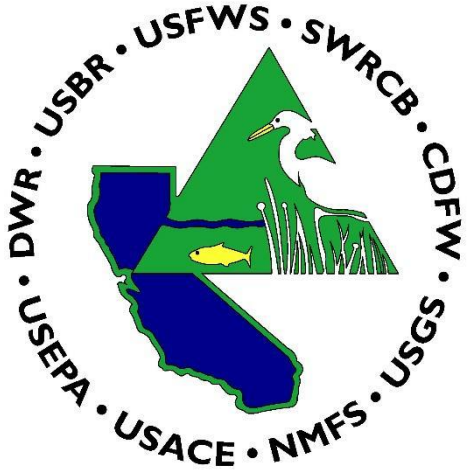
Interagency Ecological Program
2024 Annual Workshop

ABSTRACTS

April 23-25, 2024



Interagency
Ecological Program

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IEP Mission Statement

The Interagency Ecological Program's mission is to provide and integrate relevant and timely ecological information for management of the Bay-Delta ecosystem and the water that flows through it. This is accomplished through collaborative and scientifically sound monitoring, research, modeling, and synthesis efforts for various aspects of the aquatic ecosystem. The IEP addresses high priority management and policy science needs to meet the purposes and fulfill responsibilities under State and Federal regulatory requirements. The IEP relies upon multidisciplinary teams of agency, academic, non-governmental agencies, and other scientists to accomplish its mission.

IEP Community Statement

The Interagency Ecological Program celebrates equity, diversity, and inclusiveness. We embrace these pillars of excellence as crucial to healthy people and healthy communities. We welcome collaborative scientists of all affiliations and ask that you contribute within a spirit of supportive collegiality.

IEP Workshop Sponsors

The IEP Workshop Planning Committee would like to thank our sponsors for supporting activities at the workshop. The California-Nevada Chapter of the American Fisheries Society has been assisting IEP in securing the rental of poster boards for the poster session. The State Water Contractors are kindly sponsoring the Early Career Mentoring Luncheon for the 2nd year and ICF, Inc. is sponsoring our new Coffee & Tea Bar in the lobby.

COVID Safety Guidelines

The California Natural Resources Agency follows COVID-19 health and safety measures set by the Sacramento County Public Health Office. Masks are not required to be worn inside the building. However, it is highly recommended to wear masks in crowded indoor public places. Masks and hand sanitizer are available at the Registration Table. We strongly encourage participants who don't feel well or who are sick to stay home and watch the workshop remotely.

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Oral presentation abstracts are organized in the order they appear in the program

Session 2: Physical and Biological Effects of Flow

As the Smelt Swims: Re-examining the Spawning Migration of Delta Smelt

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**Presenting author*

Previous studies have demonstrated that Delta Smelt initiate their annual spawning migration towards freshwater in response to the first winter high flow and turbidity event, “first flush”. Evaluation of otoliths suggests migration takes place every year, but springtime distribution did not appear to vary in one study, suggesting that migration was completed by January or was too subtle to be detected in the survey data they used. Here we sought to better understand the spawning migration of Delta Smelt to evaluate whether we could detect a shift in distribution that was responsive to hydrology and/or water operations. We combined historical catch data spanning over 40 years (1976 - 2017) with hydrology and water operations data. We then conducted regression tree analyses to find the best predictors for the distribution and salinity space occupied by Delta Smelt during November-April period. We found that Delta Smelt may appear to have a static distribution because prior to ‘first flush’ event, Delta Smelt occupy certain ‘hot spots’ in the low salinity zone, which become freshwater after a ‘first flush’ has occurred, and therefore suitable for spawning. Additionally, we found evidence that historical water operations (i.e., Old and Middle River flows) may have affected the center of distribution for the Delta Smelt population. Lastly, we compared findings of previous studies on Delta Smelt spawning movement with data from the recently released and recaptured hatchery Delta Smelt. Using least-cost distance between release and capture sites, as well as the number of days since release, we were able to estimate individual swim speed of hatchery Delta Smelt. To date, we estimated that Delta Smelt traveled 1 to 63 km from their release sites, with an average apparent swim speed of ~2 km/day (similar to a previous estimate of ~3.6 km/day).

Evaluation of spring outflow to larval Delta Smelt (*Hypomesus transpacificus*) health and condition

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Understanding the drivers impacting larval Delta Smelt during spring outflow is crucial during this important life stage, especially in terms of spawning success and subsequent rearing. Our study spanned the spring season of three years: two dry years (2021 and 2022) and one wet year (2023). We collected field water from six sites in the San Francisco Estuary encompassing fresh and low salinity Delta Smelt habitat for chronic larval Delta Smelt toxicity testing, where one cohort of fish was used for each year's study duration. Biomarkers included health and condition, RNA/DNA, contaminant exposure, and histopathology. For the dry years 2021 and 2022, salinity was the greatest factor influencing health and condition of the larval Delta Smelt, with positive correlations observed in survival, condition factor, RNA/DNA, and glycogen stores. Mortality was observed in fish exposed to freshwater sites collected in 2021 and 2022, but surviving fish were in good condition histologically. Analytical chemistry indicated a high frequency of fungicides used in agriculture in 2021, as well as fluridone and hexazinone in 2022. In the wet year of 2023, endpoint correlations with salinity were not as strong. We generally observed higher Delta Smelt survival compared to previous years, and a higher prevalence of gill and liver alterations were observed in Delta Smelt exposed to waters collected from the Toe Drain, Cache Slough, Deep Water Ship Channel, and Sacramento River at Decker Island, where a variety of pesticides were detected. Identification of toxic water sources can inform managers on how flow and contaminants affect Delta Smelt health and abundance, help fill important knowledge gaps, and aid in understanding the relationship between water management and the health of the environment.

Improving our understanding of X2 and salt field dynamics through high resolution near-bed salinity monitoring in the San Francisco Estuary

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**Presenting author*

The size and location of the low salinity zone in the San Francisco Estuary is used for management purposes as a habitat indicator for many aquatic species that reside or migrate through the estuary. The position of the tidally averaged bottom 2 practical salinity units isohaline (referred to as X2 and measured as distance upstream from the Golden Gate Bridge) is one of the primary metrics representing estuarine habitat important for supporting native fish species. The size and location of the low salinity zone and X2 are primarily controlled by Delta outflow and to a lesser degree tidal processes. Recently, the U.S. Geological Survey installed a network of near-bed salinity sensors from Carquinez Strait to the lower Sacramento River to obtain a better understanding of and improve our ability to evaluate the relationships among X2, Delta outflow, tidal dynamics, and stratification.

Based on results of 2 years (2021-2023) of monitoring, with a representative range of hydrological conditions, we investigated periods of stratified conditions because these conditions provide a physical basis for improving estuarine habitat quality. Stratification provides the physical conditions needed to promote phytoplankton production, and creates an estuarine turbidity maximum (ETM), where detrital matter and plankton can accumulate, providing important food resources for native fish species. We found that stratification is driven primarily by horizontal density gradients and weak tides, which allows gravitational circulation to develop, stratification to occur, and accumulation of food resources in the ETM. These periods are predictable and could be paired with management actions to improve estuarine habitat quality. Study results could improve methods for estimating the size and location of the low salinity zone and our understanding of salt field dynamics in the low salinity zone, with implications for improving productivity and fish habitat in this critical region.

The Interaction of Uncertainty and Objective Weights: Value-of-Information Analysis to inform River Temperature Management for Green Sturgeon and Winter-run Chinook Salmon below Shasta Dam

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**Presenting author*

Fisheries managers often face difficult tradeoffs among management objectives, which can be particularly challenging in altered ecosystems where contemporary habitat conditions support one species of conservation value to the detriment of another. The difficulty in navigating tradeoffs can be exacerbated by uncertainty in predicted management outcomes, especially if the uncertainty concerns the strength of the tradeoff. We explored these dynamics in the Sacramento River, California, U.S.A., where federally endangered winter-run Chinook Salmon *Oncorhynchus tshawytscha* spawn in the artificially cold tailwater, and where threatened Green Sturgeon *Acipenser medirostris*, require warmer (natural) conditions for reproduction. A temperature control device is used to maintain cool water for Chinook Salmon spawning; however, uncertainties exist related to critical temperatures for Chinook Salmon egg-to-fry survival and Green Sturgeon spawning and rearing. Using models representing alternative hypotheses of early life stage dynamics, we demonstrate the use of multi-criteria decision analysis (MCDA) and expected value of perfect information (EVPI) for resolving uncertainty in this context, including an examination of how decision-making was affected by the relative weights given to the Chinook Salmon and Green Sturgeon objectives. Under uncertainty, the best performing alternatives included natural run of river temperatures when the objective weights favored Green Sturgeon, or an alternative designed to maintain cooler summer temperatures to maximize Chinook Salmon egg-to-fry survival, when objective weights favored Chinook Salmon. Interestingly, we found that the EVPI was relatively low when only one objective was favored, but was highest at intermediate weights on the objectives, showing an important interaction between scientific uncertainty and the weights the decision maker places on the objectives.

Session 4: Reconnecting Delta Food Webs

Food webs forward: Understanding the benefits and science needs for incorporating food web interactions into management in the Bay-Delta Estuary

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**Co-presenting authors*

The San Francisco Bay-Delta Estuary is a complex estuarine system that poses many management challenges due to human alteration and competing goals for ecological and human needs. This system provides two-thirds of California's water supply and houses many endemic and protected species. However, it is impacted by urbanization, agriculture, non-native species, climate change, and other factors. Traditional management approaches have focused on the direct impact of individual or combined drivers on the abundances of single species. However, ecosystem-based management that spans spatial boundaries, such as for anadromous fish migration, requires consideration of food-web interactions and species interactions that can also shift abundances of species. The species interaction work in the region has largely encompassed the base of the food web and is rarely directly connected to the upper trophic fish species models. This review by the Delta Independent Science Board synthesizes what is known about upper trophic level species interactions in the Bay-Delta using information gathered from a comprehensive literature review, a series of Delta science and management community discussions, and a public workshop on food webs in the Delta. We focus on upper trophic level food web interactions to 1) determine how an understanding of species interactions can aid management and 2) suggest actionable recommendations on how to move the science forward and utilize food web science in management. This review addresses several of the priorities identified in the long-term IEP Strategic Plan and the 2020-2024 IEP Science Strategy, including understanding the spatiotemporal components of Bay-Delta food webs and determining how tools, models, and monitoring can be used to understand food webs and support healthy ecosystems. Understanding species connections and identifying key science gaps in our understanding of Bay-Delta food webs can facilitate management strategies and crucial projections of species' responses to changes in environmental drivers, especially climate change.

The Cache Slough complex: A deep dive into a shallow wetland

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**Presenting author, †Early Career Award candidate*

The Cache Slough complex (CSC) in the Sacramento-San Joaquin River Delta (Delta) is a unique shallow-water wetland environment consisting of a flooded island, herbaceous marshes, sloughs, and channelized waterways. It has tidal influences from the San Francisco Bay as well as freshwater inputs from the Sacramento River. It often has periods where the exchange of water is limited, leading to water residence times of over 30 days in the northern reaches. In periods of low flow, nutrients are supplied by distributaries of the Sacramento River. This area is dissimilar to any other location in the Delta in terms of several biogeochemical factors like nutrient concentrations, phytoplankton communities, and aquatic vegetation, among others. Steep nutrient gradients are often observed, declining from south to north, resulting in a wide range of aquatic habitat conditions. These gradients and concentrations, however, appear to be changing. We have conducted many high-resolution water quality mapping surveys spanning the last decade. We also continuously monitor and regularly collect discrete samples to assess water quality conditions. From the rich volume of data, we construct a holistic view of the CSC, contextualizing events impacting the water and habitat quality (e.g., EchoWater Treatment Facility's upgrade, management operations, weather extremes) with a detailed record of nutrient and phytoplankton data collected across the CSC. We will determine what processes are changing and how they might affect the broader food web.

Continuous Zooplankton Observation, Detection, and Enumeration

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- Andrew Veary, Cramer Fish Sciences
- Brian Mahardja, U.S. Bureau of Reclamation
- Erwin Van Nieuwenhuyse, U.S. Bureau of Reclamation (Retired)
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**Presenting author*

Zooplankton are an important part of aquatic ecosystems and often serve as proxies for water quality and primary production. Zooplankton are also food sources for imperiled species such as Delta and Longfin smelt and have their own complex lifecycle dynamics. However, they have traditionally been assessed and monitored using spot checks with discrete samples resulting in data gaps for habitat or ecosystem wide assessments. In this talk, we present updates from a mobile sampling platform that gathers nearly continuous measurements of zooplankton along a transect, using a scanline camera to capture zooplankton silhouettes from sampled water, thus enhancing both the frequency and richness of zooplankton data. However, this method produces substantial volumes of data, necessitating a sophisticated analysis approach. To address this, we developed a multistage pipeline for the enumeration and classification of zooplankton silhouettes in images, comprising of image preprocessing, classification routines, and post-processing rules. This initial study focused on three zooplankton taxa: copepods, daphnids, and amphipods. Results from multiple systems show high discernibility up to certain thresholds of turbidity, at which point they begin to occlude the zooplankton shapes. Furthermore, our results show strong correlations between zooplankton and continuous measures of both biotic (e.g., fish abundance, chlorophyll a levels) and abiotic factors (e.g., water chemistry), demonstrating a form of validation of our methods, as well as highlighting the potential for exciting and novel future analyses examining the entire lower food web in the context of broader ecosystem functions.

Reconnecting Delta food webs: evaluating the influence of tidal marsh restoration on prey availability and diet of native fishes

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- Albert Ruhi - University of California, Berkeley
- Megan Pagliaro - University of California, Berkeley
- Jake Sousa - ICF
- Lenny Grimaldo - Department of Water Resources
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**Presenting author*

In the upper San Francisco Estuary (USFE) species introductions, wetland loss, and watershed modifications have led to long-term declines in primary productivity and native fish populations. While expansive tidal wetland restoration is underway in the region, our knowledge on how pelagic, benthic, and terrestrial components of Bay-Delta wetland food webs interact is cursory. This data gap precludes systematic understanding of restoration benefits for native fishes such as delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), and salmonids. The goal of our research is to elucidate the effects of tidal marsh restoration on food web structure and prey quality for native fishes. To accomplish this, we compared seasonal pelagic, benthic, and terrestrial prey abundance, fish diet and trophic structure, among six paired reference and restored wetlands. Our preliminary results indicate that early season (Feb) prey availability was limited at all wetlands compared with late season (May) and also varied based on location in the USFE, habitat type (wetland interior vs. exterior) and restoration age. Of 890 fish captured across all sites and processed for diet, 57% contained invertebrate prey from 8 broad taxa. Prey taxa with greatest relative importance across sites were copepods and mysids for pelagic fish species, nematodes for benthopelagic fish and amphipods for demersal fish. Percent similarity indices showed that proportions of prey items in fish from restored compared to reference sites were most similar for demersal fish (PSI 82) and least similar for pelagic fish (PSI 58). Currently we are integrating stomach content with stable isotope results from these fish to further understand linkages among prey availability, diet and food web complexity in restored compared to reference sites. Results from this on-going project will address key management questions on how restoration of tidal wetland structure translates into the recovery of food web processes and improved fish habitat

Restoring tidal marsh food web structure and energy pathways for estuarine fish communities

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Tidal marsh restoration performance is typically measured via habitat availability and recolonization of target species. However, functional metrics such as the transfer of energy from basal resources to fish can more effectively determine whether restoration of habitat structure translates into the recovery of robust food webs. We asked two questions. First, does tidal marsh restoration lead to the recovery of energy pathways that support diverse feeding strategies among estuarine fishes (measured by the distribution and volume of their isotopic niches)? Second, how does the food web structure vary between native and non-native fish? We sampled basal resources (fine particulate organic matter and phytoplankton; n=80) and fishes (n=807) in three paired reference and restored tidal marshes in the San Francisco Bay Delta in winter and summer 2020 and 2021. We quantified stable isotope ratios using δ13C, δ15N, and δ34S for common fishes and basal resources at each site, and then calculated their isotopic niche volume (standard volume encompassing all the plotted isotope values), food-chain length, and relative influence of “brown” (detrital) versus “green” (algal) pathways. We found that two of the restored sites had smaller isotopic niche volumes compared to their reference pair (in support of our hypothesis), but the youngest restoring marsh had a larger niche volume than its reference, suggesting early succession may still be influencing the energy flows within that food web. Additionally, non-native fish generally occupied a larger niche volume compared to native fish, suggesting that the former consume a wider range of food sources. Notably, a majority of the native niche was also contained within the non-native niche. Our findings show that food web structure is not immediately recovered with tidal marsh restoration, and highlight the need to incorporate the recovery of energy pathways as a key indicator of restoration success.

Session 5: Phytoplankton and Nutrients

Identification of environmental conditions driving cyanobacterial multi-species blooms and their toxicity using genome-resolved metagenomics

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The Sacramento-San Joaquin Delta has seen a cyanobacterial species richness increase in harmful cyanobacterial blooms (cyanoHABs) accompanied by uncertainties regarding full toxigenic potential of those overlooked species. In an eight months long study during a wet year, we employed genome-resolved metagenomics, chemical cyanotoxin detection (21), and environmental data to explore processes shaping cyanobacterial emergence and collapse. Our findings revealed coexisting and interchanging nitrogen-fixing and non-nitrogen-fixing cyanobacteria, both capable of producing a range of cyanotoxins beyond microcystins. Intriguingly, cyanotoxin accumulation was detected as early as April, even with low cyanobacterial abundance. This study sheds light on microbiome dynamics and cyanotoxin potential of diverse cyanobacteria along the Delta.

Using Numerical Tracers to Estimate Ecological Rates in a Phytoplankton Model

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**Presenting author*

The phytoplankton distribution in estuaries is influenced by multiple spatially variable growth and loss processes. As phytoplankton are transported by tidal and net flows, they are exposed to changing conditions of turbidity, depth, temperature, stratification, and grazing. Understanding the factors influencing the observed phytoplankton distribution patterns will allow better-informed restoration and water management efforts. We developed a Lagrangian approach driven by three-dimensional hydrodynamic model results and a simple representation of the production and losses of phytoplankton, allowing a highly efficient closed-form solution for phytoplankton biomass. Our analysis used continuous observations of chlorophyll concentration at four stations and a near synoptic chlorophyll dataset collected underway from a boat in the channels of Suisun Marsh in the San Francisco Estuary. We divided the study region into four compartments defined by the water depth and location. For each observation location, hydrodynamic model simulations calculated the time that water parcels spent in each of these compartments and the mean depth encountered by water parcels in those compartments. Then, using that information and continuous monitoring data, we inferred compartment-specific grazing rates and two additional ecological parameters. The underway chlorophyll dataset was used for model validation. The model predicted patterns of observed spatial and tidal variability in chlorophyll in Suisun Marsh. The modeling indicated that the chlorophyll concentration at a point in space in time depends largely on the relative exposure to shallow areas, with positive net productivity and deep areas having negative net productivity.

