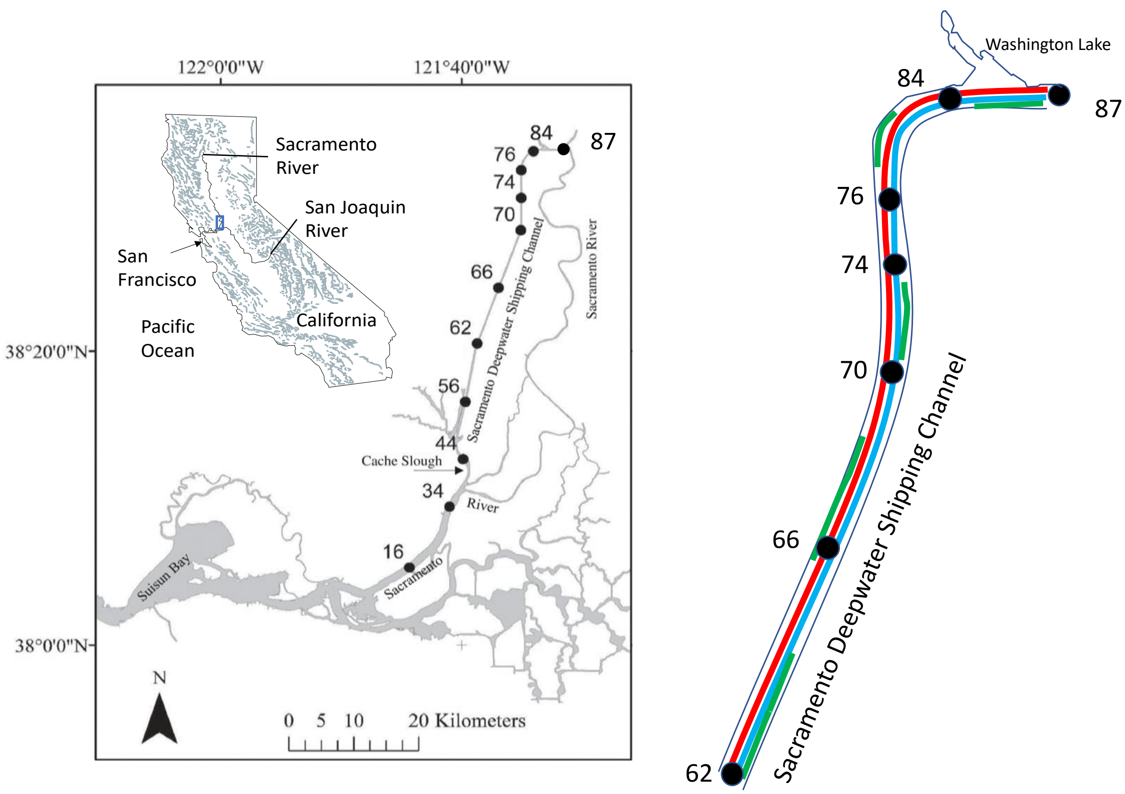
Field Sampling

We will collect fish and zooplankton community composition using a combination of Platform video and eDNA. During a sampling event, fish and macroinvertebrates will be continuously video sampled for the length of the study area (RM 62 to 87). During a subset of sampling events, composite water samples will be collected along the length of the channel and filtered for eDNA following the methods of Bergman et al. (2016), while boat latitude and longitude, water depth, boat velocity, and water quality (e.g., temperature, dissolved oxygen, turbidity, pH, conductivity, and chlorophyll a) are recorded through use of a YSI Sonde unit and Lowrance GPS fish finder and transducer. All electronically stored data will be saved in a format that contains the date and time stamp for each recorded value. Video sampling will be performed in both real-time (to continuously monitor for observations of listed species) and post-processing. eDNA collections will also be post-processed.