Benthic Overwintering *Microcystis* sp. Seedstock and its Role in Summertime Blooms

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- Janis Cooke, Central Valley Regional Water Quality Control Board

**Presenting author*

The cyanobacteria harmful algal bloom taxa, *Microcystis*, drops from the water column when temperatures decrease and cells spend an undefined period of time dormant along the sediment-water interface. With no obvious upstream sources for *Microcystis* to enter into the Delta, the most likely source of summer blooms within the system is that they originate primarily from these overwintering *Microcystis* seedstocks that recruit to the water column when conditions are favorable. The purpose of our study was to analyze sediment samples as a potential sink and source of *Microcystis* and to use summer and fall water samples to better understand *Microcystis* fate and transport within the Delta. We used genetic tools to measure overwintering *Microcystis* seedstock at eight Delta locations from November 2020 to April 2022. We found; 1) that there are substantial loss rates of *Microcystis* seedstock between November and April; 2) although there was detectable *Microcystis* seedstock at all sampling locations, the proportion of *Microcystis* seedstock remains significantly higher in static peripheral areas of the Delta in April (i.e., Stockton Waterfront, Discovery Bay, and Windmill Cove); and 3) DNA sequencing results showed relationships between static peripheral areas and adjacent interconnected waterways as well as waterways that are geographically distant suggesting transport of cells out of static peripheral areas does occur. One important finding from our study is that cyanobacteria cells do not need to be present in the water column to assess the harmful algal community of a waterbody. Instead, collecting sediment samples during the winter months provides a snapshot of all strains that exist within a system. However, samples from the water column are also needed to understand the connectivity between sites since not all strains in the sediment are present in the water at any one time.

Comparing cyanobacteria and cyanotoxins in the Delta during droughts and deluges

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**Presenting author*

Phytoplankton respond strongly to hydrologic conditions in the Sacramento-San Joaquin Delta (Delta), and the abundance of toxic cyanobacteria has been shown to vary by water year type. Extreme variability has characterized the Delta hydrology of the last 3 years. Two critically dry water years, 2021 and 2022, were followed by a record-setting wet water year, 2023. Fortunately, during these years, cyanotoxin concentrations and phytoplankton community composition were routinely monitored by the U.S. Geological Survey and California Department of Water Resources at 6 fixed stations in the Delta. Monitoring included discrete water samples, as well as deployment of solid phase adsorption toxin tracking (SPATT) samplers. At the fixed stations, microcystins, anatoxins, nodularin, and cylindrospermopsins were detected on SPATT samplers. This is the first report of cylindrospermopsin detections in the Delta. Cyanotoxin monitoring data from 2023 are still being analyzed, but preliminary results show fewer cyanotoxin detections than during the drought years of 2021 and 2022. Additionally, Franks Tract was monitored during the summers of 2022 and 2023, with and without the Emergency Drought Barrier (EDB), respectively. According to data from remote sensing and discrete samples, in Franks Tract a cyanobacterial blooms occurred in Franks Tract 2021 and 2022 but did not occur in 2023. We have not yet received all our isotope results for 2023 in Franks Tract, but we plan to compare water age in 2022, during the drought and with the EDB, and in 2023, a wet year with no barrier. These findings will increase our understanding about the risks posed by cyanotoxins across different water year types.

Assessing the dynamics of emerging spring phytoplankton blooms at the confluence of the Sacramento and San Joaquin Rivers, California

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Despite high nutrient concentrations, the San Francisco Estuary, California, is considered a low productivity estuary likely due to a combination of strong tidal mixing, light limitation from high turbidity, and benthic grazing pressure. The confluence of the Sacramento and San Joaquin Rivers (confluence) provides habitat used by several fish species, including the endangered Delta Smelt (*Hypomesus transpacificus*). In the past 10 years, spring phytoplankton blooms (> 5 µg/L) have become more frequent in the confluence. However, little is known about the environmental drivers of these spring phytoplankton blooms, the composition of the phytoplankton communities comprising these blooms, and the potential impacts of these phytoplankton blooms on the larger ecosystem within San Francisco Estuary. Therefore, we analyzed environmental and phytoplankton data collected during water years 2016-2023 to better understand the role of phytoplankton blooms in the San Francisco Estuary. Preliminary results show that the timing of the spring bloom is correlated with the development of the seasonal salinity gradient in the area, indicated by a bottom salinity of 2 PSU (locally referred to as X2) 5-10 km downstream of the confluence. Earlier (February/March) blooms occur in dry water years, and later (June/July) blooms occur in wet water years. Timing of phytoplankton blooms affected the composition of observed phytoplankton communities. February/March blooms were dominated by diatoms of the genus *Entomoneis*, and June/July blooms consisted of a mix of phytoplankton species. Changes in the timing and community composition of spring phytoplankton blooms in the confluence likely impact the productivity of fisheries in San Francisco Estuary. Therefore, understanding the environmental drivers and interannual variability can inform predictions about how climate change might impact aquatic ecosystems within the San Francisco Estuary.

Assessing Sediments as a Nutrient Source/Sink to the Sacramento-San Joaquin River Delta

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Sediments represent a large pool of nutrients within aquatic ecosystems, and porewater nutrient concentrations are often orders of magnitude higher than the overlying water column. Despite these higher pore water concentrations, several factors determine whether sediments are net sources or sinks of nutrients to the overlying water column. In this study, we deployed an *in situ* benthic flux chamber to assess the rates of nutrient fluxes between sediments and the water column on two separate dates during the summer of 2021 at 18 sites spanning a range of habitats across the Sacramento-San Joaquin Delta (Delta). During deployments, we measured changes in ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN, the sum of NH_4 and NO_3), and dissolved oxygen (DO) in the overlying water using a high frequency, boat-based, flow-through instrument package. Bivalves in sediments were sources of DIN, mainly in the form of NH_4. Overall, sediment NH_4 flux comprised the majority of sediment DIN flux, and sediments were a net source of DIN and NH_4 at 9 of 12 sites with DIN data. Seven of 16 sites with NO_3 data were net sinks of NO_3, and the magnitudes of the fluxes were smaller for NO_3 than for NH_4. About one-third of the sites showed temporally variable net NO_3 flux with sediments switching between sources and sinks between early and late summer samplings. The benthos was a net sink for DO at all sites, but magnitudes of biological oxygen demand varied spatially and temporally. Local-scale habitat influences such as residence time and clam density in sediments may substantially influence sediment DIN flux. Benthic flux rates indicate that sediments potentially release substantial NH_4 into the Delta. Study results can be used to inform nutrient management and modeling in the Delta and have implications for effects on phytoplankton blooms in San Francisco Estuary.

Session 7: Delta Smelt Supplementation

Delta Smelt Experimental Release – Summary of Year Three Activities and Initial Observations

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Cultured Delta smelt (*Hypomesus transpacificus*) were first released into the Delta in water year 2022, in preparation for a supplementation program to aid the wild population. In the first two years, over 99,000 cultured Delta smelt were released into the Delta. In the third year of experimental release (November 2023-February 2024), we set a target to release 75,000 fish with two objectives: 1) to pilot large-scale fish transport methods, and 2) to compare hard and soft release methods. To minimize experimental variables, all fish were released at Rio Vista. To pilot large-scale transport, fish were hauled in a hatchery tanker truck to the release site, where they were released directly from the tanker truck into the Delta. To compare hard and soft release methods, fish were transported to the release site in carboys, loaded onto boats, and either released directly into the Delta (hard release) or released into large enclosures and allowed to acclimate to their surroundings for up to 48 hours before release (soft release). Soft release may help fish behave in more adaptive ways, by allowing them time to recover from transport stress while acclimating to their wild environment in a predator-free setting. Meanwhile, hard release is logistically simpler, making it easier to scale up to larger releases. Experience from the pilot large-scale transport releases will directly inform future releases, which will need to scale to the larger numbers required for supplementation. Comparison of hard and soft release methods will inform future studies pairing large-scale transport with various release methods, as experimentation and learning continue into the long-term supplementation program.

Quantifying the Stress Response of an Endangered Fish Species to Support Population Supplementation

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A newly adopted supplementation program for the critically endangered Delta smelt (*Hypomesus transpacificus*) hopes to recover dwindled populations. During experimental releases, Delta Smelt are transported from a hatchery to enclosures deployed in the Sacramento-San Joaquin Delta (hereafter called Delta). This process is expected to elicit considerable stress in Delta Smelt through intensive handling in the hatchery and rapidly changing water conditions during transport. Enclosures are designed to allow Delta Smelt to acclimate to natural conditions and recover from the stress of transport before full release. Critical knowledge gaps around this supplementation methodology include 1) how long fish should remain in enclosures for stress recovery and 2) what is the optimal fish density within transport containers and enclosures to minimize stress? Answering these questions will have immediate implications as they will inform optimal time of release and transport density to maximize fish survival and performance in the Delta. In conjunction with federal and state agency releases, this study measured the stress response of Delta Smelt following transport and release into enclosures in the Delta at two densities. Stress was quantified by measuring whole-body cortisol, glucose, and lactate, and gill ionocyte morphology in Delta Smelt within enclosures at 10 timepoints across four days. We observed a significant peak in cortisol, glucose, and lactate 30 minutes after release, followed by a significant recovery of cortisol and glucose after 27 hours, and 6 hours for lactate. We did not find an effect of transport and enclosure density on cortisol, glucose, or lactate circulation. Gill ionocytes showed significant increase in surface area and microvilli type and number in response to rapidly changing water conditions during transport and in the Delta. This work will provide agency managers with robust data that can be used to optimize supplementation methodologies of Delta Smelt into the Sacramento-San Joaquin Delta.

Branding, Spraying, and Tagging, Oh my! Investigating New Methods of Marking Cultured Delta Smelt

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In preparation for a Delta Smelt supplementation program, state and federal agencies, along with university partners, began conducting experimental releases of Delta Smelt in water year 2022. In water year 2024, the team expects to release at least 75,000 cultured Delta Smelt into the wild, and the target number of released fish is expected to increase each year going forward as the effort transitions to a supplementation program. Each of these fish is currently visibly marked prior to release, which allows the team to 1) differentiate cultured from wild-origin fish; and 2) assess the effectiveness of different release methods, locations, and times. Fish are currently hand-marked individually with either a VIE tag or an adipose fin clip, which is a very labor- and time-intensive process. In 2023, we conducted a tagging study with the goal of evaluating the efficiency and effectiveness of three novel techniques for tagging sub-adult Delta Smelt: 1) Photonic Ultraviolet Grit Spray, 2) Liquid Nitrogen Freeze Branding, and 3) Otolith Thermal Marking coupled with an adipose fin clip. We then compared survival and tag retention rates to a VIE-tagged control group. These new techniques are scalable, easy to implement, and allow for differential tagging of groups. Method testing trials suggest that one or more of these methods could be a viable alternative to VIE and adipose fin-clip tagging that may substantially increase resource efficiency. The tagging trials were completed in October 2023, and tagged fish will be held for approximately 6 months to assess tag retention over time.

Enhancing Delta Smelt Conservation: A Naturalistic Approach to Rearing and Supplementation

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A comprehensive conservation effort was initiated in response to the imminent threat of Delta Smelt (Hypomesus transpacificus) extinction, starting with the development of a captive breeding program established in 1996 and a genetically managed refuge population in 2008 at the University of California–Davis Fish Conservation and Culture Laboratory (FCCL). The program was meticulously designed to maintain a low domestication index, with continuous refinement of cultivation techniques through ongoing research and experimentation. While ideal for maintaining the population, hatchery rearing inevitably results in the loss of wild phenotypes due to domestication selection, a challenge that can be only partially mitigated. Efforts to bolster the wild population through supplementation began with experimental releases in 2022 and 2023. However, reintegrating hatchery-reared fish into the wild raises concerns about the population's overall fitness. To address this challenge and alleviate the impact of domestication selection, our research explores the feasibility and benefits of rearing Delta Smelt in naturalistic environmental conditions. Our findings suggest that subjecting Delta Smelt embryos to fluctuating temperatures (16-20°C) during their development enhances the thermal resilience of the larvae upon hatching. Furthermore, adult Delta Smelt maintained in cages within impoundments for up to three months exhibited survival rates exceeding 95%, alongside significant growth and successful spawning within their enclosures. We present these promising results, which offer an alternative approach to rearing Delta Smelt in a naturalistic environment during a portion of their life cycle, thereby better preparing them for release and mitigating the impact of domestication. Additionally, rearing fish in impoundments before release can alleviate the strain on conservation hatcheries, enabling them to focus on early life stages and potentially achieve higher production rates. This innovative approach represents a significant step forward in conserving and restoring the Delta Smelt population.

Session 9: Wetlands & Floodplains: Advancements in Monitoring and Restoration

Oh, the places they'll go! Results from a Yolo Bypass adult salmon and sturgeon acoustic telemetry study

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The Yolo Bypass has been identified as a high restoration priority, and several restoration projects have been or will be implemented to improve upstream fish passage, reduce stranding risks, and provide rearing habitat for native fishes. However, there are substantial data gaps that must be filled to design and operate restoration plans, develop performance metrics for evaluation of restoration actions, and assess fisheries risks. To address these data gaps, the California Department of Water Resources (DWR) leads a long-term acoustic telemetry tagging and tracking study in the Yolo Bypass, annually tagging adult White Sturgeon and adult Central Valley fall-run Chinook Salmon as surrogates for Green Sturgeon and Central Valley salmonids, respectively. The goal is to develop a conceptual model on fish movement in the Yolo Bypass that can be used to inform fish passage operations and adaptive management strategies for the Yolo Bypass.

Here, we present results from the past two years of the DWR acoustic telemetry study. The data have not been analyzed at the time of abstract submission, but we will investigate: 1) how do residence times differ near known migratory barriers and completed fish passage projects, 2) is there a correlation between flow and route selection, and 3) what is the range of migratory fates for tagged salmon and sturgeon? We will present these results at the workshop.

No Net Habitat Loss - Quantifying Fish Response to Levee Setback Projects

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As human interventions continue to influence natural aquatic habitats, understanding the interplay between engineered structures, like levee setback projects, and fish populations becomes pivotal for ecosystem conservation and management. To gain insights into these interactions, we utilized a low-impact fish sampling technology known as the Aquatic Habitat Sampling Platform (Platform). Our study aimed to quantify and characterize fish responses to engineered levee slope attributes near setback levees with waterside habitats from 2021 to 2023. Data collected by the Platform during this period included continuous transects of environmental parameters and fish detections via video imagery. Additionally, we collected environmental DNA (eDNA) to verify species identities. The integration of these diverse data types, both spatially and temporally, offers an unprecedented view of fish utilization across various habitats. The deployment of this versatile sampling system expanded our data collection capabilities to include shallow and off-channel habitats, with the potential to transition to deeper and open water habitats. This approach allowed us to provide reliable estimates of sampling efficiency and "catch" per unit effort while enhancing our understanding of food webs, native and non-native fish populations, habitat associations, and major stressors affecting key organisms. In this presentation, we will demonstrate how a wide range of water quality and physical data, including temporal and regional factors, can explain variation in the number and diversity of fish species observed at these sites. These results are expected to directly inform the assessment of the success of past projects and contribute to the design of future, effective levee rehabilitation projects.

Integrating social and ecological research to control invasive species in Suisun Marsh

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The potential success of invasive plant management depends on how much each actor within a social-ecological system would be willing and able to engage in management actions that reduce overall invasion risk. While most research on the human dimensions of invasive plant management has focused on individual landowners' efforts, collective action has been recognized as more effective than individual efforts by reducing overall invasion risk and management cost and by increasing treatment effectiveness. The Bay-Delta estuary is a highly urbanized and invaded region, with many non-native species affecting its wetland ecosystems. One wetland invader, Phragmites australis, creates impenetrable areas impeding fish and wildlife navigation, limiting site access and views, reducing navigation, and creating a fire hazard. Control has been attempted throughout the marsh under a cost-share program for private landowners (defunct since 2018) and via inconsistently funded efforts on publicly managed lands. Unfortunately, control efforts in Suisun Marsh have been held back by the lack of regional coordination involving the intermixed private and public landowners. There has been no systematic investigation of the decision-making processes that affect landowners' willingness to participate in Phragmites control, nor research into approaches that would facilitate adoption of a coordinated management plan. Therefore, our interdisciplinary team is examining current intentions and motivations as well as past failures and successes to suggest new approaches that promise better management in the future. From this, we are developing a spatial prioritization model incorporating both social and ecological components and a framework for regional coordination on Phragmites control.

Investigation of floating peat wetlands, Sacramento-San Joaquin Delta, CA

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**Presenting author*

Tidal wetland restoration is integral to achievement of the Delta co-equal goals. However, deeply subsided islands limit the potential for tidal wetland restoration. Floating peats may offer an opportunity for creation of tidal habitat on these islands. We conducted a mesocosm experiment to assess the feasibility of floating peat blocks, potential food-web benefits, biomass production, carbon sequestration, methane emissions and water quality. Four treatments with two replicates each were implemented to evaluate varying water residence time and peat-block density in the mesocosms.

Almost 4 years after placement in the mesocosms, the peat blocks continued to float and accrete biomass at rates greater than those reported for Delta non-tidal managed wetlands. Peat blocks placed in mesocosms with 50 % open water, expanded horizontally about 3 m2 yr-1. We estimated average vertical accretion rates of 5.5 to 8.6 cm/year.

Zooplankton data indicated a 3-fold population increase relative to the Mokelumne River which was the source of water for the mesocosms. Methane emissions were generally commensurate with or lower than those reported in Delta non-tidal wetlands. Aqueous CH4 concentration data indicated significantly lower concentrations associated with the shorter water residence time of 5 days where dissolved oxygen concentrations were significantly higher than for longer residence times of 10 days. Overall, our results indicate that the floating wetlands are greater carbon sinks than Delta non-tidal wetlands.

Water quality data indicate consumption of nitrogen by wetland plants and denitrification in the mesocosms relative to the Mokelumne River. Also, that organic carbon derived from aquatic vegetation released into mesocosm surface water was consumed by microflora and fauna. Overall, our preliminary results point to potential benefits of floating peats at a larger scale. Prior to implementation at a larger scale additional questions related to peat-block behavior in open water, food web and habitat benefit requiring answering.

Additive benefits of point counts and Automated Recording Units: What do secretive marsh birds say after the survey is over?

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To help identify high-priority conservation areas for tidal wetland birds in the Sacramento–San Joaquin Delta and Suisun Marsh, we conducted strategic bird surveys during the breeding season using multiple methods. We performed a gap analysis on secretive marsh bird survey data collected by Point Blue and other partners to examine survey coverage of tidal wetland habitat conditions across the study area. We conducted breeding season point count surveys at nine long-term Point Blue monitoring sites and three additional sites selected based on results from the gap analysis, for a total of 80 survey locations. Automated Recording Units (ARUs) were deployed at 36 of the Delta survey locations to improve our ability to detect secretive marsh bird presence. ARUs were programmed to record 5 hours per day over a 3-week period coinciding with point count surveys, resulting in 4,200 hours of audio recorded. We used BirdNET Analyzer to identify candidate recordings of focal species at each point and then manually reviewed results to confirm. We compared detections from the ARUs to the point count surveys. Our analysis focused on seven focal species associated with tidal wetlands, including both landbirds (Yellow-breasted Chat, Song Sparrow, Common Yellowthroat, and Marsh Wren) and secretive marsh birds (California Black Rail, Least Bittern, and American Bittern). All seven focal species were detected in the Delta, and all but Least Bittern in Suisun Marsh. Notable preliminary results indicate detection by ARU and point count survey of Black Rails, Least Bitterns, and Yellow-breasted Chats at several locations in the Delta, with other focal species more widely distributed. The results of these new surveys will be combined with existing survey data to develop distribution models for these species, which will inform prioritization analyses and assessments of the impacts of landscape change scenarios.