Sampling Effort

In close coordination with Reclamation, CFS will deploy the Platform to collect spatially explicit pre-project (“before”) data on fish and zooplankton as part of a Before-After (BA) experimental design where sampling will occur before and after potential enhancement actions including nutrient additions, habitat restoration and/or reconnection of the SSC with the Sacramento River. The Platform will be launched into the SSC from the Army Corps of Engineers’ boat ramp located next to the barge canal sector gates in the upper SSC. Sampling will occur biweekly from May through October for three years, resulting in 12 sampling events per year and a total of 36 events (Figure 9).

Figure 9 Study area in relationship to the California Central Valley, San Francisco Bay, Sacramento and San Joaquin rivers and the Sacramento Deepwater Shipping Channel. Black circles indicate Channel Light Markers that are generally aligned with River Miles. Sampling will occur biweekly from May through October for three years, resulting in 12 sampling events per year and a total of 36 events. During each sampling event, the Platform will sample continuously in pelagic habitat from ~RM 62 to 87 (red line) and will also subsample approximately one third of that distance in littoral habitat (green lines). In addition, once monthly the crew will resample the pelagic habitat at night (blue line).



During each sampling event, the Platform will sample continuously in pelagic habitat from ~RM 62 to 87, encompassing the length of the SSC, and will also subsample approximately one third of that distance in littoral habitat (Table 1; Figure 9). In addition, once monthly the crew will resample the pelagic habitat at night. The Platform samples in pelagic waters at 3 mph and in shallow littoral habitats at 2 mph. Thus, each daytime sampling event is expected to take 2 days to complete (sampling half the SSC each day, pelagic going and littoral returning), 16 hours of which will comprise video sampling (10hr pelagic, 6hr littoral), and each night sampling event is expected to take 1 day to complete with 8 hours of video sampling. Each month is expected to produce approximately 40 hours of georeferenced and time stamped fish and zooplankton videos (32hr day, 8hr night). The distance to be covered during pelagic sampling (RM 62 to 87) is estimated at 20 miles or 32,187 m and during littoral sampling is ~6.5 miles or 10,460 m. The cross-sectional survey area of the net used to sample during transects is 2.97 m^2 and the net is typically fully submerged during transects. In a single pelagic sampling event, we will sample approximately 95,595 m^3 of water and in a littoral event 31,068 m^3. Once per month during daytime sampling events, 9-15 eDNA water samples will be collected from each habitat (1 sample during each ~2 RM) such that they can be aligned with a known portion of the transect (again, time and location is logged continuously).

Table 1 Estimated number of river miles, total sampling time (hours), and total volume of water sampled (m^3) for sampling events by time of day and habitat. The volume of water sampled is based on the cross-sectional area of the sampling platform net and the length of the SSC to be sampled. Sampling events will occur twice monthly from May-Oct for 3 years, with nighttime sampling conducted only once per month.

—	Daytime sampling			Nighttime sampling		
Habitat	Total # RMs	Est. time (hrs)	Total volume (m^3)	Total # RMs	Est. time (hrs)	Total volume (m^3)
Pelagic	24	10	95,595.1	24	8	95,595.1
Littoral	8	6	31,068	—	—	—
Total per event	32	16	126,663.1	24	8	95,595.1
Total per month	64	32	253,326.2	24	8	95,595.1
Total per year	384	192	1,519,957.2	144	48	573,570.6
Total for project	1,152	576	4,559,871.6	432	144	1,720,711.8

Data Collection and Management

Video

CFS is working to develop machine-learning based techniques for semi-automated, standardized processing of fish and zooplankton video samples. In the meantime, we continue to rely on manual video processing. Proposed sampling will yield 720 hours each for fish and zooplankton sampling. Fish video will be randomly subsampled (without replacement) to process 360 hours (50%) and zooplankton video subsampled to process 180 hours (25%). We will utilize the following protocol for processing all sampling video collected as part of the proposed study.