Session 10: Lightning Talks

Strategic communication for collective action in wetland management and restoration: engaging with the public, landowners, and agencies

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The California Delta has vast diversity in ecological, social, and political management needs and ideologies. Our field has spent decades investigating how each of these individually are contributing to the preservation and careful allocation of our natural resources for ecological and human uses. However, we still fall short when trying to implement solutions presented by scientific research, largely because of diverse viewpoints on best practices (ecological, financial, social). Invasive species management is an area that suffers disproportionately from stalled action on potential solutions because problems are time-sensitive and span property lines. We have been investigating the role that communication, including the assumption of shared literacy among stakeholders, has been playing in these management shortcomings. Using approaches in environmental psychology and strategic communication, we developed a comprehensive plan to motivate collective action among diverse stakeholders tackling Phragmites australis management. We began with surveys and interviews that produced language to discuss eleven wetland restoration topics with the public, including cultural values that build trust between communicator and audience. We next developed a survey for >170 landowners (public agencies and duck clubs) in Suisun Marsh that produced attitudes and behaviors on Phragmites management and cooperation among landowners. Then, we deployed interviews among landowners and water managers to produce language that motivates each stakeholder group to engage in collective action for invasive species management. Our next step is to test variations of these strategic communication plans to link attitudes to behaviors (i.e., whether they request resources to take action). Attitudes, behaviors, and actions operate from non-rational thought grounded in cultural values and social conditioning, so it is important to take a psychology evidence-based approach when designing strategic communication plans. While we must ground our management solutions in scientific discourse, scientific expertise alone is largely ineffective in motivating collective action in the social behavioral context.

Lessons Learned for Interweaving Traditional Knowledge and Western Science in the San Francisco Bay-Delta

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Monitoring, research, and synthesis for aquatic ecosystems are central to the Interagency Ecological Program (IEP), which is grounded in the best available science. To build credibility, trust, and legitimacy though may require participatory methods that leverage other knowledges. Place-based knowledge and land stewardship practices of Indigenous peoples typify what is known as Traditional Knowledge (TK). TK is an adaptive, participatory, and experiential process built through multigenerational observation. Building inroads for Traditional Knowledge in agency processes and products fulfills State directives, aligns with federal initiatives, and advances the missions of the Council as well as the IEP. With this motivation in mind, staff at the Delta Stewardship Council are conducting research to evaluate current and future opportunities to interweave Traditional Knowledge and Western science into San Francisco Bay-Delta practices. Agency staff conducted a team-based literature review of peer-reviewed and grey literature using snowball sampling approach to evaluate how Traditional Knowledge is applied and interwoven with Western Science in estuarine socio-ecological systems. Interviews with Tribes will provide further perspectives on how best to co-produce knowledge in the Delta. The team-based literature review evaluated a total 90 articles, with 40% coming from Indigenous scholars. One product forthcoming from the literature review is the “Guide to Interweaving Traditional Knowledge and Western Science” which highlights six strategies for the Council to consider including: 1. Beginning to understand TK; 2. Making the process of interweaving TK official; 3. Recognizing Tribes as equal partners; 4. Creating opportunities for direct and reciprocal learning; 5. Acknowledging Tribal ownership of data; and 6. Developing more accessible and inclusive language for restoration projects. As the Delta Stewardship Council explores how to best co-produce knowledge, we see recognizing Traditional Knowledge as a separate knowledge system that complements Western science is one step in the right direction.

Larval Fish Diets as Indicators of Food Web Dynamics in Tidal Wetland Restoration

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Fish populations in the San Francisco Estuary have been declining for decades due to multiple interacting factors, including a substantial reduction in tidal wetlands. Tidal wetlands are currently being restored in an effort to enhance fish populations by providing beneficial habitat and associated food web resources. Longfin smelt (LFS; *Spirinchus thaleichthys*) is one of the declining native fish populations and is a threatened species of concern. Zooplankton abundance in wetlands directly affects LFS populations, since larval LFS rely on zooplankton as their primary source of food. The aims of this study are to identify food web resources in close proximity to the restoring wetlands, compare them with ecological indicators in wetlands at different stages of restoration (early, intermediate, mature), and identify a set of zooplankton indicator species that are associated with beneficial habitat for LFS. High-throughput sequencing (HTS) will be utilized to identify the diversity of prey and indicator species in diets of larval fishes, specifically LFS, as well as Pacific herring (*Clupea pallasii*), and Prickly sculpin (*Cottus asper*), which utilize the wetlands as nursery grounds at the same time of year as LFS. HTS will identify the DNA of the prey consumed by the larval fishes, to identify the food web resources available to the larval fishes and the indicator species at each wetland restoration site. This study will provide necessary information to wetland restoration managers, such as the prey availability of specific species of zooplankton for larval fishes in their nursery grounds, an understanding of how these prey differ across wetlands at different stages of restoration, and key characteristics of wetlands that most support larval fish populations, which will ultimately benefit declining fish populations in the San Francisco Estuary.

A year of cage studies in the San Francisco Estuary to inform conservation efforts of Delta Smelt

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The endemic Delta Smelt (*Hypomesus transpacificus*), is a small pelagic euryhaline osmerid of the Sacramento-San Joaquin Delta, California and is an endangered species. Conservation strategies are underway to improve habitat conditions for Delta Smelt and reinforce the population through a developing supplementation program. To begin characterizing the effects conservation strategies may have on the species (such as survival and health), hatchery Delta Smelt were deployed in experimental cages throughout its habitat in the winter, summer, and fall of 2019. Caged smelt were compared to reference fish at the hatchery of similar age. The effects of season and location of cages on survival, health (growth, condition factor and histological condition of liver and gill), and thermal tolerance of the deployed fish were evaluated. The results demonstrate that there were both seasonal and location effects on Delta Smelt, with higher survival in the winter and fall, and in some cage sites such as Rio Vista on the Sacramento River, fish had improved condition compared to reference fish at the hatchery. Deployments were especially stressful for the species in summer, with the study site in the Yolo Bypass having no survival after experiencing high temperatures. Additionally, smelt in the summer and fall seasons showed signs of nutritional stress demonstrated by poor liver condition, that may be related to biofouling of the cages. Lastly, findings imply that laboratory measures of upper temperature tolerance may overestimate the realized tolerance in a more stochastic field environment. The study illustrates the use of cages as an experimental tool to better understand Delta Smelt responses to environmental changes in a more natural-field setting; however, more research is warranted to characterize unintended biofouling interactions.

Microorganisms as indicators of habitat conditions in restoring wetlands

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Wetlands are highly productive ecosystems that provide vital ecological services such as water purification, carbon sequestration, and biodiversity conservation. Unfortunately, wetland degradation has become a significant problem globally, including in the San Francisco Estuary (SFE), where 90% of wetlands have been lost; these losses create a pressing need for wetland restoration. Physical, chemical, and biological assessment tools are often used to monitor and conserve wetlands. However, microbial communities within these ecosystems have received little research attention. Despite their potential utility as indicators of water quality, microbial communities are frequently overlooked because diversity is high, the organisms are small and hard to identify, and sampling them is difficult. To address this issue, we are conducting a two-year study, using high-throughput DNA sequencing (HTS) to identify differences among SFE wetlands in the distribution and diversity of bacteria, archaea, and other plankton (ranging from pico to meso-sized). By characterizing the assemblages present in these wetlands, the study aims to determine which species are indicators of physical or chemical characteristics of the sampled wetlands. We will characterize bacteria, archaea, and phytoplankton using 16s rRNA HTS and zooplankton using 18s rRNA HTS to identify the organisms present and their relative abundance. We expect the microorganisms to differ between early-stage and mature wetlands with regard to the presence, absence, and relative abundance of species. The study aims to improve wetland restoration efforts by understanding microorganism diversity and distribution patterns and their links to important metrics of wetland restoration, with the goal of expanding fish habitat to increase populations.

Are Mosquito Control Pesticides Negatively Affecting Delta Water Quality?

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County vector control districts operating in and around the Sacramento-San Joaquin Delta apply a variety of insecticides to control mosquito populations and limit the spread of mosquito-borne illnesses. However, the effects of these insecticides on non-target organisms are not well understood. The organophosphate naled and the pyrethroid deltamethrin are two insecticides commonly applied for vector control, and both are highly toxic to aquatic invertebrates. These insecticides are applied over wide areas, aerially or from truck-mounted systems typically from the spring through late fall. In 2022 the Sacramento/Yolo Mosquito and Vector Control District applied naled and deltamethrin to 292,679 and 35,814 acres, respectively. In terms of pounds applied, naled is consistently the most heavily applied insecticide for vector control in the Delta region.

Following application, naled rapidly degrades to dichlorvos, another organophosphate insecticide. Naled, dichlorvos and deltamethrin are highly toxic and have low acute (57.5, 33.4, and 0.1 nanograms/liter (ng/L), respectively) and chronic (10, 5.8, and 0.026 ng/L, respectively) toxicity benchmarks for aquatic invertebrates. During ongoing Delta water quality monitoring studies, U.S. Geological Survey researchers detected naled, dichlorvos, and deltamethrin in water samples at concentrations that exceeded chronic and acute toxicity benchmarks for aquatic invertebrates. Detections corresponded to dates where aerial application of naled or ground applications of deltamethrin occurred near the sample sites 1 to 3 nights prior to sample collection. Although these studies did not specifically target vector control pesticide applications, the detection of these compounds suggests that these applications may be negatively affecting Delta water quality. Spray schedules are released 1 to 2 days in advance, making it possible to design a focused study to better quantify the occurrence, persistence, and maximum concentrations of naled, dichlorvos, and deltamethrin in Delta waterways providing much needed information to help assess their potential effects on non-target organisms.

LightDeck Technology: Evaluating A Cyanotoxin Detection Tool

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Cyanobacterial Harmful Algal Blooms pose a threat the Sacramento-San Joaquin Delta waters due to the potential production of toxins by some cyanobacteria taxa. Fast and reliable data on toxins are essential for risk assessment and decision-making. We present the results of a pilot study conducted in 2023 where we tested a new technology, LightDeck, for rapid and multiplex quantification of toxins in field samples collected monthly in the central Delta. We compared LightDeck results with gold standard laboratory methods for toxin quantification to evaluate the performance of the LightDeck technology. Microscope observations of field samples showed presence of different potentially toxigenic cyanobacteria, including *Planktothrix, Dolichospermum, Aphanizomenon*, *Microcystis*, *Phormidium* and *Planktolyngbya*, but toxins were not detected by the LightDeck. Laboratory ELISA results were consistent with LightDeck data and confirmed non-detection results by the LightDeck technology. To test positive toxin detections, we collected additional samples from *Microcystis* blooms at Cache Creek and Discovery Bay. The LightDeck consistently underestimated microcystin concentrations compared to ELISA, especially at higher concentrations. However, the limited number of samples analyzed requires further testing to fully evaluate the performance, accuracy and sensitivity of the LightDeck technology in measuring positive microcystin concentrations.

A Comparison between eDNA Concentrations & Loach Capture in the San Luis National Wildlife Refuge

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- Erika Holcombe USFWS
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**Presenting author, †Early Career Award candidate*

Sampling and analysis of environmental DNA (eDNA) is being explored as a novel method for species detection in aquatic systems, especially for rare, endangered, cryptic, and invasive species. In a 2023 project conducted by the Lodi Fish and Wildlife office, in cooperation with Cramer Fish Sciences, invasive loach species on the San Luis National Wildlife Refuge were targeted for removal using eDNA. The study had two phases: a live-car experiment which calibrated the probability of detecting loach eDNA based on variability of habitat present on the refuge, followed by a loach removal phase. If loach DNA was present at a site, ten baited minnow traps were set, and the loaches were caught and removed. This talk will discuss the comparison between eDNA concentrations, and the biomass of loach collected from corresponding sites, as well as the influence of environmental variables on the probability of eDNA detection. I hypothesize that eDNA concentrations will be positively correlated with the relative biomass of loach captured per site. Data analysis has not been conducted at the time of this submission; results will be ready at the workshop.

How Much Vegetation are IEP Fish Surveys Running Into, and Does it Matter?

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- Eric Huber, FWS
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**Presenting author*

IEP surveys have been collecting fish monitoring data for decades, primarily from unvegetated habitats such as channels. Climate change and species invasions though, have resulted in exponential growth of vegetative cover across the Delta. While some impacts to fish data are known, i.e., beach seine sites that can no longer be sampled, and trawls shifted from historic locations; we have limited understanding about the extent to which vegetation is impacting the interpretation of long-term monitoring data. Currently, no two IEP fish surveys track vegetation in the same way. This hinders our ability to determine if the trends we observe are due to shifting populations or shifts in habitat availability. In this pilot study, we asked each of the IEP fish surveys to answer a set of vegetation-related questions during their usual sampling. The data show that IEP fish surveys regularly encounter vegetation that could significantly impact how the resulting data are interpreted. We will discuss the relationships between vegetation and IEP fish data seasonally, spatially, and based on net type. Then, using pilot data, we will begin to link fish catch with observations of vegetation in the field. Based upon the findings in this pilot study, we believe a broader assessment of vegetation interactions with IEP fish sampling is warranted to confirm these preliminary findings. In the future, IEP fish surveys might benefit from adding a simple, quick, and uniform observation protocol, much like the *Microcystis* assessments which were added in the last decade.

Session 12: New and Improved Longfin Science and Monitoring

Improving our understanding of Longfin Smelt (*Spirinchus thaleichthys*) maturation and fecundity

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The genetically distinct population of Longfin Smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary (SFE) has experienced significant population declines in recent decades, resulting in an increased risk of extinction. The effectiveness of conservation strategies for this species hinges on the development of robust population models, which rely on accurate parameter estimates for age-at-maturity, size-at-maturity, and size-specific fecundity. Here, we have developed a non-destructive method to assess gonad tissues using image analysis, and we are applying these methods to assess ontogenetic, temporal, and spatial patterns in maturation and fecundity of wild Longfin Smelt collected across the SFE over the last two decades. Across the SFE the mean sex ratio was 3:1 females:males. Individuals with the highest condition K index were caught in the Alviso marsh complex in the south of SF Bay or in the Petaluma and Napa river marshes in the North of SF Bay. A distinct increase in the Gonadosomatic Index (GSI) of fish above >60 mm standard length (SL) was observed, and in extreme cases, gonads made up as much as 33% of a fish's total mass. Gonads began to ripen in fish above 60 mm SL, with 33% of fish over 70 mm SL containing gonads with fully mature oocytes. Longfin Smelt oocytes generally exhibited synchronous development, but the presence of some mixed-stage ovaries indicated multiple sequential spawning events within a given season. Females with maturing or mature ovaries were 65–106 mm standard length and contained 787–10,024 oocytes, with the average female being 75 mm and carrying 4,500 oocytes. Results are currently being combined with otolith-based analyses to assess patterns in age-at-maturation.

Larval Longfin Entrainment Sampling 2022-2024: a developing long-term monitoring program

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**Presenting author*

Longfin Smelt (*Spirinchus thaleichthys*) in the San Francisco Bay-Delta have experienced steep declines in recent decades. One factor in this continued decline is the influence of large water export facilities in the south Delta, where direct entrainment, unfavorable water quality, predation, and lack of food contribute to increased mortality. While both the CVP and SWP quantify salvage of adult Smelt, the 2020 Incidental Take Permit identified a need for quantitative estimates of larval (<20mm) Longfin Smelt entrainment. The Larval [Smelt] Entrainment Study(LE) began in 2022. We summarize two years of sampling, which in 2023 utilized SLS gear alongside a new gear with a net mesh size (940µm) mounted to an SLS frame. We conducted sampling January-April, adjacent to Clifton Court Forebay. Although historically high flows in 2023 necessitated slight changes to our sampling design and location. These flows would also lead to different larval longfin presence compared to samples collected in 2022. In addition to our monitoring efforts, a subsequent gear comparison carried out in May 2023 expanded on differences in efficiency between three townet mesh sizes; 500 (SLS), 940 µm gears (LE) and 1600 (20-mm). Finally, we will outline our 2024 sampling efforts.. These efforts will lead to improved Longfin Smelt entrainment estimates, keeping managers informed on water project impacts on a threatened native fish.

Expansion into San Pablo Bay: Smelt Larva Survey & 20-mm Survey Updates

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**Presenting author*

The Smelt Larval Survey was initiated in 2009 to document the spatial distribution of larval Longfin Smelt in reference to the zone of entrainment to the fish facilities in the South Delta. The survey conducted bi-weekly sampling from January through mid-March among 44 fixed stations from the eastern Delta to the Carquinez Strait and up the Napa River. However, the spatial distribution of larval Longfin Smelt was found to extend downstream, beyond the historic sampling frame in high-outflow years, limiting the surveys representation of inter-annual variability. Here, we leveraged a new spatial sample frame for pelagic fish surveys designed to integrate CDFW fish surveys to expand the SLS and 20-mm Survey into San Pablo Bay. Simulation analysis of historic data indicated that incorporating 6 to 15 additional tows per survey in the San Pablo Bay stratum for both the Smelt Larva Survey (SLS) and the 20-mm Survey, reduced the standard errors in abundance estimates by 25%.

The implementation of these recommendations began in the 2023 sampling season. The SLS and 20-mm Survey integrated 14 to 15 additional sampling stations into their survey design. These new sampling stations were selected using historic fixed station locations and included a mix of deep channel and shallow shoal stations. In total, this expansion added 498 additional tows to the sampling year.

For the Smelt Larva Survey (SLS), the results indicated that approximately half of the total fish catch, which amounted to 200,902 individuals, were captured at the 15 new expansion stations. This expansion in sampling stations and tows is a proactive step taken to enhance the accuracy and precision of abundance estimates for Delta Smelt, Longfin Smelt, and other fish species in the San Pablo Bay region, providing more reliable data for management and conservation efforts.

Building a Longfin Smelt Life Cycle Model

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- Leo Polansky, USFWS Bay Delta Fish and Wildlife Office
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**Presenting author*

Declining catch of Longfin Smelt (LFS) in long-term surveys suggests that a dramatic population decline has occurred. LFS were listed as threatened state-wide under the California Endangered Species Act in 2009 and the USFWS proposed listing the Bay-Delta Distinct Population Segment of LFS as endangered under the Federal Endangered Species Act in 2022. Management and recovery planning for LFS could benefit from modeling the relationships between Longfin Smelt abundance, environmental conditions, and management actions. Here we present the cooperative development of a Longfin Smelt Life Cycle Model (LFS LCM) to characterize the effects of biological and physical factors on Longfin Smelt population dynamics. The LFS LCM is intended to be a decision support tool to predict effects of proposed management actions, to assess effects of actions that were implemented, and to learn from effects of historical environmental conditions on the population dynamics of LFS. The first steps toward collaborative creation of a model plan involved collating questions and hypotheses about LFS abundance, life stage transitions, and environmental influences from six agencies. These were used as the starting point from which the LFS LCM Modeling Team developed a conceptual life cycle model. We overlaid an influence diagram to visualize both the diversity of agency priorities and the ways in which they overlap. We also identified additional environmental variables and ultimately decided on a list of variables which should be considered for modeling each life stage transition. These variables and the conceptual model will inform a dynamic process for developing the model structure and underlying dataset.

Session 13: So Many Fishes

A mark-recovery model for delta smelt

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In late 2021 and 2022, hatchery-origin delta smelt were tagged and released into the upper San Francisco Estuary as part of an experimental population supplementation program. Recoveries of tagged smelt were used to fit a tag-return model that estimated the natural mortality, entrainment mortality, and observation probabilities of delta smelt in several surveys. Critical model assumptions regarding tag retention and correct identification of recovered tags were supported by controlled auxiliary studies and genetic confirmation of each observed delta smelt. The immediate survival of delta smelt, post-release, was assumed to vary by transport and release method. Initial results indicated that transport and release directly into the center of the channel was associated with higher survival, but more data will be necessary to evaluate transport methods. Weekly estimates of mortality were interpreted as a timeline of the predicted fates of delta smelt over the December to April spawning period. Entrainment mortality during South Delta water export appeared to occur in brief periods of lower OMR and high turbidity in January and February. Similarly, observation probabilities in the Enhanced Delta Smelt Monitoring Survey increased during periods of higher Delta-wide turbidity. Residual analysis suggested that one trailer-transported cohort was entrained at a higher rate, relative to other cohorts of delta smelt at large at the same time. The model structure established here will provide a framework for future assessment of the fates of hatchery-origin delta smelt.

Automated Fish Tracking and Enumeration in Dynamic Environments

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Rivers and streams constitute highly dynamic environments. Even within a single transect, one can encounter a wide variety of conditions without needing to change streams or watersheds. This dynamic nature poses significant challenges when developing robust and reusable automated algorithms and pipelines. In this presentation, we will discuss our efforts in creating automated fish detection and enumeration from video footage captured across various habitats using a mobile sampling platform. Goals of projects utilizing this sampling technique are to fill data gaps in interactions between levels of food webs, abundances of species of interest, and landscape-scale processes to inform management decisions into the future. However, this presents unique challenges due to factors such as lighting, turbidity, vegetation, debris, and more, which can significantly impact the quality of the images being analyzed. While fish detection can be a manageable task with sufficient training data, tracking and enumeration present more complex and nuanced challenges. These difficulties depend on the sampling conditions, hardware constraints, and desired outcomes. During the development of our analysis pipeline, we explored multiple approaches to overcome these challenges. We will discuss three distinct techniques for tracking and enumeration, including the DeepSort algorithm, overlapping bounding boxes, and predictive particle filters. Each of these techniques has its own advantages, nuances, and requirements. We will delve into their pros and cons, highlighting how they can be applicable in various situations and studies. Since the primary focus of this presentation will address the unique challenges of dynamic environments, conclusions drawn from our work should have broad applicability to less dynamic systems that encounter similar issues.

Lampreys in California (*Lampetra* and *Entosphenus* spp.): Mitochondrial phylogenetic analysis reveals previously unrecognized lamprey diversity

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Lampreys display extensive diversity in morphology and life history strategy. The extent of this diversity and the underlying genetic patterns have not yet been fully characterized. Uncertainty about species boundaries and operational taxonomic units hinders lamprey management and conservation. Limited data have been collected on California lampreys (*Lampetra* spp., *Entosphenus* spp.), but evidence suggests widespread population decline across the west coast of North America. This study utilized DNA barcoding, phylogenetic analysis, and species delimitation analysis to identify which nominal species are present at study sites across northern and central California, determine whether current taxonomic classifications accurately and sufficiently describe lamprey diversity in California, and characterize the biogeographic distribution of genetically distinct lamprey lineages across the study area. Lamprey individuals (N=89) from 19 sites in the Sacramento-San Joaquin River basin, San Francisco Bay, and Klamath River basin were sequenced for the mitochondrial cytochrome b (cyt b) gene and combined with publicly available lamprey cyt b sequences for analysis. Results showed relatively deep phylogenetic divergence between *Lampetra* and *Entosphenus*. Distinct and genetically divergent lineages were observed within Lampetra, while distinct but genetically similar lineages were observed within *Entosphenus*. This study revealed novel *Lampetra* lineages in Napa River and Alameda Creek, and results suggest that the biogeographic distribution of lamprey diversity may follow patterns observed in other native fishes. Species delimitation results indicated at least seven separate candidate species of *Lampetra* can be found in California, suggesting that California holds more species-level diversity than the expected three nominal *Lampetra* species known to occur in the state. These results highlight the underestimated diversity of lamprey in California and the need for further assessment of taxonomic classifications and operational taxonomic unit designations of California lampreys.

Management implications of otolith-based insights regarding the growth, phenology, life history, genetics, fecundity, and fitness of Delta Smelt.

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**Presenting author*

Conservation and management efforts have largely failed to protect Delta Smelt in the San Francisco Estuary. As we search for answers, we have turned to novel approaches that utilize otoliths (calcified ear stones) to shed light on complex patterns in the growth, phenology, life history, genetics, fecundity, and overall fitness of the remnant wild population. In aggregate, these results highlight how numerous demographic parameters fluctuate in relation to the local environment and regional climate. Furthermore, results indicate that existing models and conservation strategies may be causing directional selection against the most successful and fittest Delta Smelt phenotypes and genotypes, with effects further exacerbated by rapid domestication of reserve and supplemental populations. While more studies are always needed, sufficient data likely exist to develop new conservation approaches that may help protect and restore California's most critically endangered Delta endemic.

Environmental drivers of fish populations in Central California

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**Presenting author*

Fish populations inhabiting the San Francisco Estuary, Delta, and Sacramento and San Joaquin River systems are changing through time in response to factors including climate change and water management. However, a large fraction of research attention is devoted to a small number of species—many of which are already known to be in decline—leaving the population trends and environmental associations of other species little studied. This study synthesizes data from several long-term monitoring programs to investigate how several environmental variables (delta outflow, position of the low salinity zone, sea surface temperature, upwelling intensity, Secchi depth, dissolved oxygen, chlorophyll-a concentration, zooplankton density) are related to temporal patterns of fall Age-0 fish abundances. We consider >20 species spanning a range of life history strategies and habitats, including several that have received little prior study. This work is a precursor to a broader effort to quantitatively estimate the relative risk of population collapse across this suite of species, potentially helping to identify species of future conservation concern while still relatively abundant.

Biofouling impacts to field enclosure studies on Delta Smelt

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To better understand the endangered Delta Smelt in the wild it can be useful to use in situ enclosure experiments, however, previous studies have exhibited excessive biofouling during the summer-fall seasons that may interfere with the interpretation of results. This dense biofouling may restrict water exchange within the enclosures, which may degrade water quality and reduce zooplankton availability. The biofouling also attracts amphipods, which can disproportionately contribute to Delta Smelt diets compared to their natural diet. Our goals were to: 1) test biofouling reduction methods and 2) test whether Delta Smelt exhibit a difference in condition between two field sites and if that difference can be detected using enclosure studies. We assessed two biofouling reduction methods: 1) scrubbing the enclosures weekly and 2) replacing the enclosures with a clean enclosure every two weeks at two locations, Rio Vista on the Sacramento River and Belden's Landing in Suisun Marsh. To compare the conditions Smelt experience inside the enclosures and the external environment, we collected ecological data from the inside, outside, and on the surface of the enclosures including flow, water quality, algae, amphipod, and zooplankton samples. At the end of the 6-week deployment we collected all Delta Smelt to determine survival and evaluate fish condition by measuring growth, critical thermal maximum, hepatosomatic index, liver glycogen, and diet. These metrics will inform potential differences in Delta Smelt responses to enclosure biofouling reduction methods and between the two enclosure deployment sites. The results of this study will have implications for the efficacy and implementation of Delta Smelt enclosure studies to test habitat management actions in the summer.

Session 14: Salmonid Habitat – Monitoring and Modeling

Reorienting to Recovery: CA Central Valley Salmonid Recovery Project

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- Rafael Silberblatt, Kearns and West
- Dr. Rene Henery, Trout Unlimited
- Dr. Natalie Stauffer-Olsen, Trout Unlimited
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- Darcy Austin, State Water Contractors
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**Presenting author*

The “Reorienting to Recovery” (R2R) salmonid project seeks to engage regional associations, interested parties, and California Tribes across the salmonid landscape in an inclusive, collaborative, and structured process to develop an effective and implementable strategy for recovering listed and non-listed salmonids in California’s Central Valley while considering other social, ecological, and economic interests in the region. The project consists of three phases: 1) Defining salmonid recovery in biological terms, 2) Defining performance metrics for salmonid recovery and values for other social, ecological, and economic interests in the region, and 3) Evaluating potential actions through modeling and structured decision making (current phase). In Phase 3, the first round of modelling actions to recover salmonids explored how the model responded to different inputs so the group could explore scenarios. Overall, no Round 1 bookend met all biological salmonid recovery targets. Multiple scenarios met salmonid recovery targets for productivity (CRR > 1 and population growth rate > 0), but no scenario met targets for spatial structure and genetic diversity (pHOS < 0.05). Since each scenario represents implementing only one type of management action and was not designed to achieve recovery, these results are expected and indicate that there are multiple factors hindering recovery that will require multiple types of management actions. The group is currently working on the next round of modelling scenarios which will explore what combinations of management actions will achieve salmonid recovery, these will be presented at a February 2024 workshop meeting, discussed and refined upon even more. This talk will discuss how the R2R project has implemented the structured decision making process to frame and explore salmonid recovery scenarios

on a large spatial scale with many diverse and interested parties, present results, and share lessons learned along the way.

Estimating abundance of endangered winter run Chinook salmon entering and exiting the Delta

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**Presenting author*

There is growing appreciation that a California Central Valley salmon monitoring network is needed to provide quantitative estimates of abundance and to improve our knowledge and resolution of life-stage success and movement across the landscape. However, accurate expansion of catch to obtain population abundance requires estimates of sampling gear efficiencies and run classification. We describe ongoing efforts to estimate trawl efficiency in conjunction with genetic stock assessments to improve the accuracy and precision of population abundance estimates for winter-run and other races of juvenile Chinook Salmon entering the Delta at Sacramento (Sherwood Harbor) and exiting the Delta at Chipps Island. We provide an overview of the initial five-year effort and describe ongoing efforts for future work to generate run-specific estimates of juvenile Chinook Salmon entering and exiting the Delta. Since 2016, over 11,000 fish were implanted with acoustic transmitters and paired with releases hatchery fish impanted with coded wire tags. Additionally, over 9,000 genetic samples have been collected and analyzed from trawl samples at Sacramento and Chipps Island with over 400 being assigned as genetic Winter-run. Winter-run abundance estimates at Chipps Island ranged from 31,800 – 92,200 at Chipps Island and efficiency varied with Delta outflow, tow location, and tow direction. Finally, we focus on describing future efforts with the trawl efficiency project, which revolve around continued paired releases of Winter-run Chinook Salmon. Additional efforts are focused on applying these methods to estimate the abundance of juvenile spring and fall-run Chinook entering and exiting the Delta.

Improving Understanding of Survival, Mortality, and Habitat Use of Emigrating Salmonids Through Applications of Multistage Survival Models

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**Presenting author*

Poor survival during juvenile Chinook salmon rearing and outmigration is arguably the one of the biggest factors impacting the species. Despite expensive restoration efforts and management actions, populations continue to decline across the Central Valley and beyond. Survival studies, typically using acoustic telemetry, show there is a positive relationship between freshwater flow and salmon survival, but reduced flows are not the direct cause of salmon mortality (except for stranding and dewatering). Instead non-flow factors interact with flow to cause mortality. However, few studies have parsed different causes of salmon mortality. We are developing a multistate modeling framework to guide future telemetry studies in acquiring high resolution data capable of distinguishing among disparate sources of juvenile salmonid mortality. Multistate modeling provides the ability to identify where and how mortality occurs, which may include factors like entrainment, disease, piscine predation, and avian predation. By developing and testing a multistate model through simulations informed by real-world management scenarios, we will demonstrate the usefulness of this modeling framework for adaptive management of fish populations. At the IEP workshop, we will introduce the concept of the multistate framework and describe two potential scenarios in which it could inform telemetry studies aimed at understanding sources of juvenile salmon mortality. Our goal is to solicit feedback from experts working in salmonid management and restoration on the types of management scenarios that would benefit from multistate telemetry studies.

Chinook Salmon and Delta Smelt Metabolic Indices: Determining their Viable Habitats across the San Francisco Estuary through Integrating Laboratory Respirometry and Environmental Monitoring Data

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Organisms are physiologically limited by their aerobic energy balance, which is intrinsically dependent on their metabolic rates as well as environmental temperature and dissolved O2 (DO) levels. However, environmental conditions vary greatly across space and time, and in general temperature is expected to increase and DO decrease across freshwater habitats. As such, a robust understanding of these interacting effects is necessary for the conservation and management of threatened and endangered species inhabiting the San Francisco Estuary (SFE). The metabolic index model integrates environmental temperature and oxygen with species-specific temperature-dependent hypoxia tolerance, which together with species distribution data can be used to spatially and temporally predict viable habitats. In this study, we conducted intermittent respirometry trials on two endangered SFE fishes: Chinook Salmon (Oncorhynchus tshawytscha) smolt and juvenile Delta Smelt (Hypomesus transpacificus). Similar to past data, salmon routine metabolic rate (RMR) and critical O2 tension (Pcrit) increased with acclimation temperatures (10, 13, 16, 19, 22ºC), and their maximum metabolic rate (MMR) and aerobic scope (AS) peaked at 16ºC. Past Delta Smelt respirometry attempts resulted in high mortality and short durations, but in the present study we successfully developed a methodology to consistently conduct intermittent respirometry to generate RMR and Pcrit data across temperatures (10, 12, 15, 17, 19ºC). Lastly, the respirometry data are being integrated with environmental temperature and DO measurements from long-term SFE monitoring programs to generate two species- and life-stage dependent metabolic indices. These datasets can better inform managers as they decide the location for fish supplementation to maximize

impact. Moreover, the metabolic indices could inform wetland restoration and habitat remediation efforts to generate greater connectivity across viable habitats, and to anticipate areas of concern due to climate change impacts.

Blinded by the Light: could reducing artificial nighttime illumination benefit native fish?

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**Presenting author*

Artificial nighttime illumination is a widespread anthropogenic pollution that poses challenges for wildlife in nearly every ecosystem across the globe. While there has been significant progress on understanding the effects of artificial light on animal behavior and interactions for many species, few studies have estimated the population level effects of artificial lighting. There is limited data on the distribution of anthropogenic sources of light at a resolution that is relevant to individual organisms. We present a case study using juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin Delta to estimate population-level impacts of artificial lighting across a species' migratory corridor. Using data from a 2019 field experiment, we identified illumination thresholds relevant to the survival of migrating salmon. We then conducted a survey of the sources and distribution of artificial illumination across the entire Delta. Combining these two datasets, we estimate the relative benefit of turning off, or dimming lights under different baseline survival scenarios. Our results suggest that reducing light glare from sources such as streetlamps, bridges, and docks, would likely have benefits for salmon populations in the Delta.

Session 15: Troubled Waters: Stressors and Aquatic Organisms

Identification of Toxic Contaminants in California Sediments using Nontargeted Analysis and *Hyalella azteca* Toxicity Tests

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Since 2008, the Stream Pollution Trends (SPoT) Program has monitored up to 100 sites for sediment contamination and toxicity, providing crucial information for impaired waterbody listings across California. While their efforts have been extremely important for sediment quality assessments, the broad scope of this campaign limits the number of targeted contaminants that can be monitored. To provide greater protection of ecological health and beneficial uses, it is essential we combine targeted approaches with nontargeted analysis to identify unknown and emerging toxic chemicals within California streams. In this study, both liquid and gas chromatography with high-resolution mass spectrometry (LC-HRMS and GC-HRMS) were used to screen for tens of thousands of suspect compounds in 30 sediment samples. Nontarget features correlated with *Hyalella azteca* (HA) growth and mortality were investigated further through targeted mass spectrometry and standard purchasing for confirmation. Out of the 5548 total features detected, 403 were correlated with HA mortality and growth. Pesticides including bifenthrin, permethrin, clomazone, and fipronil significantly correlated with HA mortality. These compounds were found in several sediment samples from across California and were confirmed with authentic standards. Ongoing work is focused on identifying compounds linked to toxicity but not yet confirmed through standards. These findings suggest that multi-mode nontargeted analyses combined with standard toxicity testing provide more complete toxicity profiles within complex environmental mixtures.

Navigating Toxic Waters: Sub-lethal Concentrations of Bifenthrin Impact the Behavior of Chinook Salmon but not their Cardiac Respiratory System

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Insecticides are used globally in agricultural, industrial, and household settings and have the potential to contaminate nearby aquatic systems through runoff and spray drift during storm events. The California Delta is no exception, significant sources of insecticides such as bifenthrin have been detected in surface water and sediment. As a result, contamination in the area has been listed as impaired under the Clean Water Act. Insecticides in the waterways have been associated with many adverse biological effects in aquatic species, ranging from sub-lethal impairments to lethality. Chinook salmon (*Oncorhynchus tshawytscha*) are exposed to the insecticides as they out-migrate from the affected rivers. The goal of this project is to assess the impact of bifenthrin, an insecticide known to impact organisms' metabolic and neurologic systems, on the cardiac system and behavior of Chinook salmon. We hypothesized that sub-lethal levels of insecticides are high enough to affect fish cardiac output, stress response, swimming behavior and social behavior. To test this hypothesis, juvenile Chinook Salmon were exposed for 10 days to four concentrations of insecticides: control, low, medium and high (125, 500 and 1000 or 2000 $ng.L^{-1}$). Sub-lethal concentrations of bifenthrin appeared to affect the behavior but had a relatively low impact on the cardio-respiratory system, of juvenile Chinook Salmon. Juveniles exposed to higher (500 and 1000 $ng.L^{-1}$) bifenthrin concentrations became more active in response to a light trigger, relative to control fish. Fish exposed to low (125 $ng.L^{-1}$) concentration displayed hypoactivity, while fish exposed to high (1000 $ng.L^{-1}$) concentration exhibited hyperactivity. In addition, fish exposed to 1000 $ng.L^{-1}$ bifenthrin concentration displayed reduced anxiety characterized by lower thigmotaxis and reduced social interaction. Altogether, those changes in behavior are likely to impact the ability for juvenile Chinook Salmon to hide from visually hunting predators in the wild.

Development of a pesticide response spectrum model for Chinook Salmon

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Our project goal is to develop a response spectrum model that associates measured internal pesticide residues with adverse biological effects in juvenile Chinook Salmon. The use of an internal pesticide concentration in the fish as the chosen dose metric has major advantages over using aqueous pesticide concentration in that internal concentrations are not limited by factors such as bioavailability or route of uptake. Previous studies conducted by our research team in waterways in the Delta have found that the current-use insecticides, bifenthrin and fipronil, and the degradation product DDE represented the most frequently detected pesticides in sediment, invertebrate, and outmigrating Chinook Salmon, thus are the focus of this study. Newly developed response spectrum endpoints include 4-d and 10-d lethality, growth rate, olfactory response, swimming performance (U_{crit}), cardio-respiratory performance (CT_{max}) and multi-behavioral assessments. The 4-d wet-weight (ww) normalized lethal residue at 50% mortality (LR_{50}) was lowest for bifenthrin (0.654 nmol /g ww), followed by fipronil (7.17 nmol/g ww) and the sum of fipronil and its sulfone, sulfide, and desulfinyl degradation products (8.72 nmol/g ww). The use of a risk quotient approach indicated that bifenthrin imparts the highest risk of acute toxicity in juvenile Chinook Salmon among the pesticides tested. The advantages of the newly developed model are that it will allow for direct comparisons of pesticide bioaccumulation data for juvenile Chinook Salmon obtained from routine biomonitoring activities to a residue-effects model. This will enable assessment of sub-lethal impacts of pesticides on these fish and potential consequences for predation risk and likelihood of migratory success. This information will guide future management decisions regarding the effects of pesticides on sensitive salmonid species.

An Assessment of 6PPD-Quinone Acute and Sublethal Toxicity on San Francisco Bay Delta Species of Conservation Concern

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Tire and road wear particles are an inevitable consequence of tire use in automotive traffic and are of particular concern in near-urban ecosystems. A toxic transformation product of a common tire additive, N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPD-quinone), has been detected in water samples from San Francisco region creeks at concentrations near and above the LC50 for Coho Salmon. The presence of 6PPD-quinone in the San Francisco Bay-Delta region thus presents a potential risk to local aquatic species. This project aims to assess the toxicity of 6PPD-quinone to five species of conservation concern: Coho Salmon, Chinook Salmon, Steelhead, Longfin Smelt, and Delta Smelt. Larvae and juveniles of each species were tested for acute toxicity with ongoing investigations of sublethal toxicity. Sublethal endpoints include behavior, thermal tolerance, and swimming performance to assess potential neurotoxicological and cardio-respiratory effects of 6PPD-quinone exposure. Results suggest interspecies differences in susceptibility, with Coho Salmon and Steelhead showing acute sensitivity at 0.07 and 5.00 µg/L, respectively. Together with acute assay details, we will also present sublethal effects determined through behavioral assessments. Observed erratic behavior in exposed Chinook Salmon and Coho Salmon support the growing weight of evidence that 6PPD-quinone acts as a neurotoxicant. The results from this study will inform ongoing conservation efforts for these critically threatened species.