1. A qualified biological technician will subsample and review videos and identify events when fish or zooplankton are observed. For fish, technicians will identify species, number, and approximate total length (+/- 5 mm). Fish observations may not always be identifiable to species; in those cases, the lowest reasonably supported taxonomic classification will be specified (e.g., genus, family, or order). For zooplankton, technicians will identify the taxonomic order (e.g., Cladocera, Cyclopoida, Calanoida) or the lowest discernable taxonomic classification and number of individuals.
2. A qualified biologist will independently review randomly selected video portions to test and validate species/taxon identifications, number, and fish length data.
3. Discrepancies between results provided by 1 and 2 will be analyzed and reported. If independent video reviews deviate by 10% or more (e.g., 10 incorrect or missed species classifications from 100 observations), then all videos analyzed by biological technicians with insufficient reliability will be re-processed.

Manual video processing as described above requires ~45 minutes of processing time for every 5 minutes of fish video and 2 minutes for every 1 minute of zooplankton video analyzed. Thus, 720 hours of fish video will require 3,240 hours of staff time to process. Similarly, processing 180 hours of zooplankton videos will require 540 hours of staff time.

eDNA

Collection of eDNA using water filtration, DNA extraction from water filters, and interrogation of DNA present will follow established standards (Bustin et al. 2009; Bergman et al. 2016) to the maximum extent possible. EDNA metabarcoding analysis will be used to assess fish (Miya et al. 2015) and invertebrate (Leray et al. 2013) community assemblages and provide context for Platform observation. EDNA Metabarcoding procedures use next-gen sequencing technology to simultaneously identify individual species' DNA contributing to the "mixed pool" of DNA present in each environmental sample. Bioinformatic comparisons of observed DNA sequences to known sequences (e.g., GenBank) allows for biodiversity assessment through genetic identification. For fish native to San Francisco Estuary, metabarcoding successfully identifies genetic sequence to species level for most species (*Cottus* species are identified to genus level only). Invasive fish species are identifiable to species or genus depending on taxonomic group. Invertebrate communities are more complex (taxonomically and genetically) and far fewer species are represented in publicly-available genetic sequence code data repositories. Identification of invertebrates is likely to be at a higher taxonomic level (family or order), although species identification is possible for both known genetic codes or retroactively when reference sequences are determine/released to the public repositories.

Data Analysis

Chl *a* data will be used as a proxy for phytoplankton standing stock. Although Threadfin Shad are considered omnivorous, over 40% (46-66%) of their diet can include phytoplankton suggesting they can be considered a good representation of primary consumers in the SSC (Miller 1967; Kelley 1966). Inland Silverside is a euryhaline, zooplanktivorous, annual fish species, suggesting it would be a good representation of a secondary consumer that could rapidly respond to variation in food web changes (Chizinski et al. 2007). Results from video analysis will be summarized as catch per volume sampled for each taxa category of fish and zooplankton. Bioinformatics results from eDNA metabarcoding will be presented as a list of identified organisms for each collection (i.e., Platform transect), with Alpha diversity (species occurring within a collection) and Beta diversity (species occurring between collections) quantified. Basic parametric statistics (e.g., ANOVA, regression analysis) will be used on video and eDNA data to test for influences and associations between physical and biological covariates including (see research questions above for specific hypotheses to be tested):

- Year, season, time of day, River Mile, wind velocity and direction, temperature, habitat, Chl *a*, and turbidity relative to fish and zooplankton species and density
- Fish species density relative to concurrent zooplankton species and density

Data Storage

Raw data, including videos, eDNA samples and electronic files of environmental data, will be stored at the CFS Lab in West Sacramento. Copies of electronic files will also be backed-up to the Cloud. Data will be released via CVPIA data standards. To facilitate this, we will follow the five-phase process of data curation and publishing outlined by the Environmental Data Initiative (EDI). This process begins with planning and organization, followed by creation of data tables, metadata and packaging, and ending with the submission to a repository and citation. https://environmentaldatainitiative.org/

Budget

Project budget is $1,056,066 ($352,022 per year) for 925 hours of surveys over 3 years, processing of 360 hours of fish video and 180 hours of zooplankton video, collection and analysis of 270 eDNA samples, permitting, data entry and QA/QC, data analysis, reporting, and coordination with and presentations to USFWS (Table 2). Project will be submitted to the Reclamation Science Division, Bay-Delta Office for funding consideration. The SSC is a conservation measure in Reclamation's BiOp and thus a high priority for restoration actions.