Monitoring and Modeling Pathogen Exposure in Salmon Migrating to the Delta

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The survival of Chinook Salmon outmigrating to the Delta is affected by a number of factors, one likely being exposure to pathogens. How pathogens affect the probability of mortality for salmon outmigrating to the Delta, the location and timing of exposure risk, and how environmental conditions influence the susceptibility of salmon reaching a disease state are important unanswered questions. This presentation highlights the findings of a Proposition 1 funded research project dedicated to addressing these critical questions. The project had two primary objectives: 1) advancing our knowledge of pathogen exposure and the salmon's immune response in the Sacramento and Feather rivers, and 2) constructing an open-source disease transmission model, informed by local field data, capable of simulating the anticipated health outcomes for salmon exposed to a specific pathogen of concern in the Central Valley—*Ceratonova shasta*.

Posters

There are seven categories of poster presentations:

1. Data Management
2. Fish
3. Food Webs
4. Management
5. Phytoplankton and Zooplankton
6. Restoration
7. Water Quality

Poster abstracts are organized alphabetically by title within each category.

Data Management

Assessing the efficacy of electronic data entry in the field for multiple long term fish monitoring surveys

- Adriana Arrambide*, USFWS, adriana_arrambide@fws.gov
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- Erly, Kate USFWS
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Replacing paper-based data entry systems with electronic data collection for field research is gaining popularity. Direct digital data entry in the field is potentially cheaper and faster but less accurate than entering data from paper datasheets into a computer. We conducted a pilot study in the fall and winter of 2023 to investigate the costs and benefits of field data entry using digital data sheets versus office data entry using paper data sheets. We analyzed data for four long-term fish monitoring surveys in the Sacramento-San Joaquin Delta conducted by the U.S. Fish and Wildlife Service – the Delta Juvenile Fish Monitoring Program's (DJFMP) beach seine, midwater trawl, and electrofishing surveys and the Enhanced Delta Smelt Monitoring Program's (EDSM) Kodiak trawl survey. Results are forthcoming.

Data pipeline, processing and visualization: Bringing the Fish Restoration Program water quality data to life

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Interagency monitoring efforts are a pathway to improve field efficiency and reduce the heavy lift of monitoring programs. However, managing the data in a cohesive and accessible manner for all contributing partners and interested parties can quickly become slow and convoluted.

The Fish Restoration Program (FRP) seeks to share a data management approach for situations where groups generate and maintain separate portions of a dataset. The FRP continuous water quality dataset is collected by two departments, CDFW and DWR, and comes from over 10 water quality stations within tidal habitat restoration sites – making the need for a shared, semi-automated data pipeline a top priority.

Through upgrades to electronic data sheets, biweekly meetings, and R code managed within GitHub, FRP has developed a data pipeline that can be accessed, updated, and managed by either department. Outcomes from this effort include faster responses to data requests, regular processing of data, and increased time for data analysis.

As a final component to the data pipeline, FRP has developed improved data visualizations for general use by the broader Program and for improved management of/response to station conditions.

Fish

2023 Pilot Experimental Gillnet Survey to inform an Enhanced Large Fish Study Design

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Fishery independent monitoring in the San Francisco Estuary (SFE) includes extensive survey coverage by the many trawl- and seine-based surveys of the Interagency Ecological Program (IEP). These surveys primarily sample small and/or juvenile fishes due to the relatively small net dimensions and tow speeds. As a result, the adult component of many SFE fish species was not well sampled, representing a shortcoming in the IEP's ability to track changes in age-structured regional fish assemblages. Through the addition of a new study to the IEP workplan, called the "Enhanced Large Fish Study" (ELFS), we aim to fill this knowledge gap and contribute to the California Department of Water Resource's compliance with State Water Resource Control Board Decision 1641 for the operation of the State Water Project.

In spring of 2023, we piloted the first field season of the ELFS, employing American Fisheries Society experimental gillnets in a stratified random sampling design in the North Delta and Lower Sacramento River corridor. In total, we set 153 approximately one-hour gillnet sets over 25 sampling days, including 33 paired day and night sets to test diurnal effects on catch. We caught a total of 16 fish species of which five were native and 11 were non-native, ranging in size between 101mm and 678mm fork length. This season proved the efficacy of using experimental gillnets to sample the large fish community within portions of the SFE. Future sampling years will include coordinated sampling with the US Fish and Wildlife Service Delta Boat Electrofishing Survey and an expansion into downstream habitats including Suisun Bay and Marsh.

Assessing the influence of water quality on the proportion of native and non-native larval fishes comprising regional assemblages in the California Sacramento-San Joaquin Delta System

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Habitat parameters can influence the reproductive success and survival of native and non-native fish. The California Sacramento-San Joaquin Delta system has undergone alterations to its water system over the years, specifically changes in flow and water quality parameters. There is a pressing need to understand how species occurrence, diversity, and interactions are influenced by water management and climate change. Our research looks to explore key habitat quality factors (bottom depth, temperature, dissolved oxygen, salinity, and turbidity) and their relationships with native vs. non-native larval fish species abundance in the Sacramento-San Joaquin Delta system. The U.S. Fish and Wildlife Service Enhanced Delta Smelt Monitoring Program has used a 20mm larval trawl net to collect larval fish assemblage data from 2017 through 2023. By utilizing this larval trawl data, we aim to uncover any patterns underlying the presence of native vs non-native larval fish, based on the regional differences in water quality conditions.

Comparison of Young White Sturgeon Abundance in San Francisco Bay Estuary in relation to the Yearly precipitation of Northern California

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The California Department of Fish and Wildlife's (CDFW) Native Fishes Unit (NFU) conducts the Smelt Larva Survey and 20-mm Survey to monitor the distribution and relative abundance of larval and juvenile Longfin Smelt (*Spirinchus thaleichthys*) and Delta Smelt (*Hypomesus transpacificus*). These surveys provide data to water managers to assess the risk of entrainment of these species into the water export facilities. While these surveys focus on Osmerids, there are other species of concern amongst the catch, including white sturgeon (*Acipenser transmontanus*). These anadromous fish are found from Gulf of Alaska to Monterey Bay. Locally, white sturgeon larvae are typically found in the upper Sacramento River (Wang et al., 2010). Within our surveys, larvae and juvenile abundance fluctuate yearly. During dry years only a few individuals are collected compared to wet years where the number of white sturgeon collected increases exponentially. Concern for white sturgeon increased due to the reoccurrence of harmful algal blooms in the San Fransisco Bay estuary, decreasing habitat, and historic overfishing. The presence of white sturgeon larvae in the most recent NFU surveys generated questions on how this species is coping with changing water years and water conditions. In this study, we collected data from various CDFW surveys within the San Francisco Bay Estuary, such as San Francisco Bay Study, Native Fish unit, and Young Fish Investigations Unit, to examine the historical trends of young white sturgeon. We compared this data to annual precipitation levels and flow data for the last 20 years. We expect higher precipitation and flow years to increase available habitat suitable for larval white sturgeon rearing. This would increase the amount of white sturgeon seen in our surveys. These results provide insight of how white sturgeon populations correlate with yearly precipitation and flow. Understanding how white sturgeon larvae survive in fluctuating hydrology patterns can help inform conservation decisions.

CRISPR-based SHERLOCK Assay for Rapid Detection of Chinook Salmon eDNA

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Detecting DNA in the environment (eDNA) from aquatic species is a non-invasive and cost-effective method of monitoring vulnerable species and is a valuable addition to the resource management toolbox. Quantitative PCR (qPCR) is currently the leading technique for aquatic eDNA detection. However, processing samples via qPCR requires expensive instrumentation, molecular biology experience, and several hours of benchwork to produce results. Outsourcing to laboratories with the necessary equipment can further increase waiting times for results. Recent advances in CRISPR-based diagnostics have enabled the development of alternative methods for eDNA detection. Specific High-sensitivity Enzymatic Reporter unLOCKing (SHERLOCK) assays use the CRISPR-Cas13a enzyme complex to detect target nucleic acids and produce a fluorescent signal. These assays are rapid (< 1 hr), sensitive, and can be performed by non-experts with inexpensive equipment under field conditions. Multiple such assays have been developed for rapid detection of aquatic species in California water bodies. We developed a SHERLOCK assay to monitor Chinook Salmon (*Oncorhynchus tshawytscha*) in western North America. We designed RPA primers and a crRNA guide sequence to target a species-specific region of the Cytochrome c oxidase subunit III (COIII) gene in Chinook Salmon mitochondrial DNA. The RPA primers duplicate the target region, if present, in an eDNA sample. The crRNA complements the target site and programs the CRISPR-Cas13a complex to activate when the target region is detected in an eDNA sample. These two factors contribute to high specificity in SHERLOCK assays. Our final assay detected tissue-derived DNA from 40 Chinook Salmon individuals from multiple populations within 30 minutes of SHERLOCK reaction initiation. We tested specificity using tissue-derived DNA from eight salmonid species that co-occur with Chinook Salmon. With further refining, we anticipate that our assay will be useful for Chinook Salmon detection across their current range.

Delta Smelt Health and Reproduction across Different Water Years

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Delta Smelt are a mostly annual species and face various stressors such as food limitation and contaminants which can impair reproduction. Using adult fish caught from 2011 to 2018 from November to May, we examined morphometric indicators (gill pathology and liver lesions), nutritional indicators (histopathologically estimated liver glycogen depletion), and physical condition (fork length and condition factor) in relation to reproductive metrics (gonadosomatic indices/GSI, fecundity, and oocyte weight) to determine if nutritional and contaminant stressors are influencing Delta Smelt reproduction. Fork length and condition factor had the strongest positive relationship with reproductive metrics. Unexpectedly, more severe glycogen depletion was associated with higher oocyte mass, and higher GSI. Gill and liver lesion severity had a negative relationship with GSI. When examining changes to physical condition, morphometric indicators, nutritional indicators, and reproductive metrics across the study years there was no clear pattern related to water year. Contaminants appear to have a negative effect on Delta Smelt reproduction; however, reproductive success appears to be primarily influenced by factors that vary on different time scales. For example, fork length and condition factor are determined by conditions an individual experiences over its life span, while the importance of liver glycogen indicates shorter term storage of energy needed for oocyte production. These factors suggest prey are important to support growth and reproduction; females need sufficient nutrition to grow and store glycogen store oocyte production.

Developing batch tagging techniques for cultured Delta Smelt

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Delta Smelt (*Hypomesus transpacificus*) conservation efforts have shifted towards culture methods in recent years due to a lack of wild spawning stocks. Distinguishing between wild and hatchery-raised fish is vital for establishing effective management practices, however current differentiation methods (i.e., fin clips, fluorescent dyes, otolith chemical signatures) are time consuming and provide minimal information of the origin of the fish. Otoliths may provide a solution to this problem, by allowing for the development of batch-tagging techniques. Otoliths provide a metabolically inert record of growth fluctuations, which can come about in response to stress from rapid changes in environmental conditions. Here, we are working with DWR and the FCCL at UC Davis to develop and test otolith-based batch-marking techniques. Larval Delta Smelt were exposed to 3 different treatments: temperature fluctuations (“thermal bar-coding”), salinity fluctuations (geochemical tagging), and a control treatment. Otolith marking treatments were imposed at 42 days-post-hatch (dph) and 86 dph, with all fish euthanized at 127 dph. Afterwards, 30 fish were selected from each treatment for otolith analysis. Otoliths were dissected and sectioned sagittally, allowing for optimal clarity of daily increments. Otoliths were then examined visually and geochemically (LA-ICP-MS) to assess the presence and timing of thermal check marks (temperature treatment) and geochemical spikes (salinity treatment), respectively, with each treatment contrasted with the control group. Patterns and shapes of otoliths were also contrasted with those observed in wild-caught Delta Smelt. These otolith-based batch-marking techniques provide a new and economical method for tagging large quantities of supplemental Delta Smelt, allowing for the identification and analysis of the success of growth and survival of Delta Smelt to inform supplementation and other population recovery efforts.

Growth and salinity histories for subadults of Delta Smelt

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Delta Smelt (*Hypomesus transpacificus*) predominantly inhabit the freshwater and low salinity regions (i.e., 0.5 to 6 psu) of the Sacramento-San Joaquin Delta and San Francisco Estuary. With a complex life history encompassing freshwater residency, brackish water residency, and migration, understanding the specie's response to salinity variations across its migratory life cycle is crucial. While previous studies have examined salinity's influence on recent growth and physiological parameters, a comprehensive investigation spanning the entire life cycle is lacking. In this study, we utilized joint otolith geochemical and increment profiles to explore the ontogenetic variation in daily growth of individual Delta Smelt in relation to daily ambient salinity fluctuations. Otoliths from 165 juvenile Delta Smelt were collected from various agency archives across the San Francisco Estuary. Daily growth chronologies were aligned with daily reconstructed salinities using a Sr-isotope-to-salinity mixing model. Generalized additive models (GAMs) were employed to examine the interactive effects of salinity and ontogeny on Delta Smelt growth. Our findings reveal that Delta Smelt larvae up to 50 days old exhibit suboptimal growth beyond a salinity threshold of approximately 3 psu, indicating vulnerability to slight changes in ambient salinity during early life-stages. However, juveniles and subadults demonstrate robust growth in salinities up to 6 psu. By elucidating the growth-salinity relationships across the species' life history in wild-collected specimens, our study enhances our understanding of the ecological dynamics of Delta Smelt populations and provides valuable insights for current conservation and population management strategies.

Evaluating a new strategy for rearing single-family groups of Delta Smelt

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Delta Smelt cultured at the Fish Conservation and Culture Laboratory are reared in multi-family groups at specific densities that vary depending on life stage. This strategy has successfully produced generations of Delta Smelt for the refuge population, but is labor intensive; for maintenance, staff count and cull fish approximately every 40 days until adulthood to maintain proper densities and tag all adults to track parentage. Also, with this rearing strategy, there is a risk that individual families could be lost due to competition within multi-family groups. Thus, developing more efficient culture protocols that mitigate these issues would benefit Delta Smelt production.

One proposed strategy is to rear Delta Smelt in single-family groups without density limits, in which each family is cultured separately, with reduced counting benchmarks, and without culling during younger life stages. To determine the effects of such a strategy, we reared Delta Smelt from 0 to 198 days post-hatch (dph) in single-family groups using smaller tanks than normal (to compensate for fewer fish per group) and without culling. We measured larvae for length and weight at 40, 80, 168, and 196 dph. We found that initial stocking density at 0 dph was negatively correlated with size at 40 and 80 dph, but was not correlated at 168 or 196 dph. We also found that fish reared under experimental conditions did not differ in size compared to those reared under normal, density-controlled conditions for the refuge population at 40 dph. However, experimental fish were smaller than refuge fish at 80, 168, and 196 dph. These results suggest that high stocking densities may stunt growth during early life stages and that this size effect becomes apparent during later life stages.

Feasibility of Acoustic Telemetry in Delta Smelt

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Fish movement and survival are key metrics for evaluating the success of supplementary releases of cultured Delta Smelt. In addition to net sampling, acoustic telemetry offers an independent and non-lethal way to gather course-scale information on survival, movement, and distribution, as well as fine-scale information on habitat use and movement behavior under various water operation scenarios. Prior to implementing acoustic tagging of Delta Smelt in natural waterways, it is imperative to understand whether the tagging process negatively affects fish health and performance. Using cultured adult Delta Smelt (mean FL = 79.1 mm, SD = 6.7) we evaluated whether a newly miniaturized acoustic transmitter (0.06g) can be implanted while minimizing effects on survival and swimming ability. We also explored potential improvements to handling and tagging techniques by evaluating survival and tag retention at two tagging locations (ventral and lateral incisions) and two water temperatures (12 and 16°C). Thirty days after tagging, survival in the surgical groups was higher than in the previous study (Wilder et al. 2016) which utilized a larger acoustic tag (0.22 g). Most mortalities occurred in the first three to eight days post-tagging. There was not a marked difference in survival between the tag implantation locations, nor did water temperature affect mortality rates. Experiments are ongoing to further improve survival by identifying a more resilient life-stage for tagging. We will also test sublethal effects of tagging, such as changes in behavior and swimming capacity. Ultimately, these data will refine handling and surgical procedures so that tagging effects are minimized in the field. Improved understanding of Delta Smelt movement behavior, survival, and habitat use in natural waterways will be key for recovering this critically endangered species.

Forty years of paired trawls highlight shifts in longfin smelt catch

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The environmental conditions in the San Francisco Estuary have led to declines in native fish populations since long-term monitoring began in the 1950s. While the wide range of monitoring studies in the region effectively identifies trends in relative abundance, it is harder to evaluate the effects of these conditions on fish habits. Longfin smelt (*Spirinchus thaleichthys*) is a listed native fish species experiencing a population decline in the estuary. The San Francisco Bay Study covers much of their range in the estuary containing a pelagic and benthic trawl. We show that catch rates by the survey's paired trawls have been diverging over the past 2 decades, as the midwater trawl catch rate shows a steeper decline than the bottom trawl rate.

We analyzed the Bay Study catch of juvenile longfin smelt since 1980 using generalized linear modeling to identify possible causes of this divergence, such as environmental factors or the potential for changes to the sampling protocols. We observed that Secchi depth in the estuary has increased by an average of 20-centimeters. This decline in turbidity is also linked to increasing depth in much of the estuary.

These trends coincide with a vertical shift in distribution of juvenile longfin smelt deeper into the water column. These results suggest that in clear water with low attenuation, longfin smelt may find refuge from predators in the darker depths.

The paired sampling design of the San Francisco Bay Study provides a unique opportunity to evaluate the role that changes in vertical distribution may have in biasing estimates of relative abundance in monitoring surveys. As longfin smelt become more bottom oriented, long-term midwater trawl data may underestimate the population size while bottom trawl data may overestimate the population size.

Hunting for Unicorns: using otolith-based tools to identify the elusive 2-year-old Delta Smelt

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Delta Smelt (*Hypomesus transpacificus*) is a critically endangered migratory fish that is endemic to the San Francisco Estuary. Most Delta Smelt are believed to reproduce at 1 year of age; however, length data from field surveys suggest the historic presence of big, old, fat, fecund females (BOFFFs in the fisheries literature) that deviate from this pattern and may spawn at age 2. These older females likely exhibit higher fecundity than age-1 spawners, thus possibly contributing disproportionately to population dynamics. Yet, it remains unclear whether these large females are truly age-2 or fast-growing age-1 fish. Here, opaque and translucent ("annual") banding patterns in otoliths (calcified ear stones) were used to reconstruct the annual ages of Delta Smelt from the California Department of Fish and Wildlife's (CDFW) Spring Kodiak Trawl Survey (2003 to 2023). Although rare, otolith-based analyses identified several large individuals that indeed survived a full second summer and were possibly preparing to spawn in their second year of life. Our results confirm the presence of this longer-lived life-history phenotype and suggest that variation in the abundance of age-2 spawners could be an important parameter for an improved understanding of the biology and conservation of this imperiled species.

Implementation of Rapid Genetic Analysis (SHERLOCK) in Genetic Monitoring Programs within the Sacramento-San Joaquin Delta

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The Genetics Monitoring Laboratory at the Department of Water Resources, Division of Integrated Science and Engineering is utilizing cutting-edge genetic monitoring methods to fulfill high-priority 2020 Incidental Take Permit (ITP) mandates pertaining to the continued operation of the State Water Project. One such method, referred to as SHERLOCK (Specific High Sensitivity Enzymatic Reporter UnLOCKing), is a reaction that uses CRISPR-Cas13a to provide rapid genetic identification from biological samples and is an essential tool for multiple mandate-fulfilling projects. Many of these projects require interagency collaboration to support genetic monitoring of endangered fish species in the Sacramento-San Joaquin Delta and will provide accurate and fast genetic results to support decision management. Through this presentation, I aim to describe the steps associated with the SHERLOCK process and highlight key genetic monitoring projects where the applied use of SHERLOCK is invaluable.

Making genetic species identification accessible to all Bay-Delta scientists: pilot implementation of SHERLOCK for rapid, non-invasive identification of Delta Smelt

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Genetic-based species identification is an essential tool for managers in the San Francisco Bay-Delta. Methods leveraging species-specific DNA patterns can distinguish between morphologically similar organisms, for example between the endangered Delta Smelt (*Hypomesus transpacificus*) and the non-native Wakasagi (*Hypomesus nipponensis*). Although these methods provide unambiguous species identification, until recently they could only be performed in a small number of specialized genetics laboratories, resulting in a delay in obtaining timely data for management decision-making. Here we describe the collaborative implementation of SHERLOCK (Specific High-sensitivity Enzymatic Reporter unLOCKing) between UC Davis researchers and agency scientists at the US Fish and Wildlife Service - Lodi Fish and Wildlife Office. The SHERLOCK method is rapid, easy to perform, and can use non-invasively sampled mucus swabs from individual fishes. The assay materials require only a small footprint in existing laboratory spaces, and the detection instrument is semi-portable and can be stored out of the laboratory when not being used if space is limited. In our presentation we will provide an overview of the protocol, infrastructure, and other considerations needed for SHERLOCK implementation at a government agency laboratory with no previous experience with in-house genetic identification. We will also present preliminary SHERLOCK species identification results for Delta Smelt swab samples collected by the Enhanced Delta Smelt Monitoring (EDSM) program during late 2023-early 2024, including summarizing the data and highlighting any technical challenges encountered during the current pilot phase implementation. Finally, we will provide general guidance on best practices for SHERLOCK implementation and highlight additional applications beyond smelt species identification. Implementing SHERLOCK at agency laboratories will ultimately improve turnaround time for producing data critical to management decisions and accelerate progress towards the long-term goal of making the technology accessible to all Bay-Delta scientists.

Mapping Spawning and Rearing Habitat of Longfin Smelt in a Dynamic Estuary

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Conservation implementation by the U.S. Fish and Wildlife Service can benefit from knowing where a listed species may be distributed, and what habitat features and areas are essential to conserving a species. For the Bay-Delta Distinct Population Segment of Longfin Smelt (*Spirinchus thaleichthys*), many of these key physical and biological parameters are only ephemerally present in the dynamic San Francisco Estuary. The locations of these features, such as favorable salinity, temperature, and turbidity can shift substantially in the estuary depending on freshwater outflow. This geographic variability presents challenges when attempting to delineate a static distribution of a key lifestage, such as spawning adults and rearing larvae. To determine Bay-Delta Longfin Smelt larval and post-larval distribution under a broad range of conditions and year types, we focused on hydrologic processes for transport and retention in the low salinity zone. Using X2 as an approximation of favorable larval habitat we examined the historical distribution of X2 during January through May (when larvae are present and require low salinity habitat) over nine decades. We then fit a series of GAMs examining the geographic distribution of larvae and potential spawners throughout the year using data from multiple long-term monitoring surveys. We compared the results of the GAMs with the historical distribution of X2 to inform our mapping exercise. This quantitative approach produced an area with clear boundaries that are protective of the spawning and rearing population. This method for projecting the DPS' distribution of this key lifestage averaged across space and time should be useful for the public, natural resource managers, and biologists who may be engaged in Longfin Smelt conservation. It should be noted that this exercise cannot replace more focused, temporally contextual distribution predictions in any given set of physical and biological conditions extant within any specific hydrological and population context.

Model Validation of Sacramento-San Joaquin Delta Juvenile Salmonid Salvage Statistical Modeling

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**Presenting author*

A statistical model of total monthly juvenile salmonids salvage at State Water Project (SWP) and Central Valley Project (CVP) export facilities was developed by multiple linear regression using 2008-2018 WY. The explanatory variables included the combined SWP/CVP monthly export pumping along with Delta inflows from tributaries that are sources of salmonids entering the interior Delta. These tributaries included the Sacramento (SAC), San Joaquin River at Vernalis (SJR), Mokelumne River flow at Woodbridge (MOKE), Cosumnes River at Michigan Bar (CSMR) and other minor eastside tributaries. The DSSM also included flows into Georgianna Slough-Delta Cross Channel (GS-DCC), Old and Middle River (OMR) flows and X2 salinity as indicators of interior Delta flow conditions contributing to entrainment of salmonids at the SWP and CVP fish salvage facilities.

Now, I plan to use the post 2018 WY explanatory data as inputs to the existing DSSM model to analyze how well model matches 2019-2023 WY salvage data.

Monitoring Larval Delta Smelt using Environmental DNA (eDNA)

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Efforts to monitor and protect rare and listed species, such as Delta Smelt (*Hypomesus transpacificus*) and Longfin Smelt (*Spirinchus thaleichthys*), are often limited by the accuracy and efficiency of sampling techniques. The small population sizes and heterogeneous distribution of these rare fishes often complicate management and conservation efforts. Environmental DNA (eDNA) methods have the potential to improve detection of rare species but have only been incorporated into routine sampling methods to a limited extent by monitoring agencies. We conducted a study to evaluate the efficacy of eDNA for routine monitoring of larval smelt at Clifton Court Forebay, a State Water Project water export area within the SF Bay-Delta region. Enhancing the accuracy of data related to larval smelt abundance in this area will improve our understanding of potential impacts from State Water Project activities. Our study goals were to 1) test the capability of eDNA sampling methods to detect varying levels of biomass (n = 0, 1, 3, 10, 30, 60, 100) of larval Delta Smelt (< 20mm and < 40 dph), under ideal laboratory conditions, and 2) generate a standard dilution curve for larval Delta Smelt eDNA relative to varying levels of biomass. Our results confirm that eDNA can be used to detect Delta Smelt larvae across a range of biomasses (n = 1 to n = 100) under ideal conditions. We also found that eDNA signal strength increases somewhat linearly with biomass. Lastly, we successfully generated a standard curve to inform our statistical models for understanding detection probabilities under field conditions. These results have important implications for future eDNA monitoring and conservation efforts for smelt species and will inform future field-based experiments planned by DWR.

Moody Weather: Storm-driven contaminants significantly impact behavior of larval Delta Smelt

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Storm events are responsible for the transport of many pesticides into the aquatic environment. In California, late winter storms coincide with Delta Smelt spawn events thus placing their offspring at risk of exposure during sensitive developmental stages. Upon hatching embryos are at further risk, particularly of uptake of lipophilic compounds through their yolk-sac. We exposed yolk-sac Delta Smelt larvae to water samples associated with three rain events in March 2023, collected at four sites within the Delta: Ryer Island, Rio Vista, Ulatis Creek and the Toe Drain. After a 96-h exposure, we conducted behavioral studies using a DanioVision chamber, which were later analyzed using Ethovision tracking software. Targeted chemical analysis determined the presence of bifenthrin at concentrations previously shown to impact larval Delta Smelt behavior, at all sites for all three events. Other pesticides detected in the water included fipronil, fipronil sulfone, fipronil sulfide, and cyhalothrin. Exposure to all ambient samples resulted in significant hyperactivity. Furthermore, we observed changes in thigmotaxis (wall hugging), where the performance of exposed individuals displayed anti-anxiety-like (cross-well) behaviors. We will present this data, along with resulting alterations on larval velocity, freezing, cruising, and bursting, following exposure to Delta water samples. Our findings indicate that early larval exposure to commonly occurring pesticides may have detrimental effects on their behavior and development, potentially increasing their risk of predation.

Morphological Differentiation of Smelt Species in the San Francisco Estuary: A Geometric Morphometric Analysis

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In the western regions of the United States, smelt species populations have significantly declined, necessitating their classification and protection under the Endangered Species Act. Specifically, the Delta smelt (*Hypomesus transpacificus*) is indigenous to the San Francisco Estuary (SFE), while the Longfin smelt (*Spirinchus thaleichthys*) inhabits the Northeast Pacific and adjacent river systems; both species are currently protected. Additionally, the Wakasagi (*H. nipponensis*) was introduced from Japan to California reservoirs in 1959. The morphological similarities among these species occasionally result in misidentification, thereby complicating conservation efforts. To address this issue, the present study employs geometric morphometric analysis to elucidate the morphological differences among these smelt species within SFE. The primary morphological distinction between Longfin smelt and Wakasagi lies in the curvature of the body section extending from the posterior end of the head to the dorsal region; it is convex in Longfin smelt and concave in Wakasagi. In contrast, Longfin smelt, and Delta smelt differ primarily in the anterior insertion points of the dorsal and pelvic regions, with Longfin smelt displaying a greater body depth than Delta smelt. The main difference between the body shape of Wakasagi and Delta smelt is noted in the anterior insertion points of the dorsal and anal regions, as well as in general body shape; specifically, Delta smelt exhibits a more slender and compact form compared to Wakasagi. These findings contribute to a more nuanced understanding of smelt morphology, thereby aiding in their accurate identification and subsequent conservation.

Otolith-based age, growth, and life history of adult Longfin Smelt

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In recent decades, the distinct San Francisco population of Longfin Smelt (*Spirinchus thaleichthys*) has been in rapid decline, raising concerns regarding local extinction risk. Accurate age and growth data are needed, therefore, to inform population models and support the development of effective conservation strategies. At UC Davis, we are developing and testing methods to quantify annual age and growth of Longfin Smelt using seasonally produced transparent and opaque bands ("annuli") in otoliths. Fish were selected from archived samples (from UC Davis and CDFW) based on numerous criteria including fork length, water year, and sampling location. Otoliths were then sectioned and polished in the transverse plane to expose annual increments for reconstructing age, growth, and life history information using image analysis and strontium isotope geochemical analysis (MC-LA-ICP-MS) to produce growth and life history chronologies for each individual. Thus far, we have generated age and growth estimates and geochemical profiles for more than 500 Longfin Smelt collected over the past 2 decades. Results will provide much-needed new information regarding variation in the age structure, growth rates, and life-histories for this imperiled native estuarine fish.

Pre-screen loss and entrainment scenarios for juvenile Longfin Smelt in dry years: Preliminary insights from surrogate mark-recapture experiments

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The mortality that occurs to the fraction of an entrained fish population before fish are transported into the state (SWP) and federal (CVP) water projects is referred to as pre-screen loss (PL). Such mortality remains a critical unknown in the upper San Francisco Estuary (USFE). We conducted preliminary analyses on juvenile Longfin Smelt to: 1) examine their historical salvage patterns, 2) estimate their entrainment into SWP and CVP, and 3) estimate the proportion of fish lost to south Delta PL. Salvage and an index of salvage per potential spawner were computed for years 1993-2022. A preliminary abundance estimate for juvenile fish in the USFE was obtained using the California Department of fish and Wildlife 20-mm survey. Critical dry year 2022 was selected as a case study for objectives 2 and 3 as it was the peak salvage year since the pelagic organism decline. Entrainment loss into water projects was derived from previous surrogate mark-recapture studies conducted at the SWP and CVP. The PL in the south Delta was based on volume expansion of fish losses estimated within the SWP. Preliminary results showed: 1) salvage per potential spawner revealed the longest continuous period of higher than average entrainment losses for juvenile Longfin Smelt occurred during the record drought 2020-2022, 2) the estimated number of juvenile Longfin Smelt entrained into the south Delta water projects in year 2022 represented ca. 1−5% of the population, and 3) the projected percent of the Longfin Smelt population lost to south Delta PL in year 2022 varied widely and tended to greatly exceed entrainment losses at the water projects. These initial findings support the need for empirical quantification of PL in Longfin Smelt in dry and critically dry years to inform life-cycle models in this species.

Quantifying the evolutionary potential for Delta smelt persistence in a warming habitat

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Long-term persistence of the endangered Delta Smelt (*Hypomesus transpacificus*) will depend, in part, on whether the species harbors the genetic variation necessary to adapt to changing environmental conditions such as warm temperatures. Temperatures in the San Francisco Bay-Delta are increasing and extreme temperature spikes are becoming more common. The availability of additive genetic variation for traits that affect fitness directly determines the ability to evolve; however, nothing is currently known about the presence of genetic variation for resistance to elevated temperature in Delta Smelt. We performed a quantitative genetics experiment to test whether Delta Smelt harbor the necessary genetic variation for adaptation to elevated temperatures. We established crosses between wild and hatchery-reared (domesticated) fish and raised siblings from each family in both an optimal temperature (15 ℃) and an elevated temperature (18 ℃). We estimated thermal tolerance (Critical Thermal Maximum; CTM) of 3,000 fish raised in these two thermal environments. Our experiments show that fish reared at warmer temperatures had higher CTMs and fish that had longer ancestry in the hatchery also had higher CTMs. We genotyped 3000 fish and identified SNPs important for thermal tolerance using GWAS. Together, this information can be used to manage the refuge population and inform supplementation by maintaining ecological genetic variation that may be crucial for resilience in a warming Delta.

SKT: A Survey in Summary

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The Spring Kodiak Trawl (SKT) was designed to improve the detection rate of adult Delta Smelt (*Hypomesus transpacificus*) during their spawning season in the San Francisco Estuary. This survey was initiated in 2002 following the conclusion of the Spring Midwater Trawl in 2001 because of its improved efficiency in catching adult Delta Smelt. The primary goal of the SKT is to provide valuable information about the population dynamics, reproductive success, and habitat use of Delta Smelt. The SKT employs surface trawls to sample the top 1.8 meters of the water column. It covers a total of 40 sampling stations distributed throughout the San Francisco Estuary, including a station in the Napa River, and extending up the Sacramento and San Joaquin Rivers. These stations are sampled once per month from January to May, which corresponds to the Delta Smelt spawning season. This study performed dissections in the field to determine the proportions of unripe, ripe, and spent Delta Smelt throughout the spawning season. Providing near-real time gonadal maturity data to water managers was used to reduce adult entrainment and infer whether the next generation might have hatched near water export pumps. The Spring Kodiak Trawl survey recently concluded in 2023. This poster provides a project overview and summary of survey results over the 22-year study.

Temporal Dynamics of Sperm Motility in Endangered Delta Smelt, Threatened Longfin Smelt, and Introduced Wakasagi

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The reproduction success of fish is directly related to sperm motility, which can be influenced by several factors, including the duration between sperm activation intervals. This study provides findings that can contribute to conservation and management efforts by examining the impact of distinct activation time intervals on sperm motility in endangered delta smelt (*Hypomesus transpacificus*), threatened longfin smelt (*Spirinchus thaleichthys*), and introduced wakasagi (*H. nipponensis*). Using a systematic experimental design, sperm samples were activated with freshwater and evaluated across various activation time intervals (0-5, 20-25, 30-35, 60-65, 120-125, 180-185, 240-245, and 300-305 sec) and then analyzed for sperm motility traits using OpenCASA software. The study also evaluated the influence of male fork length on sperm traits. The analysis revealed that the immediate activation window (0-5 sec) showed significantly high sperm motility across species boundaries, underscoring the crucial role of rapid sperm activation in boosting motility and potentially enhancing reproductive success. This study provides critical insights into the temporal dynamics of sperm motility across three fish species with different conservation statuses. The pronounced effect of activation time on sperm motility, regardless of species, along with the significant influence of male size on sperm traits, underscores the necessity for a comprehensive understanding of reproductive biology in conservation and management strategies. The findings offer a substantial foundation for further research in fertility dynamics, potentially aiding the formulation of informed conservation policies for endangered and threatened species.

Understanding thiamine deficiency complex in California salmonids

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Thiamine (vitamin B1) deficiency complex (TDC) was first observed in juvenile California Chinook salmon in early 2020 after changing ocean conditions altered the marine food web. Females low in this essential vitamin returning to freshwater to spawn were unable to allocate sufficient thiamine to their eggs needed for healthy development of their progeny. This led to high mortality rates observed in juveniles at hatcheries along with signs of TDC such as sporadic swimming patterns. A multi-agency collaboration was launched to investigate the widespread nature of this nutritional deficiency among California salmonids, as well as understand its causes and impacts. Egg surveillance since 2020 has revealed an increasing prevalence of TDC in nearly all Central Valley populations of Chinook salmon and steelhead. Lower levels of thiamine have been linked to salmon diets dominated by the booming population of northern anchovies off California coasts. High activity of thiaminase, a thiamine-degrading enzyme, has been found in these anchovies, a contributing factor to TDC emergence in many species. Tissue samples from adult Chinook salmon females reveal a shift in diet diversity since TDC emergence. Laboratory studies were conducted to develop the relationship between egg thiamine concentration and survival of progeny. This relationship was applied to egg surveillance measurements to estimate population-level impacts of thiamine-dependent mortalities. Disruption to ocean food webs has been implicated in the poor nutrition of California salmon and TDC has emerged as a new stressor impacting already threatened salmon populations.

Food Webs

Examining the changes in fish populations from various flow actions in the North Delta

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The U.S. Fish and Wildlife Service's (USFWS) Lodi office partnered with California Department of Water Resources (DWR) on the North Delta Food Subsidies (NDFS) Action study to measure the effects of managed flow pulses in the North Delta food web. Water quality data collected during the 2019, 2022, and 2023 NDFS studies will be used due to the varying amounts of precipitation and controlled flow efforts during those years. This will be compared to catch data from the Enhanced Delta Smelt Monitoring (EDSM) program taken from areas between Lisbon Weir and Suisun Bay during the months of potential flow actions in an effort to compare food availability and fish abundance. Food availability will be based on chlorophyll-a and other nutrients, which are an indicative of phytoplankton biomass. We will assess the catch per unit effort (CPUE) of planktivorous fishes, specifically Mississippi Silversides, juvenile American Shad, and *Osmeridae* species using EDSM catch data. This comparison can give insight to how various flow actions can affect nutrient levels and fish populations in the delta.

Food limitation: a likely driver of seasonal transitions of key copepods in San Francisco Estuary

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Long-term declines in threatened and endangered fish species in SFE may be, in part, due to lack of food resources during critical life stages. Two important prey species for young fish, the calanoid copepods *Pseudodiaptomus forbesi* and *Eurytemora carolleeae*, alternate in abundance in a consistent seasonal cycle. What drives the persistence of these patterns? We are investigating the mechanisms behind these seasonal patterns during key transition periods – spring (*E. carolleeae* begins to decline), spring-summer (*P. forbesi* abundance levels off), and autumn (*P. forbesi* begins to decline). We collected copepods from the field to estimate copepod abundance and egg production rates, and to set up lab-based growth rate experiments. During growth rate experiments, copepods were incubated in ambient water (containing ambient prey) or ambient water supplemented with a ≥ 10 µg chl L-1 mixture of 4-5 phytoplankton species of various sizes, morphologies and motilities. During the seasonal peaks of both copepods, food supplements provided little or no boost to copepod growth rate, but a larger (albeit still modest) boost was observed as each species approached the time of its seasonal decline. Our results so far support the theory that, in our study sites, *Pseudodiaptomus forbesi* growth and reproductive rates during the autumn seem to be limited by food resources, and this likely contributes to the declining population during the autumn transition. This trend was similar for *Eurytemora carolleeae* in spring, although the underlying mechanism may not be identical to that for *P. forbesi*. A better understanding of the seasonal pattern of food (zooplankton) available for smelt in the upper San Francisco Estuary will show the times of the year when proposed management actions in SFE, intended to bolster food supply (i.e., phytoplankton for zooplankton), will most effectively fill gaps in food availability for fish species of concern.