Table 2 Detailed budget for 3 years of Sacramento Ship Channel baseline data collection.

Task	Subtask	Labor	Phone	Travel	Direct	Misc.	Totals
1. Project preparation	1.1 Update Permits	$7,466	-	-	-	-	$7,466
	1.2 Prep Equipment	$61,400	-	-	$1,500	$1,000	$63,900
	1.3 Coordinate fish monitoring programs	$17,304	-	-	-	-	$17,304
	1. TOTAL	**$86,170**	**$0**	**$0**	**$1,500**	**$1,000**	**$88,670**
2. Field sampling, analysis, reporting	2.1 Fieldwork- Video sampling	$368,103	-	$1,687	$9,000	-	$378,790
	2.2 Fieldwork - eDNA sampling	$23,436	-	-	$110,850	-	$134,286
	2.3 Field shuttle service	$13,950	-	-	-	-	$13,950
	2.4 Field season maintenance	$39,479	-	-	-	-	$39,479
	2.5 Video review – fish	$200,880	-	-	-	-	$200,880
	2.6 Video review – zooplankton	$33,480	-	-	-	-	$33,480
	2.7 Data Entry	$13,248	$60	-	-	-	$13,308
	2.8 QA/QC	$28,152	-	-	-	-	$28,152
	2.9 Data Analysis	$29,320	-	-	-	-	$29,320
	2. TOTAL	**$750,048**	**$60**	**$1,687**	**$119,850**	**$0**	**$871,645**
3. Management	3.1 General Management	$30,806	-	-	-	-	$30,806
	3.2 Annual Reporting (2)	$32,200	-	-	-	-	-
	3.3 Final Reporting (1)	$15,480	-	-	-	-	$15,480
	3.3 Report Review and Edits	$31,008	-	-	-	-	$31,008
	3.4 Present to FWS	$18,300	-	$157	-	-	$18,457
	3. TOTAL	**$127,794**	**$0**	**$157**	**$0**	**$0**	**$95,751**
Total CRAMER Project		**$964,012**	**$60**	**$1,844**	**$121,350**	**$1,000**	**$1,056,066**

Collection and ESA Take Permit Needs

Channeling of fish and invertebrates through a viewing chamber, coupled with subsampling for image identification validation, requires an SCP, State and Federal ESA take permits, and allocation of Delta Smelt incidental take (as issued by USFWS). CFS presently has an SCP and would need to update incidental take information. Applying for these permits requires estimates of how many Delta Smelt, Longfin Smelt, and winter-run Chinook Salmon be observed by the Platform during the study.

Delta Smelt, Longfin Smelt, and winter-run Chinook Salmon mean catch per unit effort (CPUE) values are calculated for the months of May through October using catch and volume data from the most recent 5 years (2015-2019) at three California Department of Fish and Wildlife monitoring sites (797, 796, 795, Figure 8) and USFWS data (through March 2020) collected within the Project study area. Five gear types are employed within the study region during this period: Summer Tow Net (STN) surveys June-Aug, Fall Midwater Trawl (FMWT) surveys Sep-Oct, CDFW Kodiak Trawl through May, USFWS Kodiak Trawl July-Oct and EDSM 20 mm Survey June-July. The SKT, STN and FMWT survey data were obtained from the Access Database files available online (CDFW FTP site, Access Database file) and USFWS Kodiak trawl and EDSM 20 mm survey data were obtained from Catherine Johnston, USFWS, Lodi Office. The CPUE values for each method were calculated as fish/m^3 and these values were averaged and then multiplied by the volume of water to be sampled by the Platform each month (Table 1). This provided an estimated Platform CPUE as fish/month. Estimated Delta Smelt CPUE and number of Delta Smelt observations for the Platform May-Aug are provided in Table 3. Estimated Longfin Smelt CPUE and number of Longfin Smelt observations for the Platform May-Aug are provided in Table 4. Estimated winter-run Chinook Salmon CPUE and number of winter-run Chinook Salmon observations for the Platform May-Aug are provided in Table 5.