Isotopes in the Toe Drain: Building an isoscape to trace flows to food

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Strategic releases of water through Yolo By-Pass in summer and fall (collectively referred to as “North Delta Food Subsidy actions”) are intended to ameliorate downstream food limitation for Delta Smelt (Hypomesus transpacificus) and other pelagic fish species. Augmentation of flows in the Toe Drain during these months can increase local productivity, but there is substantial uncertainty regarding the spatial and temporal sphere of influence on consumers. To understand the mechanisms that result in increased productivity and document the spatiotemporal impacts of these management actions on fish, we assessed the potential for using stable isotope tools to quantify food web dynamics associated with flow releases. Representative ecosystem constituents (particulate organic matter, macrophytes, zooplankton, macroinvertebrates, and fish) were collected from six locations ranging from high upstream in the Toe Drain to the Rio Vista Bridge downstream and analyzed for isotopes of carbon (δ13C), nitrogen (δ15N), and sulfur (δ34S). Preliminary results indicated spatial patterns in all three isotopes for particulate organic matter, zooplankton, and macroinvertebrates, indicating strong potential for use of stable isotope tools to track the impact of flow actions on local food webs.

Gaining Control: Why baseline monitoring during non-experimental seasons matters

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The Cache Slough Complex (CSC) is an important component of the California Delta which provides critical habitat for aquatic species, including Delta Smelt, flood protection for nearby cities, and water delivery for agricultural and municipal uses. Once a productive ecosystem supporting robust native fish populations, the CSC faces issues of reduced geomorphic complexity, non-native species competition, water diversions, and a warming climate, all of which has impacted the food web causing challenges for native species. Despite these alterations and stressors, the CSC represents one of the largest tidal wetland habitats in the Delta and contains habitat which has been deemed critical for the persistence of Delta Smelt. The North Delta Food Subsidies (NDFS) project was conceived to improve habitat in the CSC by creating managed flow pulses through the Yolo Bypass Toe Drain into the CSC. Multiple summer/fall flow pulses over the past decade have been implemented in coordination with local landowners. Nutrient concentrations have been monitored as well as phytoplankton and zooplankton responses before, during and after management actions. Despite some initially promising results, uncertainty about the efficacy of management actions in subsequent years has led to continued assessment of flow actions and other factors that potentially affect habitat quality in the region. With no managed flow pulse conducted in the summer/fall of 2023, this was an opportunity to investigate differences in lower trophic seasonal and regional patterns with other comparable wet years with managed flow actions (2019) and without managed flow actions (2017 & 2023). In these wet years, we expect to find a seasonal pattern as the ecosystem transitioned from a productive spring following extensive flooding with possible influences from other point sources such as regional wastewater effluents or nearby agriculture.

Nutrient and phytoplankton productivity responses during flow pulses through a flood plain in the North Sacramento-San Joaquin Delta

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The experimental North Delta Food Subsidies Study is an adaptive management strategy of the Delta Smelt Summer-Fall Habitat Action. It is designed to improve understanding of the processes by which the Yolo Bypass may provide a summer-fall food web subsidy for Delta Smelt in the Cache Slough Complex and downstream, especially with augmented summer flows, such as the experimental managed flow action conducted in 2016. The baseline conditions without managed actions are key to interpretation of the actions' food web effects. Here we describe data collected from 2017 to 2023 over a spectrum of hydrologic conditions including years with and without experimental, managed flow actions. Water quality, nutrient conditions, chlorophyll, and primary production were measured along a downstream transect from Ridge Cut Slough near Knights Landing through the Yolo Bypass to the Sacramento River at Rio Vista with seven stations sampled consistently over the years, up to six times each summer-fall. Consistent spatial patterns emerged, with clear distinctions in many parameters between upstream locations in the Yolo Bypass Toe Drain and downstream in the Cache Slough Complex (Liberty Island to Rio Vista). Upstream sites were characterized by high turbidity, high nitrate (up to 200 uM) and phosphate (> 40 uM), high phytoplankton biomass (chlorophyll often peaking above 40 ug/L). Downstream, water was less turbid and ammonium higher due to the influence of the Sacramento River, until summer 2021 following the Regional San wastewater treatment plant upgrade. In 2022, nitrate and chlorophyll were much lower than other years at upstream sites, possibly a result of historically lower fields farmed, irrigated, and fertilized (~1% of normal rice planting) due to the extreme drought conditions. Forthcoming results aim to demonstrate how these different sources of nutrients fuel elevated productivity and food subsidies, knowledge that is needed to evaluate future management actions.

Seasonal changes in piscivorous distribution within the Sacramento-San Joaquin Delta

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The Sacramento-San Joaquin Delta is a vast river system that supports a diverse range of non-native and native fish species. It also serves as a major highway for juvenile salmonids migrating to the ocean. Increased predation from both native and non-native fishes along highly utilized juvenile travel routes is one of the first hurdles they must face when making their journey to the ocean. Our goal for this poster is to use data from the Lodi Fish and Wildlife Office's delta boat electrofishing survey, collected from 2018-2022, to identify potential seasonal distribution changes in piscivorous fishes and identify possible "hotspots" of predation that could affect juvenile salmonids traveling through the delta. We believe that there will be seasonal hotspots in piscivorous activity in areas highly utilized by juvenile salmonids. We also plan to examine salmon catch data from the Delta Juvenile Fish Monitoring program's trawl and beach seine projects collected during the same time frame, to highlight possible areas of increased interaction. We are currently in the process of completing our results.

Unraveling the DNA of Aquatic Food Webs: eDNA Metabarcoding Reveals Zooplankton Trends in the Bay-Delta

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To gain a deeper understanding of long-term trends in aquatic food webs within the Bay-Delta region, accurate tracking of shifts in zooplankton species composition is crucial. We aim to advance non-invasive zooplankton sampling techniques by utilizing environmental DNA (eDNA) sampling. Using a process called 'metabarcoding,' we can identify species within a mixed community of organisms through Next-generation Sequencing. Each species' unique genetic code allows for precise identification of organisms within the community. In this study, our metabarcoding tool specifically targets copepoda, amphipoda, and cladocera species to assess shifts in species composition and periodicity in zooplankton populations, which serve as essential food sources for larval and juvenile fish, including Delta and Longfin smelt.

Using Image Analysis of Zooplankton to Fill Gaps in Food Webs of Fishes

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Zooplankton monitoring in the San Francisco Estuary by IEP has produced an extremely valuable historical record of the food available to fishes. To assess the quantity of this food we need estimates of biomass for the zooplankton taxa present throughout the estuary. The goal of this project is to present the scientific community a well-designed, tested, and accurate set of tools for estimating biomass of zooplankton that can be applied to monitoring. Our approach was to calibrate zooplankton volume-to-carbon estimates from image analysis. Results showed that 2% glutaraldehyde was the best preservative to conserve fluctuations in volume and carbon content.

We sampled zooplankton taxa across various salinities to capture as many species as possible throughout the northern estuary, sorted the sample by taxon, measured, imaged, and analyzed each species on an elemental analyzer for carbon content. We have developed volume-to-carbon conversions for copepods (*Eurytemora carolleaee*, *Pseudodiaptomus* spp., *Acanthocyclops* sp., *Acartiella sinensis*, *Acartia* sp., *Sinocalanus doerrii*, and *Tortanus dextrilobatus*), cladocerans (*Daphnia magna*, *Bosmina* sp., and *Diaphanosoma* sp.) and mysids (*Neomysis kadiakensis*, *Hypercanthomysis longistrostis*). We will continue to calculate relationships for more taxa and work to develop a technique to estimate carbon from bulk samples to streamline our approach and provide the scientific community a reliable and economical approach to estimating food quantity for fishes.

Warmouth in the Sacramento San Joaquin Delta

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Fish monitoring programs in the delta provide valuable information about the ecosystem, but some sampling methods are not the best for detecting species associated with cover such as Warmouth (Lepomis gulosus). However, the Lodi Fish and Wildlife Office's (LFWO) boat electrofishing survey can provide insight into these species because electrofishing can sample in obstructed habitats unlike net-based surveys like trawling or seining.

We are planning to use data from boat electrofishing to explore the distribution and specific habitat preferences of a non-native centrarchid associated with vegetative cover, the Warmouth, within the Sacramento-San Joaquin delta. We aim to gain insight into the Warmouth's spatial distribution and density as a function of sample location and catch per unit effort in fish per minute. We will also look at detection probability within different habitat types. Finally, we plan to look at potential environmental influences (temperature, dissolved oxygen, turbidity) and fish assemblage associations that might predict Warmouth presence.

Management

AIMS for wildlife: Developing an automated interactive monitoring system for true adaptive management

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- Austen Lorenz, USGS Western Ecological Research Center
- Cory Overton, USGS Western Ecological Research Center
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To effectively manage species and habitats at multiple scales, population and land managers require rapid information on wildlife use of managed areas and responses to landscape conditions and management actions. GPS tracking studies of wildlife are particularly informative to species ecology, habitat use, and conservation. Combining GPS data with administrative data and a diverse suite of remotely sensed, geo-referenced environmental (e.g., climatic) data, would more comprehensively inform how animals interact with and utilize habitats and ecosystems and our goal was to create a conceptual model for a system that would accomplish this – the 'Automated Interactive Monitoring System (AIMS) for Wildlife'. Our objective for this study was to build a "proof of concept" system based on our 8-year GPS tracking dataset of ~11 million locations from 1338 individual (16 species) avifauna and make actionable, real-time data on animal movements and trends available to managers and stakeholders for rapid application in day-to-day management. The AIMS ecosystem consists of three primary components: 1) data ingestion 2) data processing and storage and 3) product delivery. Outputs can be easily customized into customized wildlife reports (CWR'S), web applications, wildlife alerts and basic data summaries emphasizing the broad application of an animal movement data source. Utilizing diverse, extensive telemetry data streams through scientific collaboration can aid managers and conservation stakeholders with short and long-term research and conservation planning and help address a cadre of issues from local-scale habitat management to improving the understanding of landscape level impacts like drought, wildfire, and climate change on wildlife populations.

Coming Through! Fish utilize environmental infrastructure to avoid stranding.

- Jeff Jenkins*, CA Dept of Water Resources, jeff.jenkins@water.ca.gov

**Presenting author*

Examining fish passage success through a designed facility in the Fremont Weir following recent flooding and weir overtopping events. Collaborative efforts between state & federal agencies, landowners, and county supervisors allowed operation of the facility outside permitted timelines and resulted in successful fish passage for threatened or endangered species that would have otherwise been stranded. Key topics: Fish passage facility, designed floodplain inundation, threatened or endangered species, science communication, reduced migratory delays, floodplain restoration.

Customized Wildlife Reports: Streamlining GPS Telemetry Data for Enhanced Wildlife Management

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AIMS for Wildlife is a system specifically designed facilitate more effective wildlife management by simplifying the interpretation of complex wildlife GPS telemetry data. Specifically, AIMS generates highly reproducible Customized Wildlife Reports that include refuge, state, species, and joint venture reports; all of which can be tailored by date, species, and location. Through a user-centric approach designed in close collaboration with wildlife biologist and decisionmakers, these reports are presented in interactive easy-to-understand tables, maps, figures, and formats. This feature makes them accessible to a broad range of users, ensuring that the tool meets the needs of those directly involved in wildlife management.

Customized Wildlife Reports are designed to improve access to wildlife GPS telemetry data and enhance its comprehensibility. The tool reduces the need for specialized skills such as GPS, data management, and GIS analysis. By transforming complex telemetry data into a more accessible resource at management-relevant spatial and temporal scales, Customized Wildlife Reports enhance the capacity of wildlife managers and stakeholders to make informed decisions and contribute to more effective conservation.

Fostering Collaboration and Transparency in the Sacramento-San Joaquin Delta Science Community

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- The Science Tracker team at the Delta Science Program

**Presenting author*

The Sacramento-San Joaquin Delta, a critical and complex ecosystem, hosts a multitude of scientific endeavors conducted by diverse entities, including government agencies, academic institutions, non-governmental organizations, and private research groups. Despite concerted coordination efforts, a standardized inventory to track these activities has been notably absent. This deficiency hinders accountability and impedes opportunities for collaboration and coordination. Addressing this gap, the Delta Science Tracker emerges as a pioneering web-based platform, generously supported and spearheaded by the Delta Science Program. This publicly accessible hub is designed to centralize comprehensive information about science activities across the Delta landscape, providing an invaluable resource for researchers, managers, decision-makers, and the public alike.

The Delta Science Tracker's primary objective is to improve communication and connectivity within the Delta science community. In a landscape where the breadth and diversity of scientific work can be overwhelming, this platform offers a structured, easily navigable interface, enabling stakeholders to discern and engage with relevant projects and expertise.

In line with the Delta Science Plan's visionary concept of 'One Delta, One Science,' the Delta Science Tracker embodies a shared commitment to building a collective body of scientific knowledge. This dynamic resource has the capacity to adapt and inform future water and environmental decisions, thereby ensuring the long-term sustainability and resilience of the Sacramento-San Joaquin Delta.

Furthermore, in an era marked by escalating uncertainty regarding climate, water supply, and the Delta's native ecosystem, the imperative for multi-institutional collaboration has never been more apparent. The Delta Science Tracker serves as a catalyst for enhanced collaboration by connecting managers, policymakers, and scientists across disciplines and geographies. This collaborative approach is vital for making informed decisions that will shape the future of the Delta ecosystem and water resource management.

Lessons Learned from the Delta Salinity Management Workshop Series

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- Laurel Larsen, Delta Stewardship Council
- Dylan Chapple, Delta Stewardship Council
- Xoco Shinbrot, Delta Stewardship Council
- Christina Greene, University of Arizona
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- John DeGeorge, Resource Management Associates

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The Delta is the most significant water hub in California, providing essential water supply to communities, farms, and industries inside and outside the Delta. The Interagency Ecology Program Science Priorities for 2020-2024 focuses on Bay-Delta Resilience to climate change, where variables like salinity intrusion are identified as a major challenge for managing species of concern. During extended drought conditions, reduced freshwater inflows to the Delta make it more difficult to maintain the salinity levels needed to maintain beneficial uses for humans, fish, and wildlife in the Delta. Starting in 2022, the Delta Stewardship Council launched a series of workshops that engaged a wide range of interested parties to identify challenges associated with ocean salt intrusion in the Delta, identify knowledge gaps that must be filled to address those challenges, and lay the groundwork for a long-term collaborative adaptive management approach. This series included workshops, two funded independent research projects, and thematic focused working group meetings. One research project improves upon and demonstrates the use of high resolution hydrodynamic and salinity transport models in combination with the CalSim statewide water operations model to estimate potential water costs and savings associated with changes in Delta geometry and operations. The other research project explores the human dimensions of salinity management through interviews. The final workshop in early 2024 will synthesize results from these efforts and foster discussion about tradeoffs and next steps for a long term approach to adaptively managing salinity in the Delta.

This presentation will include preliminary results from the workshop series and the two research projects with an emphasis on lessons learned for adaptive management.

Managing Subsided Lands in the Sacramento- San Joaquin Delta

- Delta Independent Science Board, Edmund Yu*, edmund.yu@deltacouncil.ca.gov

**Presenting Author*

Drainage of land in the Sacramento-San Joaquin Delta has caused extensive oxidation of peat soils, lowering approximately 386 mi2 of land from 10 ft to as much as 29 ft below sea level. Although decades of subsidence have already depleted peat soils in areas of the Delta, subsided lands continue to cause significant challenges, such as increasing costs to drain soils, declining arability for agricultural production, water quality degradation, vulnerability to levee failure and flooding, and substantial emissions of greenhouse gases in areas where drained peat soils remain. A broad cross section of stakeholders, including public agencies and private sector parties, are developing and testing many different approaches to manage subsided lands. The scale of subsidence in the Delta and the severity of its consequences for Delta agriculture, greenhouse gas emissions, and water quality indicates a need to assess existing management of subsided lands and the social, cultural, and economic trade-offs among different management approaches. To help address this, the Delta Independent Science Board is working to synthesize and evaluate the state of science related to adaptive management of subsided lands and provide recommendations to address knowledge gaps. This poster will share emerging insights into scientific knowledge gaps, economic and decision-making perspectives from landowners and public agencies, as well as recommendations to improve the adaptive management of a complex Delta.

Monitoring and Adaptive Management of the Big Notch Project

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The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Big Notch Project) is a nearly complete environmental infrastructure facility located in the Fremont Weir that aims to help restore California's native salmonid and sturgeon populations. This project is jointly funded by the California Department of Water Resources and the US Bureau of Reclamation to mitigate for the State Water Project and Central Valley Project. The Big Notch Project is likely to be operational by November 2024. The objectives of the Big Notch Project are to: 1. Create floodplain rearing habitat and entrain juvenile salmonids; 2. Reduce migratory delays and loss of adult anadromous fishes; and 3. Limit unforeseen impacts to existing land uses. The DWR Restoration Ecology Unit along with the multi-agency and multi-disciplinary Fisheries and Engineering Technical Team (FETT) have jointly drafted a protocol for responding with adaptive management if the project is not meeting one or more objectives. The team will use a variety of monitoring categories, including telemetry, sonar imagery, fish rescue data, rotary screw trap data, hydraulics, and land use impacts to inform the adaptive management process. This poster describes the monitoring and adaptive management process, explores the monitoring categories planned for this effort, and gives examples of potential adaptive management responses if intervention thresholds are exceeded.

Phytoplankton and Zooplankton

Examining the abundance and distribution of Maeotias marginata in the San Francisco estuary using the Enhanced Delta Smelt Monitoring Program dataset

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The Black Sea jellyfish (*Maeotias marginata*) is a small hydromedusa that was introduced into the San Francisco Estuary in the 1950's. Previous research conducted on this invasive species suggests that salinity and water temperature may affect distribution and abundance. We plan to explore catch data collected by the Enhanced Delta Smelt Monitoring (EDSM) Program to determine how abundance, distribution, and timing of blooms may vary over time as it relates to environmental factors (turbidity, conductivity, temperature, and dissolved oxygen). Our goal is to create a density map of these jellyfish blooms from year to year to gain insight on how these animals respond to extreme environmental events as this dataset covers several drought and flood years. This information may be useful in determining how changes in water and salinity levels caused by extreme weather events may alter the timing and density of blooms and how this may affect native species in the San Francisco Estuary.

Light limitation or low-light adapted: Phytoplankton productivity quantified using stable isotopes along floodplain-estuary transect.

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A stable isotope of carbon (13C), when incorporated into bicarbonate, can be a powerful analytical tool to trace and quantify the uptake of inorganic carbon by phytoplankton. The fixation of bicarbonate occurs during photosynthesis and can be used as a proxy to determine phytoplankton productivity in aquatic systems. Phytoplankton productivity in the northern San Francisco Estuary (nSFE) is characteristically low, even among other comparable estuaries. Light limitation, a result of high turbidity, is a driving theory to explain low productivity. Counterintuitively, however, as water clarity in the nSFE increases, an expected rise in phytoplankton productivity has not been observed. A similar counterintuitive observation occurs when comparing the turbid Yolo Bypass floodplain (YB) where productivity is high and the relatively clear Sacramento River where productivity is low. A parallel theory to light-limitation is that phytoplankton in these systems are chronically low-light adapted, hindering productivity when conditions are ephemerally optimal. We present over 70 ‘productivity versus irradiance’ curves along a transect of the YB (5 stations) and nSFE (4 stations) downstream from West Sacramento to Grizzly Bay between March and November of 2023. The initial slopes of these curves indicate the efficiency at which phytoplankton utilize light and the saturation point indicates the photosynthetic capacity of phytoplankton. Initial results show a downstream trend of increasing efficiency in light utilization by phytoplankton, with a variable downstream trend in photosynthetic capacity. This suggests that a physiological change is occurring in phytoplankton as they are advected downstream. Further processing and analysis of this data may illuminate where along this transect this physiological change is occurring and what factors may be the cause. These results can lead water managers to a more thorough understanding of hydrologic factors controlling the base of the food web.

Pesticide resistance across invertebrate species in the Delta: what does this mean for fish?

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**Presenting author*

The invertebrate community within the San Francisco Bay Delta faces significant stressors, particularly from storm-driven contaminants including phenylpyrazole and pyrethroid insecticides. These stressors impacts the Bay-Delta food web through shifts in prey items and invertebrate community structures. There have been recorded instances of invertebrates evolving resistance to insecticides, particularly the non-target crustacean *Hyalella azteca*, which suggests ecological impairment and contributes to trophic transfer of high insecticide concentrations to fish. However, the extent of adaptive resistance across invertebrate communities is not known. To better understand the extent of adaptive resistance in the San Francisco Bay Delta, common invertebrates were collected for evaluation of resistance in two genes: resistance to dieldrin (RDL) and voltage-gated sodium channel (VGSC). These genes are common targets of phenylpyrazole and pyrethroid insecticides and mutations in these genes can confer resistance to these insecticides. The collected invertebrates were divided by their orders, including Trichoptera, Plecoptera, Diptera, Amphipoda, Cladocera, Copepoda, Ephemeroptera, and Odonata based on their taxonomic identification. For each order and gene, degenerate primers were made for RDL and VGSC and tested for their validity on a small number of samples from each order. In addition, cytochrome oxidase I (CO1) was used to identify organisms to genus or species level. To determine if invertebrates collected from different regions of the San Francisco Bay Delta have developed resistance to phenylpyrazole or pyrethroid insecticides, we are investigating target site mutations in RDL and VGSC. The prevalence of resistance varies across different orders with some aquatic insects showing no detection of developed resistance. In this poster, we will present our final results of the resistance analysis across different invertebrate species in the Delta and discuss the potential implications for fish species.

Predicting the spatial extent and duration of possible phytoplankton blooms based on initial chlorophyll, nitrate and ammonium concentrations: a physiological approach

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- Alex E Parker (California State University Maritime Academy)

**Presenting author*

Improving the existing ability to predict phytoplankton blooms in the San Francisco Estuary/Delta (SFE) is key to management actions designed to enhance food production for Delta Smelt and for evaluating the likelihood of HABs, such as the recent red tide in Central SFE. Phytoplankton blooms need a nutrient base to occur and in the SFE the major source is nitrate, the largest pool of DIN. However, the other form of DIN, ammonium may occur at levels that can repress the uptake and assimilation of nitrate by phytoplankton - a well know inhibitory role of ammonium in higher plant physiology. The sequence of bloom development in SFE results from this interaction. In Phase 1 ammonium is taken up by the phytoplankton, biomass increases, and the ammonium concentration drops below inhibitory levels; In Phase 2 ammonium and nitrate uptake together result in rapid increase in phytoplankton biomass, a bloom; finally in Phase 3 – nitrate is drawn down to zero and phytoplankton biomass decreases by sinking and grazing. An important, forgotten factor that also contributes to the bloom is the initial seed stock concentration of phytoplankton. The higher the initial biomass the more rapid the nitrate will be drawn down to zero and the bloom will be confined to a short period and a small area. Multi-dimensional plots of chlorophyll, ammonium and time-to- nitrate depletion provide a platform for analyzing bloom potential. Examples of using this platform will be shown from pre- and post- Echowater Regional San wastewater treatment plant upgrade conditions in the northern SFE, and also Central SFE during the Heterosigma red tide of 2022. Bloom prediction requires monitoring nitrate and ammonium and chlorophyll concentrations. Using these parameters that could be measured with in situ continuous analyzers offer a simple approach to meet IEP adaptive management concepts.

This or SPATT? Designing a cyanotoxin monitoring program in the Sacramento-San Joaquin Delta

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To develop a robust program for monitoring cyanobacterial harmful algal blooms (cyanoHABs), Solid Phase Adsorption Toxin Tracking (SPATT) samplers and collection of whole water cyanotoxin samples were added to pre-existing water-quality monitoring sites operated by the U.S. Geological Survey in the Delta. The goal of this research is to evaluate the utility of deploying SPATT samplers to monitor for cyanotoxins in estuaries, specifically how SPATT sampler data complement data from discrete whole water samples. From October 2020 through October 2022, SPATTs and whole water samples were collected every two to four weeks alongside water-quality samples at six sites spanning salinities of 0 to 8 PSU. Cyanotoxins were analyzed with liquid chromatography tandem mass spectrometry (LC-MS/MS). Of 204 SPATT samplers analyzed, five toxin classes were detected, with a total of 72 microcystin, 50 anabaenopeptin, 39 anatoxin, 18 cylindrospermopsin, and 11 nodularin detections. The highest concentrations were observed for microcystins (mean = 278, max = 3,621 ng/g), followed by anabaenopeptins (mean = 62.1, max = 915 ng/g). Out of 248 whole water samples, three classes of cyanotoxins were detected: 47 anabaenopeptin, 8 microcystin, and 4 anatoxin detections. Of the whole water samples, the highest concentrations were observed for anabaenopeptins (mean = 11.3, max = 219 µg/L), followed by anatoxins (mean = 3.70, max = 11.6 µg/L), and microcystins (mean = 0.118, max = 0.31 µg/L). Because there are multiple analytical methods for measuring cyanotoxins, twelve whole water samples were submitted for analysis by enzyme-linked immunosorbent assay (ELISA) for comparison with LC-MS/MS results. One microcystin detection analyzed via ELISA contained 1.81 µg/L microcystin, which exceeded the California tier 1 trigger threshold of 0.8 µg/L. Study results demonstrate the high sensitivity of SPATT samplers and their ability to detect cyanotoxins at low environmental concentrations.

Restoration

Exploring the links between physical and biological changes in a restored tidal wetland using low-impact monitoring tools

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Location and time have major implications for habitat restoration outcomes, often dictating physical conditions, correlating with species abundance, influencing genetic variance, and forming the foundation for biodiversity. This study delves into fluctuations in environmental conditions and fish biodiversity within a designed tidal wetland, the Dutch Slough Tidal Marsh Restoration Project. The challenges presented by the intricacy of reticulated tidal habitats, which prove difficult to survey using traditional net methods, along with sensitive species “take” restrictions, necessitated the incorporation of low impact survey techniques: DNA metabarcoding and the Aquatic Species and Habitat Sampling Platform (Platform). A sampling design was implemented before and after the breaching of levees, thus allowing observation of environmental and fish community changes resulting from merging the restored habitat with the San Francisco Estuary.

Combining fish detection through eDNA and video sampling with associated physical data within this habitat provides insights into fish behavior, interactions, and habitat utilization. Together, these methodologies revealed that post-breach, fish biodiversity in the restored habitat surged, with fish from the surrounding area colonizing the newly accessible environment.

Data analysis for this project is ongoing, with a projected completion date of late 2023. Preliminary analysis of DNA data has revealed that non-native species were approximately double the number of native species, mirroring the inherent condition of the Estuary. Out of the 42 fish species identified through ongoing eDNA surveys, five protected native species, including Chinook Salmon, Green Sturgeon, Longfin Smelt, Pacific Lamprey, and Rainbow Trout, were discerned within the revitalized habitat. We hypothesize that fish video and physical data collected by the Platform will mirror the DNA data. By amalgamating DNA metabarcoding with video observation and environmental conditions, this joint research offers a comprehensive understanding of fish biodiversity and the dynamic interplay of species within restored habitats.

Paradise Cut Imagery and Photogrammetry – 2023 High-Water Event: Phase 1 & 2

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In 2023, the DWR Division of Regional Assistance drone team, consisting of an FAA-licensed UAV Operator/Pilot, a licensed land surveyor, a GPS assistant, and a visual observer will plan, coordinate, fly, and collect a series of high-resolution aerial images videos, and 3-dimensional digital data at Paradise Cut in the southern Sacramento-San Joaquin Delta. Paradise Cut typically acts as a backwater tidal Delta slough, but also consists of a rock weir that is intended to alleviate high flows (17,000 cfs) from the San Joaquin River, and act as a flood control system for the city of Staockton, CA. Due to the wet water year and extended high flows in the San Joaquin River in 2023, the drone team planned to capture imagery and video footage of the floodplain area within Paradise Cut and after the floodwaters receded. Two flights were conducted in Paradise Cut, 1) during June 6th to capture a flooded period and 2) on August 9th to capture normal to low flow period. The objective of the project is to generate survey grade photogrammetry to inform DWR's efforts associated with Delta modeling, flood planning, long-term water quality monitoring studies, and public education. The drone team was able to achieve this objective by using the RTK Phantom drone which consists of high GPS accuracy and Trimble survey equipment, and installed ground control points to create survey grade photogrammetry. Finally, after all photogrammetry was collected for the two flights, the photos and GCPs were uploaded into ArcGis Pro to create a high quality orthomosaic of the entire Paradise Cut levee to levee channel area to visualize flow patterns and flooded landscapes. The use of drone technology in DWR environmental monitoring projects are proving to be invaluable, and data acquisition using drones continues to provide more accurate, efficient, and safer ways to collect georeferenced datasets.

Water Quality

AquaWatch California-Australia: International Cooperation to Pilot a "Weather Service" for Water Quality in the Sacramento-San Joaquin Delta

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Water quality is a critical component of water security. As climate change continues to challenge sustainable water resource management, there is an increasing need for near real-time water quality monitoring and early warning forecasts to inform water resource managers, ecosystem managers, and the public. AquaWatch is a collaboration between California and Australia that is seeking to develop a 'weather service' for water quality for California, Australia, and eventually, globally. AquaWatch is integrating ground-to-space based water quality monitoring with advanced, cloud-based data analytics forecasts within an Internet of Things (IoT) framework. The project seeks to use existing networks of in situ water quality sensors and contribute additional in situ sensors for high-accuracy ground-based measurements. These will be combined with satellite observations made from a constellation of existing and future custom-built earth observing satellites to scale highly precise water quality across large regions.

The first California pilot site is being deployed in the Sacramento-San Joaquin Delta, with a first focus on turbidity, followed by development for other optically active water quality constituents such as dissolved organic matter and algal blooms. The work is part of the Action Plan under the recently signed Memorandum of Understanding (MOU) between the Commonwealth of Australia and the Government of the State of California

to address climate change and a transition to green energy. A critical facet of the MOU and the project is the exchange of scientific knowledge and technical expertise, and co-design of the system with local indigenous, public, and private water resource managers. The purpose of the poster presentation is to raise awareness of the project, seek input for the co-design process, and seek future opportunities for collaboration and exchange of knowledge and expertise.

Continuous and discrete monitoring of agricultural drainage water quality on Delta islands to constrain carbon, nutrient, and pesticide dynamics

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Drainage waters from managed agricultural lands can transport nutrients, particulate matter, carbon, and pesticides into receiving waterways. This transport of these constituents can significantly impact aquatic habitats, drinking water quality, and recreational uses. In the Sacramento-San Joaquin Delta, where much of the agricultural land has subsided below the level of surrounding waterways, water drainage via mechanical pumping is also crucial for the viability of agricultural activities and the protection of island infrastructure. Due to the high carbon content of Delta island soils, the regular and sustained discharge of drainage waters from islands to Delta waterways can also be a pathway for lateral loss of carbon and associated constituents, which can exacerbate ongoing land subsidence. Because many Delta islands are currently or planned to undergo land use and land cover (LULC) changes, such as wetland restoration and changing cropping patterns, with the goal of reversing land subsidence and reducing carbon emissions, constraining how LULC changes affect island chemical budgets is important to contextualizing the efficacy of these changes. Additionally, from an aquatic habitat and water quality perspective, the discharge of drainage waters into Delta waterways represents a poorly constrained source of pesticides, nutrients, and other ions, which may be important to consider in terms of ecosystem health, harmful algal blooms, and drinking water quality.

Correlations Between Pesticide Presence, Land Use and Streamflows in the Yolo By-Pass

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In collaboration with the California Department of Water Resources (DWR), the U.S. Geological Survey (USGS) Pesticide Fate Research Group is monitoring a large suite of pesticides in the Yolo By-Pass that receives non-managed seasonal and local flow and managed flow pulses from agricultural drainage or the main stem of the Sacramento River. Augmented flow pulses are hypothesized to increase net positive flow during summer–fall in the Yolo By-Pass, thereby enhancing plankton availability in the Cache Slough complex. However, flow pulses may also result in unintended negative effects of increased pesticide levels that are transported through the Yolo By-Pass. In this study we evaluated pesticides in the Yolo By-Pass during the 2021–2023 water years and evaluated observed concentrations with respect to acres used for rice growth and streamflows. Water samples were collected by DWR personnel biweekly for two months between August and October at up to 7 sites. These samples were analyzed by the USGS for a suite of 178 current-use pesticides and pesticide degradates; these included a range of herbicides, insecticides, and fungicides. Fifty-two compounds were detected in water samples collected during the study, at concentrations ranging from below method detection limits to 4,538 nanograms per liter. The sum of average concentrations for pesticides that are used exclusively on rice were highest in samples collected in 2023, followed by samples from 2021 and 2022. Acreage dedicated to rice crops during 2023, 2021, and 2022 were 514,000, 471,000 and 256,000, respectively. Pesticide concentrations positively correlate with acreage of rice growth and daily mean discharge. These results can help us understand the impact of flow and changes in agriculture on pesticide occurrence and concentrations in the Yolo By-Pass and other areas of the Sacramento-San Joaquin Delta.

Kayak Mapping to Document Water Quality Gradients in Shallow Hard to Access Wetland Environments

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Across the Sacramento-San Joaquin Delta, wetland restoration efforts have been implemented, are under construction, or are being planned, with the explicit goals of providing habitat for native species and providing food web supplementation to benefit endangered species within these restored sites and in downstream habitats. Understanding how existing wetlands function is critical to informing adaptive management and the design of future wetland restoration sites. Documenting spatial and temporal trends in water quality, nutrients, and phytoplankton is a key part of evaluating wetland performance and can provide insights into how wetland design impacts hydrodynamics, water residence time, primary productivity, and habitat quality. Water-quality data collected using discrete sampling or continuous monitoring stations provides key information, but the spatial and temporal limitations of these data may not sufficiently characterize hydrodynamically, geomorphologically, and biologically variable wetland ecosystems. The Biogeochemistry Team at the U.S. Geological Survey California Water Science Center collected high-resolution water quality data in shallow wetland environments by equipping an inflatable kayak with a flow-through system and a suite of in situ instrumentation. This approach builds on USGS experience collecting high-resolution water quality, nutrient and phytoplankton data on larger boats in channels and deeper open-water habitats. The system was deployed as a proof-of-concept in the First Mallard Branch wetland on November 20, 2023. We will present pilot study results and demonstrate the spatial variability of parameters such as temperature, specific conductance, turbidity, dissolved oxygen, pH, phytoplankton abundance, and dissolved organic matter in this dendritic wetland system. The observational data collected using this approach can be used by modelers to validate and calibrate their models.

Remote Sensing of Water Quality in the Delta: Everyone Measuring Everything All At Once

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Models to estimate chlorophyll a and other water quality parameters from satellite-based, multispectral, remote sensing instruments such as Landsat and Sentinel 2 are often inaccurate in optically complex waters like the Sacramento-San Joaquin Delta (Delta). However, hyperspectral instruments provide more detailed spatial (meter scale) and spectral remote sensing data that can be leveraged for sophisticated water quality parameter products. One such instrument, the Airborne Visible Infrared Imaging Spectrometer (AVIRIS-3), was deployed during the week of September 11- 15, 2023, with the primary goal of characterizing aquatic vegetation as part of the ongoing ecosystem research led by University of California Davis. The U.S. Geological Survey (USGS) completed two concurrent boat-based high spatial resolution water-quality mapping surveys during the September 2023 AVIRIS-3 flights. Water quality parameters collected during boat-based water-quality mapping surveys included chlorophyll a, turbidity, phytoplankton enumeration, and a suite of optical measurements. The integrated remote sensing–in situ dataset can be used to develop improved remote sensing models using machine learning techniques that maximize the information that can be derived from these datasets. Models can be developed using this approach to distinguish phytoplankton functional groups, improve chlorophyll a products, and explore the impact of varying turbidity and dissolved organic matter on those models. Additionally, the models developed with this dataset could be applied to hyperspectral data collected during upcoming satellite-based remote sensing missions, such as NASA's Surface Biology and Geology (SBG) sensor.

Sublethal Toxicity Testing of Commonly Used Pesticides at Varying Salinities in Menidia beryllina

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Various stressors due to climate change including sea-level rise and drought impact estuarine ecosystems and contribute to fluctuations in salinity levels. When there is a high salt concentration in an ecosystem, increased competition between salt ions and other compounds for interactions with water molecules reduces the amount of a chemical dissolved in water and may cause an increase in its ability to concentrate in the fat tissue of fishes. As a compound becomes more lipophilic (less water soluble), coastal organisms may be more sensitive to chemical exposure as uptake into the body can increase. Pesticides are chemical compounds commonly used for agricultural and household purposes, and they can enter estuarine ecosystems through runoff. To determine if there is a difference of pesticide toxicity at varying salinities, *Menidia beryllina* embryos at six days post fertilization (approximately 1-day pre-hatch) were exposed to sublethal levels of six pesticides (bifenthrin, chlorpyrifos, dicloran, myclobutanil, penconazole, triadimefon) at two salinities (5 PSU and 25 PSU) for 96 hours. Menidia beryllina (Inland silverside) are a euryhaline model species, which allows for the ability to observe stressor effects over a broad range of salinities. Behavior, growth, and gene expression are endpoints that will be analyzed for effects at sublethal exposure levels as impacts observed at early life stages of fish could have potential population effects due to organism fitness contributing to overall survival.

Insights from 5 (and counting!) years of Delta-wide high-resolution mapping surveys

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To collect spatially rich water quality, nutrient, and phytoplankton data across the entire Sacramento-San Joaquin Delta (Delta), the U.S. Geological Survey completed high resolution mapping surveys across the Delta in spring, summer and fall of 2018, 2020, 2021, 2022, and 2023. High-resolution data from these surveys provide detailed information about spatial and temporal variability that cannot be captured by discrete sampling or continuous monitoring stations. Each survey represents a snapshot in time which can be used for a variety of data analytics pathways and can help inform a wide range of research and management questions. For example, these data document Delta-wide nutrient gradients through different phases of the EchoWater resource recovery facility's Biological Nutrient Reduction upgrade. When contextualized with management actions and extreme weather events (e.g, gate operations and droughts), we can explore links to phytoplankton abundance and distribution. We can identify point-source nutrient inputs, document the extent of harmful algal blooms, demonstrate rapid nutrient drawdown associated with phytoplankton blooms, and calculate water age. These data are also being used by modelers to build, calibrate, and validate linked hydrologic and biogeochemical models. Individual researchers may delve into data from specific areas of interest (e.g., a river reach or slough) to gain insights into the water quality and health of the lower food web in their target locations. Remote sensing models can also be improved upon with these spatially rich data. In this poster presentation, we will highlight some of the ways these data are being used and some of the findings.