Figure 10 Location of status and trend monitoring stations in the Sacramento Ship Channel. Stations 797, 796, and 795 fall within the Project sample area and were used to calculate estimated take of Delta Smelt, Longfin Smelt, and winter-run Chinook Salmon. All three stations are sampled by the SNT June-Aug and by the FMWT Sept-Oct.

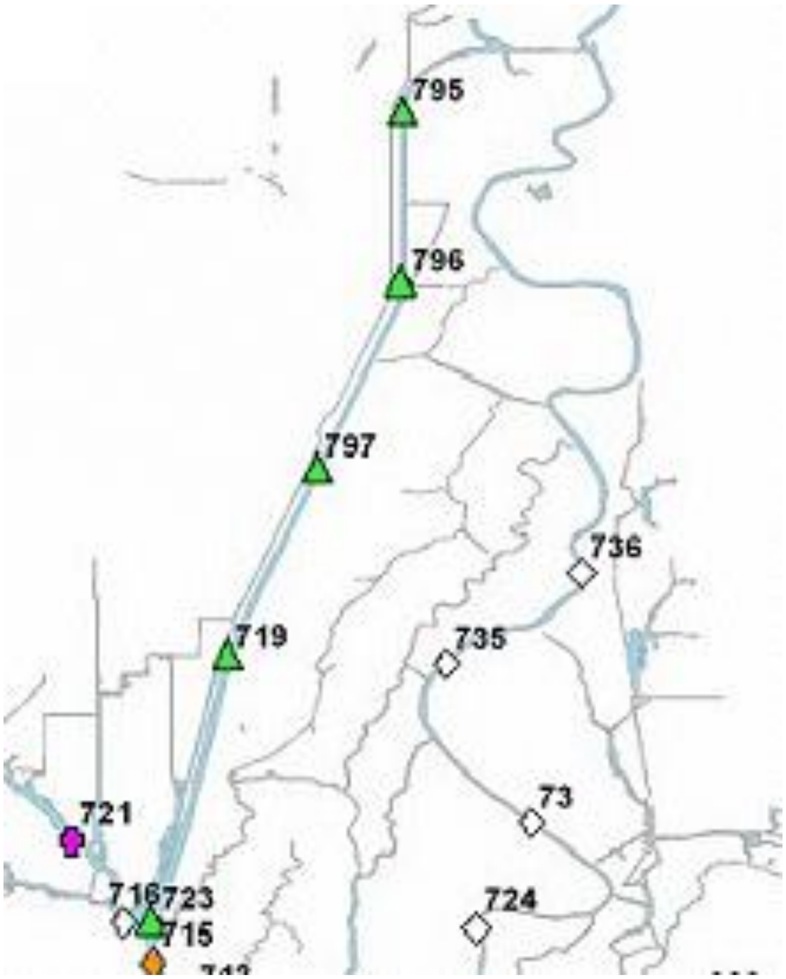


Table 3 Estimated Delta Smelt CPUE and Delta Smelt observations for the Platform May through Oct. Values are based on CPUE values (for Delta Smelt) calculated from data at monitoring stations in the study areas during the months of May through Oct in years 2015-2019 (see details above). The average CPUE (as fish/ m^3) was multiplied by the volume of water to be sampled in a single sampling event by the Platform (daytime 126,663.1 m^3, nighttime 95,595.1 m^3) to obtain an estimated CPUE for the Platform as fish/sampling event by time of day. The daytime CPUE was then multiplied by 2 and added to the nighttime CPUE, as daytime sampling will occur twice monthly, to determine Delta Smelt observations made by the Platform in each month during the study.

Month	CPUE (fish/sampling event) estimate by month for the Platform		Delta Smelt observations by month ($(CPUE_{DT}$ x 2) + $CPUE_{NT}$)
	Daytime	Nighttime	
May	0	0	0
June	2.91	2.19	8
July	1.09	0.82	3
August	0	0	0
September	0	0	0
October	0	0	0
Total Delta Smelt observed per year	—	—	**11**
Total Delta Smelt observed over 3 years	—	—	**33**

Table 4 Estimated Longfin Smelt CPUE and Longfin Smelt observations for the Platform May through Oct. Values are based on calculated CPUE values (for Longfin Smelt) calculated from data at monitoring stations in the study areas during the months of May through Oct in years 2015-2019 (see details above). The average CPUE (as fish/ m^3) was multiplied by the volume of water to be sampled in a single sampling event by the Platform (daytime 126,663.1 m^3, nighttime 95,595.1 m^3) to obtain an estimated CPUE for the Platform as fish/sampling event by time of day. The daytime CPUE was then multiplied by 2 and added to the nighttime CPUE, as daytime sampling will occur twice monthly, to determine Longfin Smelt observations made by the Platform in each month during the study.

Month	CPUE (fish/sampling event) estimate by month for the Platform		Longfin Smelt observations by month (($CPUE_{DT}$ x 2) + $CPUE_{NT}$)
	Daytime	Nighttime	
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
Total Longfin Smelt observed per year	—	—	**0**
Total Longfin Smelt observed over 3 years	—	—	**0**

To estimate the number of Delta Smelt at specific life stages (sizes) that could potentially pass through the Platform and be observed during the study, available data from the STN and FMWT (CDFW FTP site, Access Database file) was downloaded, and the fork length data for all Delta Smelt captured and measured at monitoring stations proximal to the study area (from years 2011-2019) was extracted and analyzed for each species. The proportion (percent) of Delta Smelt within three size classes, representing three life stages, was averaged across all sites for each month of the proposed study period (May through October). The life stage/size classes for Delta Smelt include: larval (less than 20 mm), juvenile (20 to 58 mm), and adult (greater than 58 mm). The proportions of Delta Smelt at each size were used to refine the observation estimates by month into each size class (Table 6). As there was no predicted take for either Longfin Smelt or winter-run Chinook Salmon, this analysis was not performed for these species.

Table 5 Estimated winter-run Chinook Salmon CPUE and winter-run Chinook Salmon observations for the Platform May through Oct. Estimates are based on average CPUE values (for winter-run Chinook Salmon) calculated from data at monitoring stations in the study areas during the months of May through Oct in years 2015-2019 (see details above). The CPUE (as fish/ m^3) was multiplied by the volume of water to be sampled in a single sampling event by the Platform (daytime 126,663.1 m^3, nighttime 95,595.1 m^3) to obtain an estimated CPUE for the Platform as fish/sampling event by time of day. The daytime CPUE was then multiplied by 2 and added to the nighttime CPUE, as daytime sampling will occur twice monthly, to determine Longfin Smelt observations made by the Platform in each month during the study.

Month	CPUE (fish/sampling event) estimate by month for the Platform		Winter-run Chinook salmon observations by month
	Daytime	Nighttime	(($CPUE_{DT}$ x 2) + $CPUE_{NT}$)
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
Total winter-run Chinook salmon observed per year	—	—	**0**
Total winter-run Chinook salmon observed over 3 years	—	—	**0**

Using the generated CPUE estimates for Delta Smelt for the Platform (described above), and calculating fish observations, we estimate that an adult equivalent of 11 Delta Smelt may be observed by the Platform during each six-month period of the study, totaling 33 over sampling 3 years. The fact that the Platform methodology facilitates observations without direct handling or detention of fish should be considered when reviewing estimated take.

Table 6 Delta Smelt observation estimates for the Platform at each life stage by month. The calculations are based on sampling for twice monthly during the daytime and once monthly at night May through Oct. The total estimated number of Delta Smelt observed in each month from Table 3 was split into life stages by applying the calculated proportions of Delta Smelt in each size class from SNT and FMWT data (described in the above paragraph). The equivalent adult take column is based on the IEP Delta Smelt take calculation spreadsheet.

Month	Total Catch	Larval (<20 mm FL)	Juvenile (20 – 58 mm FL)	Adult (>58 mm FL)	Equivalent Adult Take
May	0	0	0	0	0
June	15.44	0	15.44	0	8
July	4.34	0	4.15	0.19	3
August	0	0	0	0	0
September	0	0	0	0	0
October	0	0	0	0	0
TOTAL	19.78	0	19.59	0.19	11

Disposition of Collected Organisms

The Platform was designed to minimize or prevent lethal take of sampled and sensitive species; fish are funneled by a net into a live box equipped with cameras and then discharged from the boat stern. No fish will be detained or handled during this study. All fish will pass through the sampling unit with only images recorded by video. Associated water samples will be collected to archive concomitant eDNA without handling listed organisms.

Reporting

Deliverables

Cramer Fish Sciences and the Reclamation project manager will provide regular updates to USFWS. Results will be submitted in two annual reports and a final comprehensive report and communicated to the broader science community through three annual presentations to USFWS.

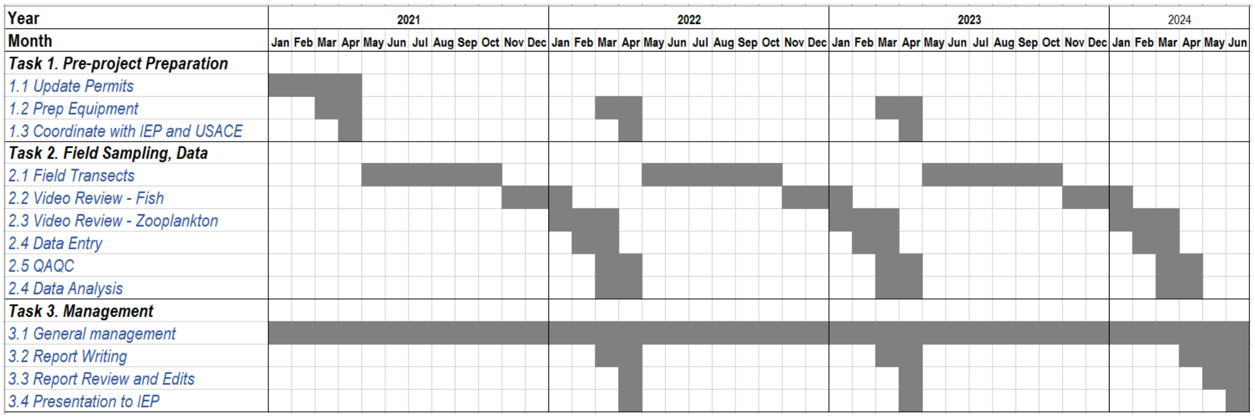
Data Sharing

Data collected from this study will be made available to USFWS as an Access database after completion of QA/QC. Following completion of the project, all data will be published on the EDI web site.

Timeline

Field sampling preparation and coordination are expected to occur in late spring. Field sampling will occur from May-October each year. Video review, data entry and QA/QC, and analysis will occur during the fall and winter. Report writing and presentations will occur in winter and early spring.

Figure 11 Timeline of project tasks.



Coordination with other fish monitoring

The proposed Platform sampling will be coordinated with other fish monitoring activities in the ship channel. The surveys include:

- California Department of Fish and Wildlife (CDFW) – coordinate sampling of pelagic habitats (summer tow net survey)
- Delta Juvenile Fish Monitoring Program – coordinate sampling of shallow water habitat (Beach Seine) and pelagic habitat (Kodiak Trawl)
- US Fish and Wildlife Services (USFWS) – coordinate sampling of pelagic and littoral habitats (Enhanced Delta Smelt Monitoring Program)
- California Department of Water Resources (DWR) – coordinate sampling (The North Delta Flow Action Project)

External reviews

An initial pilot study on the efficacy of nutrient additions to the SCC (CFS 2020) was reviewed by IEP and a report was completed, reviewed and edited with a final report delivered to Reclamation. This baseline survey proposal builds on that work and a draft report has been reviewed by Reclamation.

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